

**Objectives, management practices, and perspectives
of small-scale private forest owners**



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Submitted by
Malin Kristin Tiebel

born on 13th June 1993 in Preetz, Germany

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1. Referee: Prof. Dr. Tobias Plieninger
2. Referee: Prof. Dr. Carsten Mann
3. Referee: Prof. Dr. Claudia Bieling

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Cover Photo: Colorful maple leaves as a symbol of the diversity of small-scale private forests and their owners. Photo: Lukas Flinzberger.

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Summary

Climate change and diverse societal demands ranging from resource use and recreation to biodiversity conservation are influencing forests today and have sparked an intensive debate about future forest management. One important group to consider are small-scale private forest owners. They not only own a substantial share of the total forested area but also contain a high potential for the implementation of nature conservation as important forest structures are found on their land. However, private forest owners often possess small and fragmented forest areas. They are not primarily concerned with their forest in their daily lives, subject to socio-demographic changes, and have heterogeneous objectives and perspectives. Thus, forest policy faces challenges in appropriately addressing private forest owners and considering their backgrounds, needs, and demands. This has led to conflicts, such as in the design and implementation of nature conservation policy. Against this background, it is important to understand the objectives, activities, and perspectives of small-scale private forest owners to successfully design a forest policy approach aiming to integrate societal demands in sustainable forest management. In this thesis, I provide an overview of the current state of research regarding small-scale private forest owners in Europe and North America. Further, I offer detailed insights into the background of private forest owners in the study area, the Lower Saxon Hills.

The first part of this dissertation, a literature review, revealed similar historical developments of public and private forests in Europe and North America. Across both continents, small-scale private forests were related to a variety of management approaches and habitats connected to cultural landscapes. As forests are often located in a mixed-ownership landscape, cross-boundary management is important. It needs to systematically consider each ownership type without homogenizing the management as well as to integrate biodiversity conservation and social-ecological conditions.

A second literature review found that current scientific literature on the conservation perspectives of European small-scale private forest owners is biased towards studies in north and western Europe and the use of quantitative methods, with little research concentrated on small-scale forest owners (< 20 ha). The parameters female gender, high levels of education, formalized forest management, active relation to the forest, and ecological values of the property were positively related to conservation perspectives. This study synthesized the given recommendations. To improve conservation in small-scale private forests, policy instruments need to be better adapted to private owners, while relevant information must be better designed and distributed. Further, the interaction between different stakeholders needs to be improved.

An analysis of a quantitative survey, conducted in the Lower Saxon Hills, focused on the Natura 2000 scheme as the largest network of conservation areas worldwide and differentiated between owners with and without forest stands in Natura 2000 areas. In general, survey respondents valued regulating and cultural ecosystem services higher than provisioning ones. Owners with stands designated as Natura 2000 area rated provisioning services and profit maximization as more important. Looking at conservation activities, only the protection of habitat trees was performed more often by this group. Certain silvicultural measures such as thinning and planting introduced species were more frequently taken. Further, attitudes towards nature conservation were more negative. These results indicate a low effectiveness and acceptance regarding the implementation of the Natura 2000 system. A stronger adaptation of Natura 2000 towards small-scale private forest owners via participatory approaches or attractive incentive schemes is needed.

In a second analysis of the survey data, I differentiated three forest owner groups based on their activities. All groups perceived biodiversity conservation as important. Multiple-use-oriented owners

were most active, also in terms of conservation measures, while conservation-oriented owners mainly focused on passive measures (such as the protection of dead wood). Conventional owners showed only little engagement with conservation-related activities. Despite these differences, the analysis of the typology revealed universal factors promoting conservation activities. These included for example on-site consultation, information about legal regulations, and financial incentives. Focusing on the four system characteristics parameters, feedback, design, and intent, I deducted leverage points of transformative change towards integrative, conservation-oriented forest management. Promising pathways are changing the discourse, adapting measures to the local context, increasing awareness, knowledge, and interest as well as accounting for the heterogeneity of private forest owners, for their desire for autonomy and control, and for uncertainty related to climate change.

To summarize, I found that private forest ownership is embedded in a complex environment shaped by socio-economic, institutional, natural, and historic conditions. Private forests provide a large variety of ecosystem services that positively affect the well-being of the wider society. While small-scale private forest owners form a heterogeneous group with various objectives, management approaches, and perspectives, their stands as well as their perspectives generally offer high potential for integrative conservation-oriented forest management. However, in the past, forest policy was not always successful in addressing the needs and demands of small-scale forest owners. A transformative change of the current political approach, including changes to relevant sectors, institutions, and stakeholders as well as to the underlying paradigms and values of the current system, has high potential. With regard to the large share of private forest owners, nature conservation is only successful if it considers local landowners and decision-makers.

Zusammenfassung

Der Klimawandel und verschiedene gesellschaftliche Anforderungen, die von Ressourcennutzung über Erholung bis hin zum Erhalt der biologischen Vielfalt reichen, beeinflussen unsere Wälder und haben eine intensive Debatte über die künftige Waldbewirtschaftung ausgelöst. Eine wichtige Gruppe, die es dabei zu berücksichtigen gilt, sind die Besitzenden von Kleinprivatwald. Ihnen gehört nicht nur ein erheblicher Anteil des Waldes, sondern auf ihren Flächen befinden sich auch naturschutzfachlich wertvolle Strukturen, sodass hier ein großes Potenzial für die Umsetzung von Naturschutzmaßnahmen besteht. Allerdings nennen Privatwaldbesitzende oft kleine und fragmentierte Waldflächen ihr Eigen, sie beschäftigen sich im Alltag nicht primär mit ihrem Wald, sind soziodemographischen Veränderungen unterworfen und haben vielfältige Ziele und Perspektiven. Daher steht die Forstpolitik vor der Herausforderung, die privaten Waldbesitzenden und ihre Hintergründe, Bedürfnisse und Forderungen angemessen zu berücksichtigen. Dies war in der Vergangenheit nicht immer erfolgreich und hat zu Konflikten geführt, zum Beispiel bei der Gestaltung und Umsetzung der Naturschutzpolitik. Vor diesem Hintergrund ist es entscheidend, die Ziele, Aktivitäten und Perspektiven von Kleinprivatwaldbesitzenden zu verstehen. Auf diese Weise kann eine Forstpolitik gestaltet werden, die es ermöglicht, gesellschaftliche Anforderungen in eine nachhaltige Waldbewirtschaftung zu integrieren. Diese Dissertation gibt einerseits einen Überblick über den aktuellen Stand der Forschung zu Kleinprivatwaldbesitzenden in Europa und Nordamerika. Darüber hinaus liefere ich detaillierte Erkenntnisse über private Waldbesitzende in unserem Untersuchungsgebiet, dem Niedersächsischen Bergland.

Eine Literaturanalyse als erster Teil der vorliegenden Dissertation konnte vergleichbare historische Entwicklungen der Wälder im öffentlichen und privaten Besitz in Europa und Nordamerika nachweisen. Auf beiden Kontinenten sind kleine Privatwälder durch eine Vielzahl von Bewirtschaftungsansätzen und Lebensräumen der Kulturlandschaft charakterisiert. Da sich Wälder häufig in Landschaften mit gemischten Besitzverhältnissen befinden, ist eine besitzgrenzüberschreitende Bewirtschaftungsplanung von entscheidender Bedeutung. Sie sollte darauf abzielen, systematisch jede Besitzform zu berücksichtigen, ohne die Bewirtschaftung zu homogenisieren und dabei den Erhalt der biologischen Vielfalt und die sozial-ökologischen Bedingungen integrieren.

Eine zweite Literaturstudie zeigte, dass die derzeitige Forschung zu Naturschutzperspektiven im europäischen Privatwald vor allem auf Nord- und Westeuropa sowie quantitative Methoden ausgerichtet ist und dass sich nur wenige Untersuchungen auf Waldbesitzende mit kleinen Flächen (< 20 ha) konzentrieren. Die Parameter weibliches Geschlecht, hohes Bildungsniveau, formalisierte Waldbewirtschaftung, aktiver Bezug zum Wald und ökologische Werte des Waldbestands standen in einem Zusammenhang mit positiven Naturschutzperspektiven. Die Studie fasste die Empfehlungen der analysierten Artikel zusammen. Um Naturschutz im Kleinprivatwald zu stärken, sollten die politischen Instrumente stärker an die privaten Waldbesitzenden angepasst und relevante Informationen besser aufbereitet und verbreitet werden. Außerdem muss die Beziehung zwischen den verschiedenen Akteursgruppen verbessert werden.

Die Analyse einer quantitativen Umfrage im niedersächsischen Bergland konzentrierte sich zunächst auf Natura 2000 als größtes Netz von Schutzgebieten weltweit und verglich Waldbesitzende, die Flächen in solchen Gebieten haben mit solchen, bei denen das nicht der Fall ist. Die Befragten bewerteten insgesamt die regulierenden und kulturellen Ökosystemleistungen als wichtiger im Vergleich mit den versorgenden. Besitzende, deren Bestände als Natura-2000-Gebiet ausgewiesen

sind, stuften die Versorgungsleistungen und die Gewinnmaximierung als wichtiger ein. Die einzige Naturschutzmaßnahme, die in Natura-2000-Beständen häufiger umgesetzt wurde, war der Erhalt von Habitatbäumen. Verschiedene waldbauliche Maßnahmen wie Durchforstung und Anpflanzung eingeführter Arten wurden ebenfalls öfter durchgeführt. Die Einstellungen hinsichtlich Naturschutzes waren negativer. Diese Ergebnisse deuten auf eine geringe Wirksamkeit und Akzeptanz bei der Umsetzung des Natura-2000-Netzwerks hin. Eine stärkere Anpassung an private Kleinwaldbesitzende durch Partizipation oder die Einführung von attraktiven Anreizsystemen ist erforderlich.

In einer zweiten Analyse der Befragungsdaten unterschied ich drei Waldbesitzgruppen basierend auf ihren Aktivitäten. Alle Gruppen erachteten den Erhalt der biologischen Vielfalt als wichtig. Die auf Mehrfachnutzung ausgerichteten Waldbesitzenden waren am aktivsten, auch in Bezug auf Naturschutzmaßnahmen, während sich die naturschutzorientierten Befragten hauptsächlich auf passive Maßnahmen konzentrierten (z.B. den Erhalt von Totholz). Konventionelle Waldbesitzende engagierten sich nur in geringem Maße für Naturschutzmaßnahmen. Trotz der Unterschiede zeigte die Analyse dieser Typologie universelle Ansätze zur Förderung von Naturschutzmaßnahmen auf, wie z. B. Beratung vor Ort, Informationen über gesetzliche Regelungen und finanzielle Anreize. Ausgehend von den Charakteristika eines Systems, Parameter, Feedback, Gestaltung und Intention, leitete ich Hebelpunkte für einen transformativen Wandel hin zu einer integrativen, naturschutzorientierten Waldbewirtschaftung ab. Vielversprechende Wege sind die Veränderung des Diskurses, die Anpassung von Maßnahmen an lokale Bedingungen, die Steigerung des Verständnisses, des Wissens und des Interesses ebenso wie die Berücksichtigung der Heterogenität der privaten Waldbesitzenden, ihres Wunsches nach Autonomie und Kontrolle und der Unsicherheiten im Zusammenhang mit dem Klimawandel.

Zusammenfassend habe ich festgestellt, dass privater Waldbesitz in ein komplexes Umfeld aus sozioökonomischen, institutionellen, natürlichen und historischen Bedingungen eingebettet ist. Privatwälder erbringen eine Vielzahl von Ökosystemleistungen, die sich positiv auf das Wohlergehen der gesamten Gesellschaft auswirken. Obwohl die Kleinprivatwaldbesitzenden eine heterogene Gruppe mit unterschiedlichen Zielen, Bewirtschaftungsweisen und Perspektiven bilden, bieten ihre Bestände sowie ihre Perspektiven im Allgemeinen ein hohes Potenzial für eine integrative, naturschutzorientierte Waldbewirtschaftung. In der Vergangenheit ist es der Politik jedoch nicht immer gelungen, die Bedürfnisse und Ansprüche der Kleinwaldbesitzenden zu berücksichtigen. Ein transformativer Wandel des derzeitigen politischen Ansatzes, der relevante Sektoren, Institutionen und Akteursgruppen miteinbezieht und die zugrundeliegenden Paradigmen und Werte des derzeitigen Systems verändert, hat großes Potenzial. Naturschutz ist in den flächenmäßig sehr bedeutenden Privatwäldern nur dann erfolgreich, wenn er die lokalen Landbesitzenden und Entscheidungsträger:innen mitberücksichtigt.

1. Introduction

"I fear that the rights of forest owners will be lost as a result of increasing environmental protection and nature conservation. The duties [...] on the other hand, are constantly increasing."

"In a way, the conservation of the forest is also a kind of hobby in continuation of the long-standing family property."

"My problem is that I don't know what to do with the forest. I only have costs and would actually like to sell the forest, but I don't even know who would be interested."

"For me, as a farmer, the forest is a "tree field" that should produce."

Statements received in the survey

Within Europe, forests are the main type of natural vegetation (Kraus & Krumm, 2013) and cover 35% of the total terrestrial area (Forest Europe, 2020). Anthropogenic activities have influenced this ecosystem throughout the continent (Welzholz & Johann, 2007) and since ancient times (Angelstam et al., 2005) as forests are managed to provide a diverse range of ecosystem services (Sotirov & Arts, 2018). Nowadays, primary forests cover only 0.7% of Europe's forest area and are mostly located in boreal or alpine regions (Sabatini et al., 2018). With changing societal demands in the last decades, conflicts between the intensification of forest management and biodiversity conservation occurred, for example, due to the shortened crop rotation times, removal of dead wood, planting of exotic species, and changing harvesting methods (Young et al., 2005). As trees are mainly harvested when economically valuable, forests in a late or degrading phase only rarely exist, even though their habitat continuity is highly valuable for biodiversity (Kraus & Krumm, 2013). Managing forests for different purposes is challenging and results in paradigms such as sustainable, multifunctional, or integrated forest management aiming at fulfilling multiple objectives at once (Sotirov & Arts, 2018).

Sustainable management of forests is a central element of forest strategies within the EU and its member states (Edwards & Kleinschmit, 2013). It is integrated into policies such as the Common Agricultural Policy or in conservation schemes such as Natura 2000 (Young et al., 2005). While these approaches aim to consider different societal demands (Borrass et al., 2017; Sotirov & Arts, 2018), forest management is often based on an economic paradigm. Innovation mostly focuses on provisioning ecosystem services (Mann et al., 2022) as revenue is primarily generated by marketable goods such as timber (Maier et al., 2021).

1.1 Importance of small-scale private forests in Europe

Current and past forest management as well as land tenure influence forest ecosystems, their services, and the state of biodiversity (Bengtsson et al., 2000; Munteanu et al., 2016). As European forests are embedded in a mixed-ownership landscape, differences in ownership status and related objectives influence the provision of forest ecosystem services and conservation values (Schaich & Pliening, 2013). Public forests can be influenced directly by programs aiming at multifunctionality (Borrass et al., 2017). However, this is more difficult for private forests which are an important type of forest ownership both in Europe and Germany. Private forests account for 47% (Forest Europe, 2020) and 48% of the total forested area (BMEL, 2018) respectively, with large variations between the countries (Forest Europe, 2020).

Within private forests, management activities vary widely (Ziegenspeck et al., 2004), and a general distinction can be made between large and small-scale private forests. Large private forests are mainly owned by individuals, companies, or institutions like churches and their size can vary between a few hundred and several thousand hectares (Mölder et al., 2021). Among the member states of the United Nations Economic Commission for Europe (UNECE) however, 88% of private forest parcels are smaller than ten hectares (excluding Russia and North America) (UNECE & FAO, 2020). Within Germany, for example, private forest parcels have an average size of 12 hectares with a median of 2 hectares (Feil et al., 2018). While large forests are managed mainly for timber production, the often fragmented small-scale properties belong to owners with diverse objectives (Berges et al., 2013). These owners are subject to change (Haugen et al., 2016; Weiss, Lawrence, Hujala, et al., 2019) as the economic importance of the forests and the agricultural background of the owners is declining (Ziegenspeck et al., 2004). Female (Follo et al., 2017), non-resident (Eggers et al., 2014), as well as aging owners are on the rise (Haugen et al., 2016). Thus, the objectives in small-scale private forests are further diversifying (Weiss, Lawrence, Hujala, et al., 2019).

Due to this heterogeneity, small private forests in Europe and North America are characterized by a variety of valuable habitats and structures (Mölder et al., 2021). For example, small private forests have been associated with higher structural diversity, more deadwood, a larger carbon storage capacity (Schaich & Plieninger, 2013), more microhabitats (Johann & Schaich, 2016), a more complex vertical structure of the canopy, and a higher tree species richness (Rendenieks et al., 2015). Furthermore, remnants of traditional management such as coppicing or wood pasture are more frequently found here (Mölder et al., 2021). At the same time, the demand for wood is growing (Ceccherini et al., 2020) and private forests are receiving increasing attention from governments aiming to increase management levels in Slovenia and Serbia (Pezdevšek Malovrh et al., 2015), France (Arnould et al., 2021), Germany, and the Netherlands (Deuffic et al., 2018). The promotion of wood mobilization led to rising timber usage. In the old federal states of Germany, the harvesting rate grew by 49% when comparing the periods from 1987 to 2002 and 2002 and 2012 (Henning, 2018). This development is expected to continue as the EU aims to achieve a climate-neutral economy by 2050 (Blatter et al., 2020; European Commission, 2018) and due to the current energy crisis and the associated high demand for firewood. However, the intensification of resource use has to be harmonized with biodiversity conservation in small-scale private forests (Schaich & Plieninger, 2013).

1.2 Opportunities and challenges of nature conservation in small-scale private forests

The importance of private land conservation increased in recent years (J. L. Gooden, 2019) as a focus on merely public land proved not to be sufficient to sustain global biodiversity (Kamal et al., 2015). While currently 14.9% of the earth's terrestrial area is protected (UNEP-WCMC et al., 2018), higher shares are demanded. The Kunming-Montreal Global Biodiversity Framework aims for a coverage of 30% by 2030 (Secretariat of the Convention on Biological Diversity, 2022) and the Half-Earth approach promotes a share of up to 50% (Dinerstein et al., 2017). Appropriate management of the surrounding working land complements protected areas by considering biodiversity and providing additional habitats while producing other goods and services (Kremen & Merenlender, 2018). Private forest owners and their land are important due to their prevalence (Joa & Schraml, 2020) and relevance for structures of conservation concern (Mölder et al., 2021). Further, private land conservation contributes to human well-being (Yasué et al., 2020) and local economies (Sims et al., 2019). Depending on the design of the conservation process, including private forest owners and their land can result in the consideration of local knowledge (Joa & Schraml, 2020). Furthermore, active

participation accounts for the desire for autonomy, increases acceptance, and reduces conflicts (Sorice et al., 2013).

Biodiversity is a public good (Kamal et al., 2015), usually unrewarded in the market (Nordén et al., 2017), and its conservation may limit the activities of local landowners (Tikka & Kauppi, 2003) while at the same time creating costs (Nordén et al., 2017). Thus, the individual motivation to perform conservation activities is often low and promoted by government intervention (Kamal et al., 2015) in the form of incentives, regulations, and capacity building (Janota & Broussard, 2008). Thereby, the design of effective conservation approaches is complex and challenging due to competing societal demands, climate change, and associated uncertainties, as well as the socio-economic surroundings of the individual private forest owner (Eriksson & Fries, 2021). In their review, Gooden and 't Sas-Rolfes (2020) differentiate three groups of challenges in private land conservation. "Implementation effectiveness" includes the difficulty to secure permanent and effective conservation agreements as well as financial problems, a lack of skills, resources, and information, as well as limited accountability. "Value conflict" addresses, among others, issues related to cultural conflicts, inequity, exclusion, self-serving motifs, neoliberalism, and dependence. "Economic inefficiency" accounts for challenges related to the risk for society if incentives suppress the minimization of conservation costs as well as intergenerational equity. As a consequence of these challenges, the implementation of conservation instruments in private forests is not always successful and can even result in adverse actions (Hiedanpää, 2002; Jokinen et al., 2018). More specifically for small-scale private forests, the problems in implementing conservation are often related to poor communication (Brukas et al., 2018), fear of restrictions in decision freedom, economic consequences (Jokinen et al., 2018), or conflicting objectives (Urquhart et al., 2012).

1.3 Research gaps and general aims of the thesis

An understanding and consideration of small-scale private forest owners and their perspectives is required to create a forest policy that is capable of dealing with diverse challenges and to design effective nature conservation (Eriksson & Fries, 2021; Paloniemi & Tikka, 2008). At the same time, knowledge about forest ownership in Europe is limited. There are knowledge gaps regarding ownership change (Weiss, Lawrence, Hujala, et al., 2019), objectives and behavior beyond timber utilization, and the linkage between owners' backgrounds, goals, and activities. Regarding the design of suitable policy approaches, there is limited research on factors that result in behavior change (Quiroga et al., 2019), how certain owner types respond to different policy instruments (Weiss, Lawrence, Lidestav, et al., 2019), how small-scale forest owners act in the face of current challenges (de Groot et al., 2021), and their information needs (Lupp et al., 2017).

As conservation aspects are often not adequately addressed in forest policy aiming at small-scale private owners and due to the described research gaps, I offer insights on:

- forest ownership patterns and their linkages to forest structure, biodiversity, and conservation in Europe and North America
- European small-scale forest owners and their conservation perspectives
- Natura 2000 and its relation to the objectives, management activities, and attitudes of private forest owners
- the differences and similarities between different groups of forest owners and the identification of a pathway to transformative change.

2. Research approach and objectives

A combination of literature reviews and quantitative data analysis addresses these four research aims in four articles (Tab. 1).

Table 1: Overview of the articles used in this dissertation.

| Number of the article | Reference |
|-----------------------|--|
| 1* | Mölder A, Tiebel M, Plieninger T (2021) On the interplay of ownership patterns, biodiversity, and conservation in past and present temperate forest landscapes of Europe and North America. <i>Current Forestry Reports</i> 7:195–213. https://doi.org/10.1007/s40725-021-00143-w |
| 2 | Tiebel M, Mölder A, Plieninger T (2021c) Conservation perspectives of small-scale private forest owners in Europe: a systematic review. <i>Ambio</i> 51:836–848. https://doi.org/10.1007/s13280-021-01615-w |
| 3 | Tiebel M, Mölder A, Plieninger T (2021b) Small-scale private forest owners and the European Natura 2000 conservation network: perceived ecosystem services, management practices, and nature conservation attitudes. <i>European Journal of Forest Research</i> 140:1515–1531. https://doi.org/10.1007/s10342-021-01415-7 |
| 4 | Tiebel M, Mölder A, Bieling C, Hansen P, Plieninger T (2023) Engaging small-scale private forest owners for transformative change towards integrative conservation. In revision |

*As I am not the first author of this article, the term “author team”/we is used when referring to this article. To simplify and to generate a pleasant reading flow, “I” is used for the other articles.

All articles are interconnected and build upon each other (Fig. 1). With a focus on Europe (and North America), the author team provided background knowledge on small-scale private forest owners and conservation issues in the first two articles, with different forms of literature reviews employed in each. With my empirical work in the form of a quantitative survey, I reduced the spatial scale by focusing on the study area (largely in concordance with the Lower Saxon Hills) and generated more detailed insights into the specific topics of Natura 2000 (Article 3), different types of forest owners, and transformative change (Article 4).

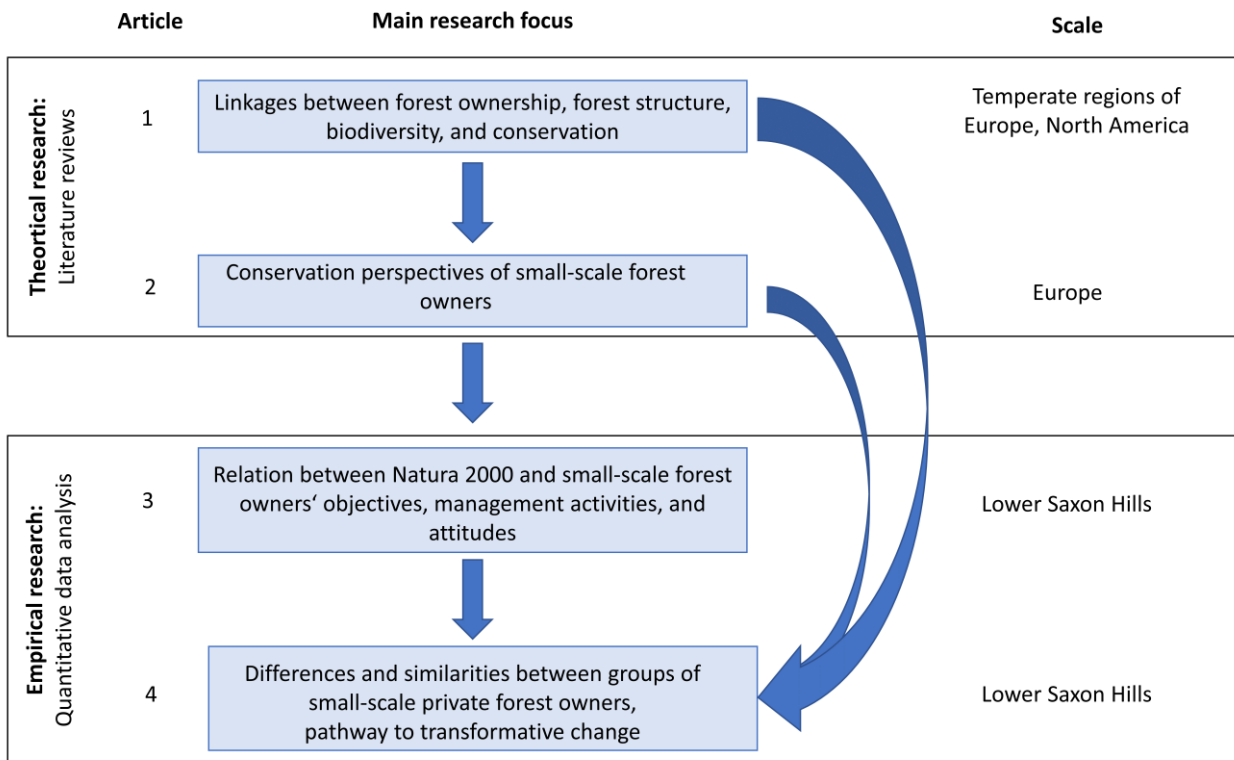


Figure 1: Overview of the dissertation and the interconnection between the articles (simplified). The main results are presented and discussed in chapter 3. The articles are attached in the appendix.

In the first article, a literature review focused on the linkages between forest ownership patterns and forest structure, biodiversity, and conservation in the temperate regions of Europe and North America. Building upon these linkages and their historical development, the second article generated knowledge on the actual conservation perspectives of small-scale forest owners across Europe. By reviewing the current state of research, I identified social-ecological factors which influence conservation perspectives as well as recommendations made to improve current conservation policy. The third article analyzed how the world's largest network of protected areas, Natura 2000, is related to small-scale private forest owners' objectives, management practices, and attitudes in the Lower Saxon Hills. As the adaptation of current conservation policy in small-scale private forests played an important role in all three articles, I identified differences and similarities between the forest owners to gain concrete insights on the local level by creating a typology. Based on that, specific recommendations indicate how conservation can be addressed within each group. To achieve substantial improvements to the current system, a holistic change is required reaching beyond private forest owners. I, therefore, provide leverage points that can help to design a process of transformative change towards integrative conservation.

2.1 Study area for empirical research

I conducted empirical research in the federal state Lower Saxony in northwest Germany. More specifically, the focus was on the landscape unit Lower Saxon Hills and its adjacent areas (Fig. 2). Adjacent areas consist of the remaining territory of the counties in which the forest holdings of the survey recipients are located.

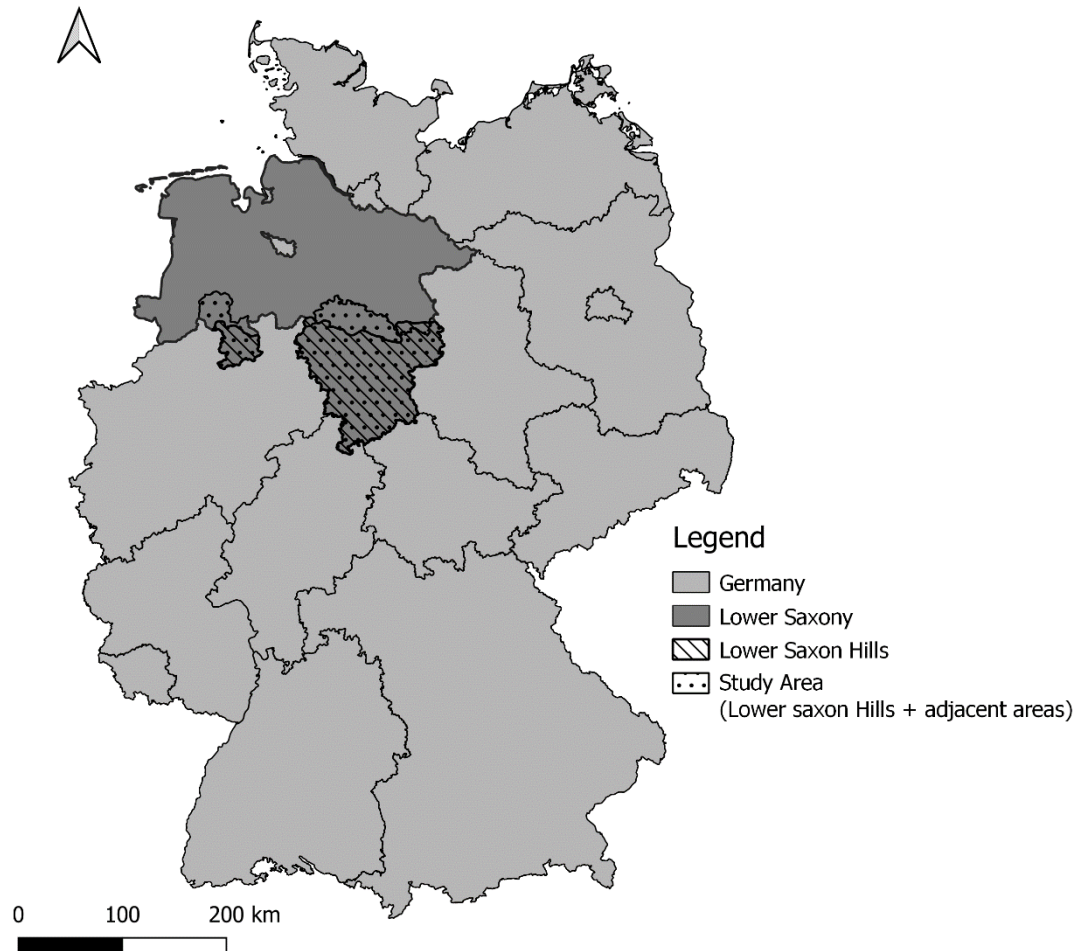


Figure 2: Study area in the context of Germany, Lower Saxony, and the Lower Saxon Hills. Geodata: Germany and federal states (GeoBasis-DE and BKG 2021), administrative borders of the study area (LGLN 2021), Lower Saxon Hills (Gauer 2005, slightly modified according to ML Niedersachsen 2014).

This study area is suitable for empirical research because of its consistent legal situation, the uniform forest administration, and most importantly, its fragmented and small-scaled ownership structure can be compared to many (western) European countries (Tab. 2). This enables a certain transferability of the findings.

The Lower Saxon Hills have a forest coverage of 33% with 43% of the forest area being privately owned. Both shares are comparable to the German and European average of forested area (32% and 35%, respectively) as well as of private ownership (48% and 47%, respectively). Within Lower Saxony, 45% of the private forest owners own holdings with a size smaller than 20 ha (ML Niedersachsen, 2014). According to my results, 91% of forest owners in the Lower Saxon Hills possess holdings smaller than this threshold. This fragmented structure was created by the partitioning and privatization of common woodlands in the 18th and 19th centuries (Brakensiek, 1994; Mölder, 2016).

In the last federal forest inventory in the Lower Saxon Hills (2012), European Beech (*Fagus sylvatica*; 35%) is the dominant tree species, followed by Norway spruce (*Picea abies*; 29%) and oaks (*Quercus sp.*; 11%). In comparison to Lower Saxony (2012), Germany (2012), and Europe (2020, including Russia, Tab. 1), the share of European Beech is relatively high, while the share of Scots Pine is rather low (*Pinus sylvestris*, 3%). Forest sites with long ecological continuity are present in the Lower Saxon Hills leading to a relatively high share of forests in a close-to-nature condition (46% as compared to 29% for Lower Saxony) (ML Niedersachsen, 2014). Relicts of historical forest management, such as coppicing, have resulted in valuable wildlife habitats up to today (Mölder, 2016). In the private forests of the Lower Saxon Hills, comparably large wood volumes are harvested [7.7 m³ of harvested wood volume per year and ha on average, as compared to 5.1 m³ in Lower Saxony as a whole]. However, within Lower Saxony, private forests smaller than 20 ha contribute less to these utilization rates, with a harvested wood volume of 3.4 m³ per year and ha (ML Niedersachsen 2014). The study area was affected by storms in 2018 (Rohde et al. 2019) and 2022 (ML Niedersachsen, 2022) as well as by drought and a large-scale bark beetle infestation in conifer forests between 2018 and 2020 (Rohde et al. 2020a, b).

Table 2: Forest and ownership characteristics in Lower Saxon Hills, Lower Saxony, Germany, and Europe. Based on ML Niedersachsen (2014b), BMEL (2018), Forest Europe (2020), unless marked otherwise. The number in brackets in the column “Europe” shows the data for EU-28.

| | | Lower Saxon Hills | Lower Saxony | Germany | Europe |
|--|----------------|-------------------|--------------|-----------------------|--|
| Forest coverage [%] | | 33 | 25 | 32 | 35 (38) |
| Private ownership [%] | | 43 | 59 | 48 | 47 (61) |
| Private ownership < 20 ha [%] | | 91 (own data) | 45 | 50 (Henning, 2018) | Not available |
| Dominant tree species across ownership groups [%] | European Beech | 35 | 14 | 15 | 12 |
| | Norway Spruce | 29 | 17 | 25 | 34 |
| | Scots Pine | 3 | 29 | 22 | 30 |
| | Oak(s) | 11 | 13 | 10 | 10 |
| Forest with “close to nature” condition [%] | | 46 | 29 | 36 | Undisturbed by men: 2 (2) Semi-natural: 94 (93) |
| Harvest rate in private forests [m³/y ha] | | 7.7 | 5.1 | 7.0 | Roundwood: 3.1 (3.3) |
| Harvest rate in small-scale (< 20 ha) private forests [m³/y ha] | | Not available | 3.4 | 6,1 | Not available |

2.2 Methodology

Literature reviews

In the first article, a narrative literature review based on specified search terms, concentrated on the historical development of forest ownership patterns and their influence on forest structure and biodiversity in temperate regions in Europe and North America. A subsequent systematic analysis used criteria for eligibility and thus identified 22 articles that explained the relation between today’s ownership patterns and present-day forest structure and biodiversity. Findings from both approaches were combined to determine implications for conservation management in mixed-ownership forest landscapes.

The second article created an overview of the current state of research regarding European small-scale forest owners and conservation. Thereby, the research approach followed the guidelines by Pullin and Stewart (2006) for a systematic literature review as well as the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standards (Moher et al., 2009). The search strategy resulted in 46 publications. I analyzed these articles regarding applied research approaches, social-ecological factors influencing private forest owners’ conservation perspectives, and recommendations that were developed by the respective authors.

Quantitative data analysis

I conducted a mail survey and designed and distributed it according to Dillman’s Total Design Method (Dillman, 1991). It included 26 questions regarding the owners’ relation to their forest, framework conditions, and sociodemographic as well as forest stand characteristics. After performing a pre-test, I sent the survey to 4,204 private forest owners organized in three local forest owners’ associations. Participants were asked to answer online or by post. Intensive public relations work and sending a

reminder/thank-you-postcard to all forest owners ensured a high reply rate. This way, 1,671 responses (39.8%) were usable for the subsequent analysis.

In the third article, I analyzed this data by differentiating between forest owners with and without designated Natura-2000 areas. Thereby, the Mann-Whitney U test and the Chi-square test determined the differences between the two groups. Further, the effect size provided information about the strength of these differences.

A hierarchical cluster analysis differentiated between owner groups in the fourth article. I employed the Kruskal-Wallis test and the Chi-square test to analyze the differences between the groups. The Conover-Iman test and a posthoc analysis were used to determine inter-group-specific differences. The effect size was calculated and interpreted.

Critical methodological reflections

The methodological approach used in the literature reviews (Articles 1 and 2) was suitable to identify research gaps and interesting themes for the design of the survey, as well as to gain a broad knowledge base before contacting private forest owners. I further discussed and pre-tested drafts of the survey with private forest owners, researchers, and forest officials and adapted it accordingly. Thus, its design was suitable to the target group. The high response rate might indicate that the questions were of interest to the private forest owners and designed appropriately. However, also the pandemic and the resulting lock-down might have led to the circumstance that survey recipients had more time to answer. The data quality might be impacted by a non-response bias. Certain individuals will have a higher likelihood to have answered the survey, especially if they were interested in the topic, were knowledgeable, or had enough time (Stockemer, 2019). Further, comments on the survey indicated that some people did not participate due to old age or because the time of the survey collided with harvest activities. Additionally, passive forest owners are frequently underrepresented (Bieling 2004).

I focused on one specific area by sending a postal survey to all owners in the study area instead of distributing an online survey. Thus I was not able to collect answers from private forest owners across Germany. While this limits the representativeness in some regards, it has the advantage of providing an in-depth understanding of a large part of the ownership group in the study area. The survey also reached those owners who were not motivated or capable to answer online, which had a positive effect on the representativeness of the data. An analysis of its representativeness showed that it can be transferred to other regions with a similar ownership structure (Tiebel, Hansen, et al., 2021; Tiebel, Mölder, et al., 2021b). When analyzing the data, I created categories of different forest management activities in my third and fourth articles. Due to new insights, expert consultation, and the enhancement of my research approach, the chosen categories have been refined and adapted to the study context. Therefore, they differ between the articles. This might confuse the readers, but I chose to use new categories as they fit my research aims more appropriately. Inaccuracies may also result from respondents who provided information on their forest stand (analyzed in Articles 3, 4) but do not visit their stand regularly and thus, might not be aware of the current stand characteristic. However, this is only true for a minority of the respondents. An article by Peter Hansen and others will further expand the knowledge by combining survey and field data (Hansen et al., 2023).

Qualitative interviews would have been helpful to understand the underlying reasonings behind certain response patterns. The recommendations presented here would have further benefited from a solution scanning workshop in which experts from conservation, forestry, and science as well as

foresters, forest owners, and political decision-makers would have discussed, improved, or validated the suggestions. Both qualitative research approaches were not possible due to time restrictions and the pandemic situation. However, the open questions as well as a short solution-scanning exercise in the project-accompanying working group gave insights into these topics. These impressions helped to understand the context. For example, quotations from the open questions were used in the discussion of the third article.

3. Main results and discussion

With a focus on Europe and North America, an analysis of the linkages between forest ownership, forest structure, biodiversity, and conservation found small-scale forest ownership to be important for certain conservation values (Article 1). Thus, an understanding of conservation perspectives of these owners is crucial for effective conservation policy (Article 2). Among other findings, I deduced a need to improve current conservation approaches. Therefore, a subsequent analysis focused on Natura 2000, the largest network of protected areas, and its relation to small-scale private forest owners (Article 3). The findings indicated that the Natura 2000 approach to conservation is not well adapted to private forest owners. I analyzed differences and similarities within the group of small-scale private forest owners by creating a typology and deduced owner-specific approaches and an overarching pathway to transformative change for integrative conservation (Article 4). The interconnections between the articles are displayed in Figure 1. Here, I will describe and discuss key research findings answering the research objectives.

3.1 Linkages between forest ownership, forest structure, biodiversity, and conservation (Article 1)

In the first article, a literature review analyzed forest ownership in the temperate regions of Europe and North America. Focusing on the historical development and today's situation, our author team aimed at specifying the linkages between ownership patterns, forest structure, and biodiversity. Private forests are embedded in a social-ecological system. Thus, this background serves as a basis upon which a more specific understanding of private forest owners and their relation to conservation and resource use can be built.

Key finding 1: Historical agrarian individualism, the demand for efficient management, and subsequent parcellation still influence today's structure of private forest ownership.

To understand private forest ownership today, its historical development must be considered. In Europe, the privatization of common woodland started during the 18th century as a consequence of agrarian individualism (Brakensiek, 1994). In the same period, modern land-use schemes were developed and resulted in efficient and more intensive forest management with new techniques (Farrell et al., 2000). Private property was regarded as essential for efficient forest management (Brakensiek, 1994). The division of the land among the commoners resulted in a high parcellation of the forest which was in some regions reinforced by property division due to inheritance (Nonic et al., 2011). As land consolidation was not systematically performed, this structure widely remains until today. About 100-150 years later, a similar development can be found in North America. Here, the parcellation is mostly due to property division among heirs (DeCoster, 1998), a stronger orientation towards non-timber products (Zhang et al., 2005), uncertainty about regulations, and urbanization (Mehmood & Zhang, 2001).

Key finding 2: Private forests frequently harbor important conservation values which are especially related to cultural landscapes.

Private forests were and are characterized by a diversity of management approaches and intensities resulting in a diverse mosaic of forest structures and habitats (Maltamo et al., 1997). The systematic literature review revealed that the small and fragmented structure of small-scale private forests results in positive effects on structural diversity and biodiversity, especially related to cultural landscapes. This finding is following the environmental heterogeneity hypothesis stating that heterogeneity in land cover, vegetation, and other factors has a positive influence on species richness (Stein et al., 2014).

Traditional management techniques such as coppicing were conducted longer in private compared to public forests and their remnants can still be found today (Mölder, 2016). The long period with lower management intensity and more diverse approaches resulted in a higher level of deadwood, structural diversity, and carbon storage capacity (Schaich & Plieninger, 2013). In contrast, nature reserves and sites with long ecological continuity (Reise et al., 2019) are mainly found in public forests. As a result, forest landscapes with mixed ownership structures contain a more diverse range of habitats compared to those with one type of ownership.

Key finding 3: Cross-boundary, integrative forest management and systematic conservation planning are guiding principles for conservation in mixed-ownership landscapes.

Our author team deduced four guiding principles of conservation in a mixed ownership working landscape. In this synthesis, I will introduce the three most substantial ones, called cross-boundary ecosystem management, integrative forest management, and systematic conservation planning (Fig. 3). The fourth guiding principle is rather specific and proposes the implementation within biosphere reserves.

As the forest landscape in Europe is dominated by a mixed ownership landscape, *cross-boundary ecosystem management* is crucial. This implies the focus on a landscape level and the consideration of more than one ownership type. Ownership-type specific peculiarities and conservation values need to be accounted for while homogenizing the management approaches needs to be prevented.

Society as well as private forest owners place diverse demands on forests. Thus, *integrative forest management* is necessary which combines conservation with social-ecological

and economic aspects. As the focus of small-scale private forest owners is partly shifting towards other ecosystem services than wood production, novel management approaches need to consider the perspectives of this changing ownership group. A wide range of approaches ensures the maintenance of the diverse mosaic of forest management with its benefits for conservation value.

Systematic conservation planning ensures a large conservation effect while minimizing costs. The evidence-based identification of conservation hotspots or habitats that need to be connected requires continuing social-ecological research in this realm as well as improving the availability of conservation data, especially in small-scale private forests.

3.2 Conservation perspectives of small-scale private forest owners (Article 2)

In the second article, the systematic literature review created an overview on the current state of research regarding small-scale private forest owners and their conservation perspectives. I identified research approaches, determined factors influencing conservation perspectives and summarized frequent recommendations made by the authors. This expanded the background knowledge the empirical work was based on and closed important research gaps.

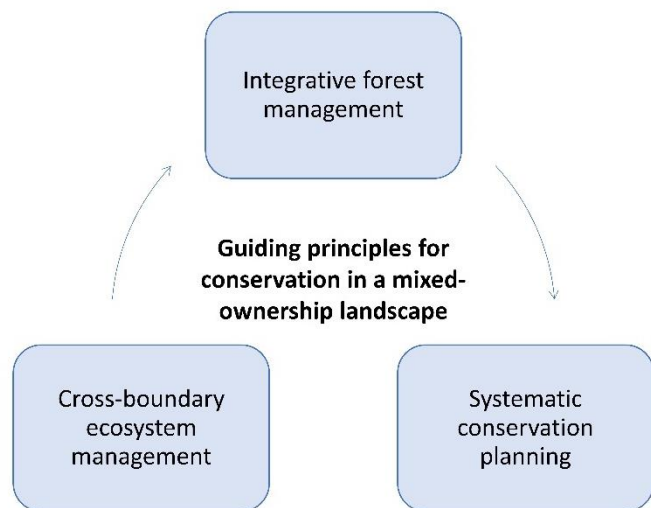


Figure 3: Guiding principles for conservation in a mixed-ownership landscape.

Key finding 4: The scientific literature on private forest owners has national and international research gaps.

The systematic literature review focused on Europe and revealed a geographical bias, with most studies analyzing forest owners in Sweden and Finland. In contrast, Mediterranean and Eastern European countries were only rarely included (Fig. 4). While different research approaches were used, studies on a national or international level were underrepresented as well as the use of qualitative or mixed methods (Fig. 5). More research in the underrepresented regions or with the use of the respective methods may contribute to the understanding of the perspectives of small-scale forest ownership as well as of efficient conservation policy.

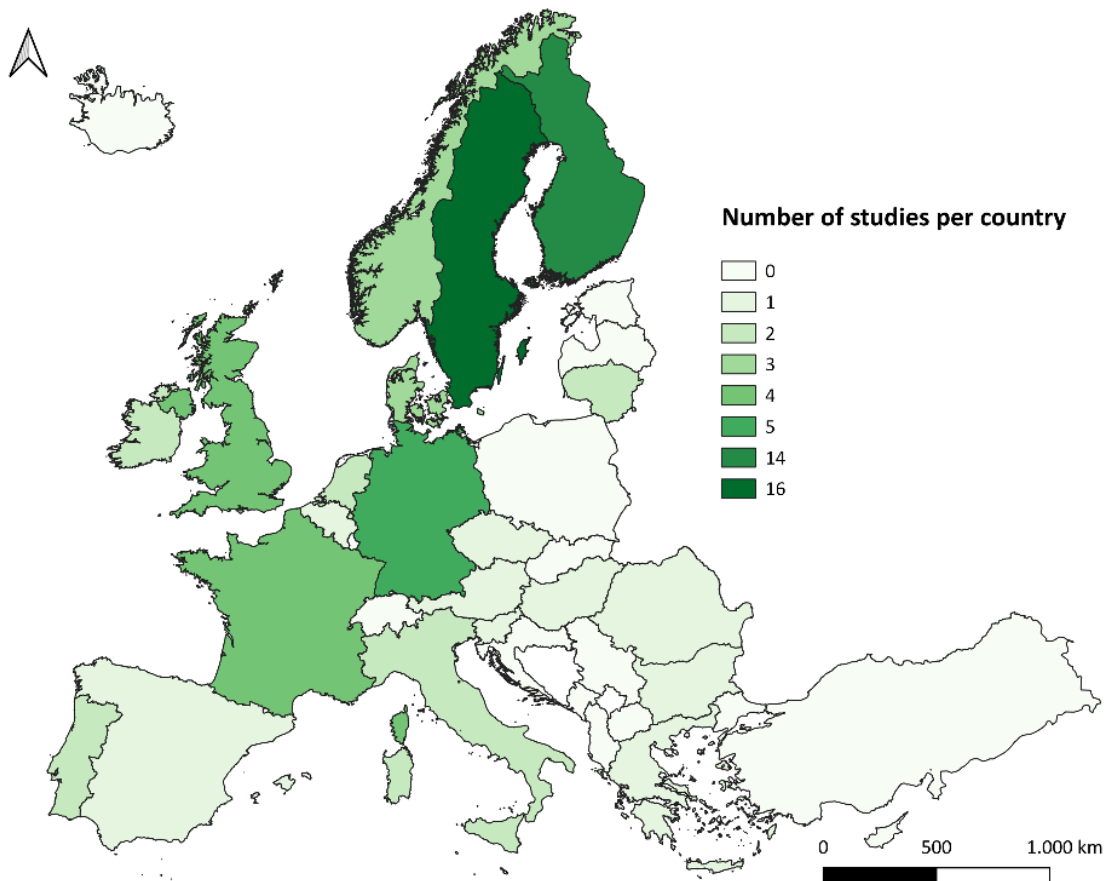


Figure 4: Spatial focus of the reviewed studies. Administrative boundaries: © EuroGeographics.

Despite the emphasis on small-scale and non-industrial forest owners in the search strategy, only a small minority of studies focused on private ownership with an average forest holding size smaller than 20 ha (Fig. 5). Most studies did not specify the size. While “small” may be understood differently depending on the forest structure of the country, transparent communication of these numbers seems essential, especially when terms such as “small-scale” are used, as specific characteristics of small-scale forest owners are partly related to their parcel size.

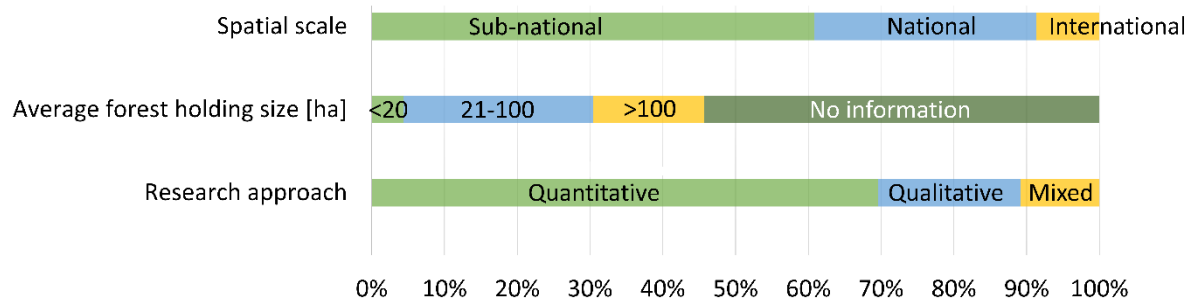


Figure 5: Selected general characteristics and research approaches of the reviewed studies.

Key finding 5: Various social-ecological factors drive conservation perspectives.

As private forest owners are influenced by their social-ecological environment, I identified variables that affect conservation perspectives based on the reviewed studies and categorized these drivers according to Gatto et al. (2019). Certain variables were linked to either a stronger or weaker expression of conservation perspectives (Tab. 3). Female gender, education, formalized forest management, and an active connection to the forest had a positive influence. In contrast, economic factors, the holding size, and both economic and sentimental value had a weakening effect. Further, conservation perspectives were negatively influenced by being old, male, and rural-oriented. In general, many factors inhibited a high share of ambiguous influences. Thus, the results can only be interpreted carefully.

Table 3: Effects of social-ecological factors on conservation perspectives, categorized according to Gatto et al. (2019). Bold numbers show the main direction of influence (excluding ambiguous).

| Category | Sub-category | Variables included [/ explanations] | Positive [%] | Negative [%] | Ambiguous [%] |
|---|---------------------------|---|--------------|--------------|---------------|
| (a) Owners' objective and subjective factors | Age | [being old] | 9.1 | 36.4 | 54.5 |
| | Rural orientation | Proximity to forest, countryside currently / during childhood, agricultural profession | 5.0 | 25.0 | 70.0 |
| | Gender | [being female] | 29.4 | 5.9 | 64.7 |
| | Education | [being highly educated] | 43.8 | 0.0 | 56.3 |
| | Formalized management | Forest management plan, member in ownership association, management by third party | 45.5 | 18.2 | 36.4 |
| | Active relation to forest | Knowledge, frequency of visits, level of activity | 37.5 | 12.5 | 50.0 |
| (b) Forest management factors | Economic factors | Forest income | 22.2 | 56.6 | 22.2 |
| | Product factors | Self-consumption, orientation towards forest products | 12.5 | 12.5 | 50.0 |
| (c) Property structural factors | Forest holding size | [having a large forest holding] | 27.8 | 50.0 | 22.2 |
| | Ecological value | Ecological value, share of broad-leaved forest / protected area, mature forests, forest certification | 50.0 | 10.0 | 40.0 |
| (d) Property value from perspective of the owner | Economic value | Importance of forest-related business, financial investment as motive of forest ownership, economic value / orientation | 6.3 | 68.8 | 25.0 |
| | Sentimental value | Ownership duration, inheritance, emotional attachment | 8.3 | 25.0 | 66.7 |

Connecting these insights with current trends in private forest ownership provides a mixed picture regarding future conservation potential. The rising numbers of female (Hamunen et al., 2020) and urban forest owners (Eggers et al., 2014) might result in a stronger consideration of conservation

aspects in future forest management decisions. At the same time, however, forest owners with little knowledge and interest in forest management are also on the rise (Weiss, Lawrence, Hujala, et al., 2019) and difficult to reach (Bieling, 2004).

Considering the background behind these values and their influence on conservation perspectives is important to understand the underlying reasons as well as to identify approaches to improve current conservation policies. For example, the negative effect of economic factors and values on conservation perspectives indicates that current conservation instruments do not necessarily allow successful integration of resource use and conservation. While the literature review revealed patterns, it is important to notice that private forest owners are a heterogeneous group.

Key finding 6: Effective conservation policy needs to improve its substance, procedures, and stakeholder relationship.

I used the natural resource conflict management framework by Walker and Daniels (1997) to classify recommendations of pathways to improve conservation policies made by the authors of the reviewed studies. This framework consists of three parts: substance, procedure, and relationship (Fig. 6, left part).

As for the substance of conservation policy and thus, the design of policy instruments, most recommendations of the reviewed studies addressed specific conservation instruments due to the individual focus of the studies. Generally, the literature review revealed that the attractiveness of conservation instruments needs to be improved by ensuring suitable conditions, for example, to be fair (Joa & Schraml, 2020) and acceptable (Mäntymaa et al., 2009). A combination of different instruments was regarded as useful (Van Gossum et al., 2005) as well as the provision of sufficient resources (Brukas et al., 2018). Further, the heterogeneity among forest owners and their ownership rights need to be more strongly considered (Joa & Schraml, 2020).

To improve the procedure, defined as the process and implementation of conservation instruments, most studies proposed to improve the distribution of information. Ideas ranged from adapting advisory services (Salomaa et al., 2016) and sharing concrete experiences (Van Gossum et al., 2005) to the use of education (Uliczka et al., 2004) and marketing strategies (Mäntymaa et al., 2009). Information should be distributed to other relevant stakeholders such as forest advisors (Salomaa et al., 2016) or the social networks of the forest owners (Vainio et al., 2018). Such information should include ecological (Mäntymaa et al., 2009), cultural (Paloniemi & Tikka, 2008), and economic aspects (Mäntymaa et al., 2009). The use of targeted measures toward specific groups of forest owners was frequently recommended.

As for relationships, the authors focused on an improvement of the relationship between forest owners and other stakeholders (Salomaa et al., 2016) as well as among forest owners themselves (Nordén et al., 2017). This way, mutual learning (Joa & Schraml, 2020), a higher uptake of the instruments (Mäntymaa et al., 2009), an increased quality of conservation action (Nordén et al., 2017), lower costs (Polomé, 2016), and a resolution of conflicts can be achieved (Jakobsson et al., 2016).

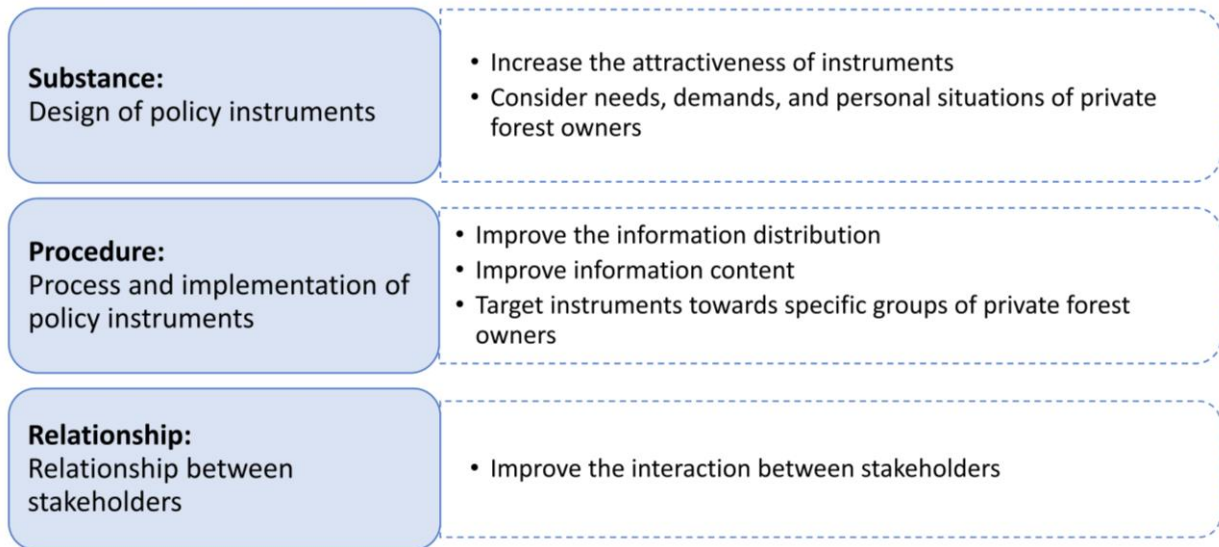


Figure 6: Pathways for effective conservation policy, categorized in the natural resource conflict framework by Walker and Daniels (1997).

3.3 Natura 2000 and small-scale forest owners' objectives, management activities, and attitudes (Article 3)

The scientific literature review (Article 2) revealed the need to adapt current conservation policies to small-scale forest owners. To gain a more detailed understanding of this ownership group, I conducted a survey in northwest Germany. Thus, the third article provides insights into the objectives and activities of these owners as well as into the role of Natura 2000. By bringing together private forest owners' objectives, activities, and perspectives in general as well as regarding the specific conservation scheme Natura 2000, this policy can be further improved.

Key finding 7: There is a gap between forest owners' strong conservation objectives and their actual management activities.

Survey recipients ranked the importance of objectives regarding their forest, classified by the concept of ecosystem services. Ecosystem services describe the benefits that people receive from ecosystems. The concept distinguishes provisioning (e.g., food), regulating (e.g., carbon storage), cultural (e.g., spirituality, recreation), and supporting (e.g., nutrient cycling) services (Alcamo et al., 2003). Respondents assessed regulating ecosystem services, such as preserving a stable and healthy forest stand, protecting soil, water, and air quality, and conserving biodiversity, as most important. This is followed by cultural services. The provisioning ecosystem service valued the highest was wood production for personal consumption, which was ranked in eighth place and considered important by 68% of all respondents.

The analysis found a discrepancy between conservation-related objectives (Fig. 7a) and the actual activities in the forest (Fig. 7b). While 90% of respondents considered biodiversity conservation important, only 45% maintained habitat trees or deadwood, which were the most common conservation activities carried out. This discrepancy did not exist regarding resource use. Sixty-two percent of respondents assessed wood production for sale as important, with the same percentage also indicating that they are currently selling wood.

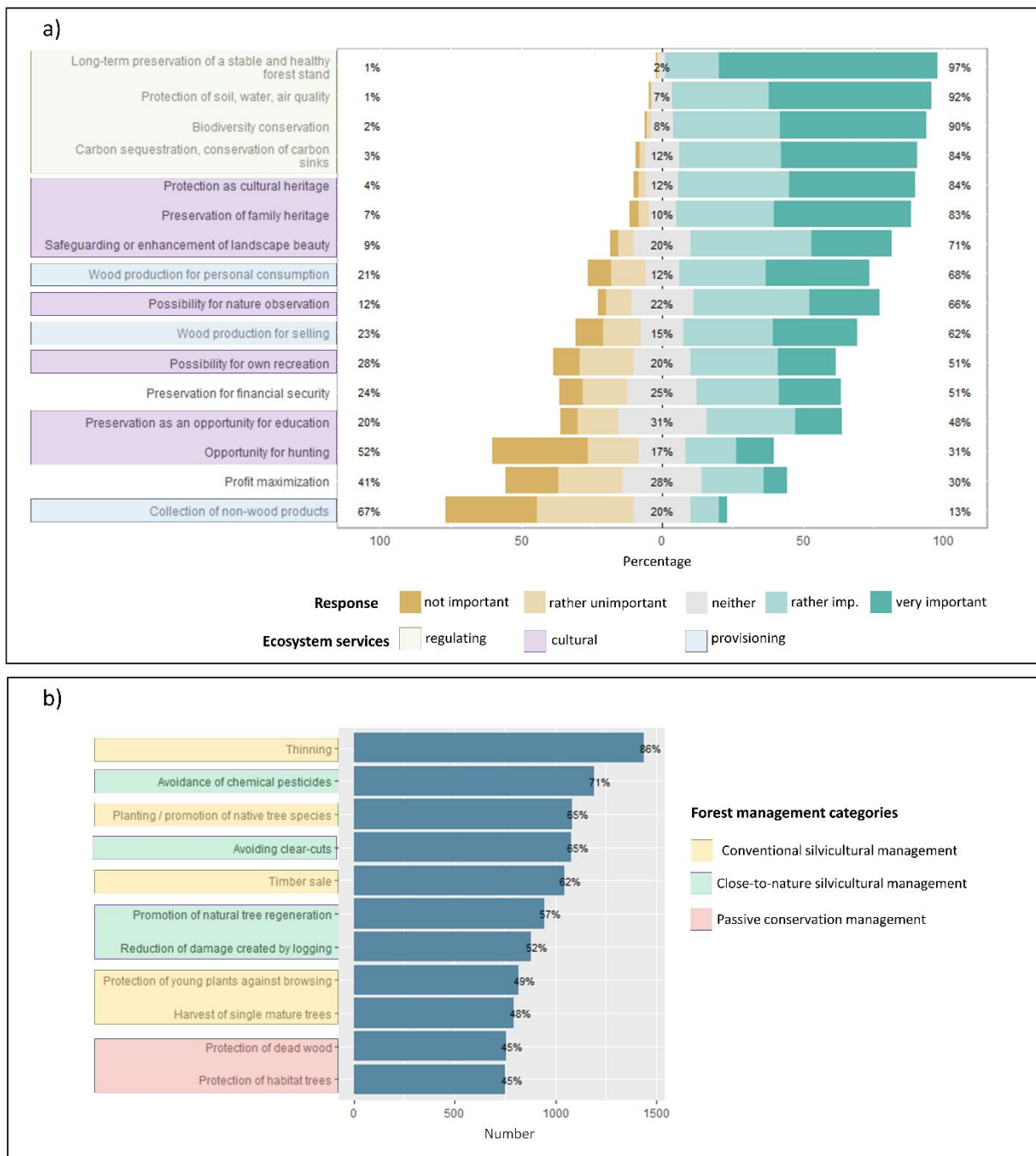


Figure 7: Objectives (classified into the ecosystem service framework, a)) and activities (performed by at least 45%, classified into forest management categories, b)) of small-scale private forest owners in northwest Germany.

This difference between conservation perspectives and activities may be due to private forest owners perceiving their management as being close-to-nature (Takala et al., 2019) or as not influencing the stand characteristics (Bieling, 2004). The “wake theory” suggests that by focusing on wood production, other ecosystem services are automatically achieved as well (Peters & Schraml, 2015) which might result in a focus on resource use. Additionally, accruing costs (Kline et al., 2000) and recommendations of forest professionals (Hujala et al., 2007) may strengthen this focus. In some cases, forest stands might be too young for the conservation of certain structures, such as habitat trees.

Key finding 8: Natura 2000 is not well-adapted towards small-scale forest owners resulting in low effectiveness and acceptability.

The systematic designation of protected areas is a key strategy of modern biodiversity conservation (Adams et al., 2018). Currently, European Union's Natura 2000 is the largest coordinated network of protected areas in the world (European Union, 2020). Due to its focus on forests (European Commission, 2015), its effectiveness depends significantly on small-scale private forest owners, who represent the largest forest ownership group in Europe (European Commission, 2013). The general multifunctional perspective of the private forest owners is a good foundation for the effective implementation of Natura 2000, which aims to address economic, social, and cultural conditions (The Council of the European Communities, 1992).

While forest owners with and without Natura 2000 sites did not differ regarding the perceived importance of most ecosystem services, wood production for personal consumption and sale was regarded as more important by the first group. Silvicultural measures such as thinning, promoting natural tree regeneration, and planting were performed significantly more often by owners with Natura 2000 stands, while habitat tree protection was the only conservation measure that was conducted more frequently. Also, this ownership group had more negative perspectives on conservation. More frequently, they regarded restrictions as too strict, personal freedom as being endangered, and the costs associated with conservation as high. Further, this group had a greater desire for involvement in the decision-making process about conservation.

The implementation of Natura 2000 is criticized due to the difficulty to combine biodiversity conservation with wood production and other demands (Rosenkranz et al., 2014), ineffective funding (Sarvašová et al., 2019), and conflicts related to contradictory interests, procedural difficulties, and negative perceptions (Blondet et al., 2017). In accordance, my results indicated a low effectiveness of Natura 2000 as forest owners with Natura 2000 stands had a stronger focus on the use of wood resources. However, the question of cause and effect between the designation as Natura 2000 area and the focus on resource use cannot be answered from this data. Active forest management might have contributed to the high conservation values and thus to the designation as Natura 2000 site. This is indicated in some survey comments and is in concordance with the theory of biocultural diversity (Bridgewater & Rotherham, 2019) or the effect of historical management techniques such as coppicing (Mölder, 2016). However, also the designation as a protected area and the impeding restrictions might contribute to a stronger focus on resource use by displeased private forest owners. The identified negative perspectives on conservation indicate the low acceptability of this network. This is also seen in other countries (Ferranti et al., 2017; Hiedanpää, 2002) and is explained by insufficient information, lack of knowledge, and poor communication (Grodzinska-Jurczak & Cent, 2011).

Key finding 9: Participation, stronger consideration of private forest owners, and effective payment models are needed to improve the Natura 2000 scheme.

Both the gap between conservation objectives and activities as well as the low acceptability of Natura 2000 show the need to improve current conservation policy. Participation during the implementation of conservation is highlighted in scientific articles (Grodzinska-Jurczak & Cent, 2011; Winkel et al., 2015) as well as in my results. A profound participation strategy needs to include mutual learning, establish trust, and integrate a broad spectrum of different stakeholders, which results in a long process (Blondet et al., 2017). Despite the imminent lawsuit of the European Commission due to Germany's poor implementation of the Habitats Directive (European Commission, 2021) and the resulting need for action, a strong engagement with local forest owners is required. A focus should be put on Natura 2000 sites that are yet to be legally secured and on the development of management

plans. Aside from increased profound participation, a stronger adaptation of the Natura 2000 conservation scheme towards the needs, demands, and personal situations of small-scale forest owners is needed. While most Natura 2000 forest owners regarded financial incentives and on-site consultation as helpful for increasing their conservation practices, the current Natura 2000 compensation payment model in Lower Saxony failed to reach most private forest owners within the study area. This is in concordance with other research across Europe (Sarvašová et al., 2019; Winkel et al., 2015). Further, many conservation payment schemes focus on compensation and thus assume a conflict between forest ownership and conservation and do not acknowledge past nature conservation efforts by private forest owners (Paschke, 2018). Contract-based conservation, however, shows a large potential by providing economic incentives for implementing conservation actions (Demant et al., 2020). Such an approach has shown to be better accepted by forest owners than the current implementation of Natura 2000, mainly due to cooperation beginning from an early stage (Frank & Müller, 2003).

3.4 Differences and similarities between groups of small-scale private forest owners and pathways to transformative change (Article 4)

The literature reviews (Articles 1, 2) as well as the analysis of the quantitative survey regarding Natura 2000 (Article 3) showed the need to better adapt current conservation policies to small-scale forest owners. Thus, in the fourth article, I used the survey data and analyzed the differences and similarities of private owners by classifying them into a typology based on their activities. I deducted owner-specific approaches as well as an overarching pathway to transformative change for integrative conservation. The term integrative conservation is derived from integrative forest management which addresses the multiple societal demands private forests face today. It aims “to maximise the cross-section between the different main functions of modern forestry: production, protection, and conservation” (Krumm, Frank et al., 2013, S. 257). Variations of this concept are described using the terms integrated (Aggestam et al., 2020), multifunctional (Hoogstra-Klein et al., 2017), or close-to-nature (Bieling, 2004) forest management. While all forest functions are important, integrative conservation, as used here, emphasizes the latter aspect. This focus was chosen as there is an overlap between forest management measures that promote resilient forests and those which foster biodiverse forests (Thompson et al., 2009). Thus, a focus on conservation aspects may contribute to forest ecosystems that are better adapted to future climate change challenges. In private forests, however, innovative concepts for and research on integrative conservation are mostly missing, especially in small-scale private forests. Thus, I meet this gap by providing recommendations for integrative conservation.

Key finding 10: Within the study area, private forest owners can be differentiated into 1.) multiple-use oriented, 2.) conventional, and 3.) conservation-oriented forest owners with varying conservation focus.

As small-scale private forest owners are a heterogenous group, I differentiated the respondents into three forest ownership types based on their forest management activities and compared the groups with each other (Fig. 8).

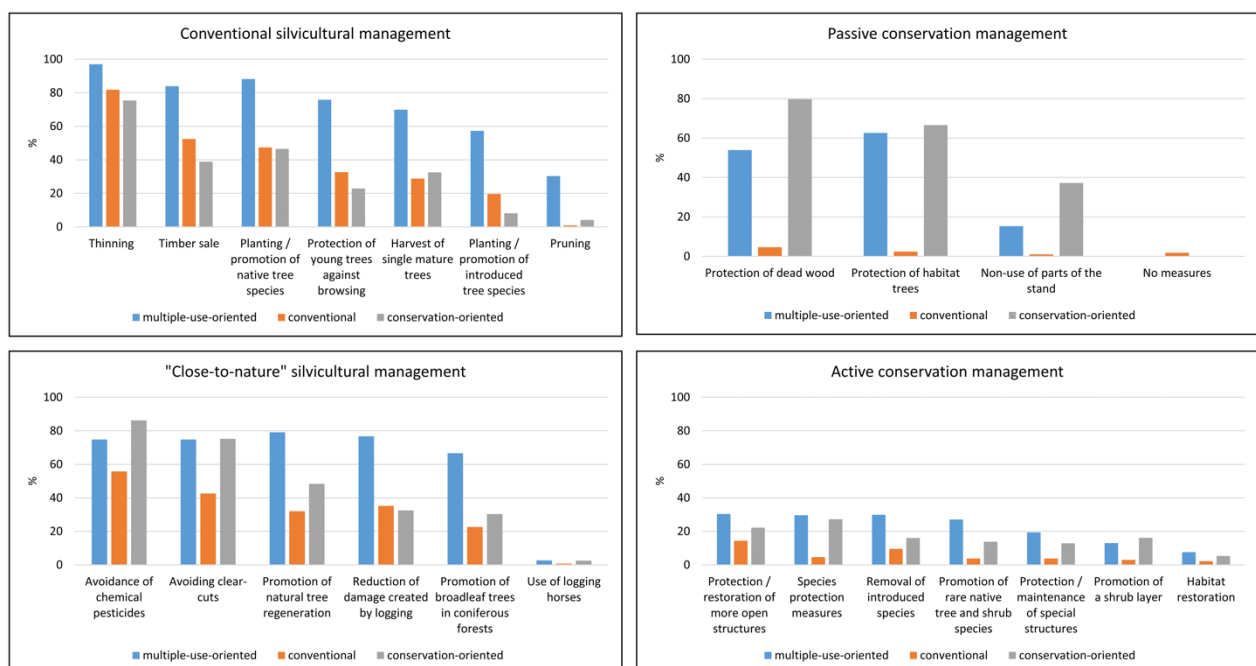
Multiple-use-oriented forest owners (45%) carried out conventional silvicultural and historical management practices, as well as most close-to-nature activities and active conservation measures more frequently than the other two groups. Owners in this group ranked provisioning ecosystem services as well as economic objectives as more important. Half of the regulatory services were also

valued higher in comparison to both other types. To a significantly greater degree, multiple-use-oriented forest owners wanted to be more strongly involved in decision-making processes around conservation.

Conventional forest owners (30%) carried out most conservation and close-to-nature measures less frequently. As for conventional silvicultural measures, this forest ownership group had intermediate shares. Conventional forest owners rated half of the regulating ecosystem services and most cultural ecosystem services as less important compared to the other two groups. They assigned mostly medium values to the provisioning services and economic objectives. This tenure type was least likely to believe that its management ensured natural forest conditions and that structures with conservation value are present in their stands. They were also least likely to agree with promoting conservation without financial support.

Conservation-oriented forest owners (25%) conducted three of seven conventional silvicultural measures less frequently than the other groups, while they applied half of the passive conservation measures more often. As for close-to-nature activities and active conservation, they showed an intermediate share of implementing these measures. Conservation-oriented forest owners rated half of the provisioning ecosystem services and both economic objectives as less important compared to the other groups. For most regulating and all cultural services, this ownership group showed no significant differences from the other two groups. Conservation-oriented forest owners were significantly more likely to support conservation without financial support, while they were less likely to believe that conservation imposes high costs and threatens freedom of choice.

Figure 8: Average share [%] of forest owners who stated to perform certain forest management activities, differentiated by owner type. Historical forest management is not depicted as it was only carried out by multiple-use-oriented forest owners.



Key finding 11: The three groups of private forest owners differ regarding their needs, perspectives, and affinity with conservation approaches.

As found in the second article, the majority of studies recommended using a targeted approach to address certain forest owner groups (Tiebel, Mölder, et al., 2021a). However, to avoid high costs with low benefits, Danley (2019) suggested to aim instruments at different owner types simultaneously. In the typology, I discovered both the different needs between groups of forest owners which resulted in the possibility of targeted conservation approaches (key finding 11) as well as common perspectives towards certain instruments or stakeholders (key finding 12).

Multiple-use-oriented forest owners are committed and connected to their forests with a variety of goals and activities. Aspects of conservation were considered but were not the primary focus for these owners. Forestry stakeholders exerted the greatest influence on this group. Since personal relationships are associated with trust (Hujala & Tikkanen, 2008), the provision of conservation-related practical advice by forestry actors can promote the implementation of conservation measures in this group. In addition, contract-based conservation could be effective (Demant et al., 2020). In this context, potential conservation measures must be compatible with aspects of resource use. Since multiple-use-oriented forest owners were the largest group among respondents and forest owners here reported the largest average forest size, it might be particularly worthwhile to motivate this group to engage in conservation measures.

Conventional forest owners were less active and showed less interest in various objectives, except for timber production. Conservation-related behavior within this group can be encouraged if interest, knowledge, and awareness about the forest and its nonproductive aspects are increased. Since providing information is unlikely to change the underlying discourse (Takala et al., 2019), and since resource use has been important to this forest ownership group, it may be useful to focus on measures with low trade-offs. This means implementing less ambitious measures that do not compromise economic goals and allow for self-determination (Miljand et al., 2021). Financial incentives could also help ensure that conservation measures are implemented.

Conservation-oriented forest owners rated economic goals and resource use as less important while being more positive about conservation. However, they limited their conservation activities to passive measures. Since they reported to have stand structures with high conservation value, continuing their rather extensive management approach may be useful for promoting biodiversity. The focus on passive measures may be due to a lack of knowledge and skills. Those who want to be more active in implementing their conservation goals could be empowered through knowledge transfer (Miljand et al., 2021) in practice-based advisory programs.



A differentiation between groups of small-scale private forest owners is useful to understand their backgrounds, perspectives, and activities as well as to design conservation policy accordingly. However, limited resources may require more focus on overarching improvements. Being able to combine resource use with conservation activities is of central interest to two of the three ownership groups. Forestry stakeholders seem to be appropriate advisors who might be able to increase the interest in conservation.

Key finding 12: The three forest owner groups concur regarding their perceptions of conservation instruments, influential stakeholders, obstacles, and information desires.

The three forest ownership groups strongly concur regarding the usefulness of instruments promoting conservation activities, the influence of stakeholders on forest management decisions, the presence of obstacles to implement one's objectives, and the desire for information (Tab. 4).

Despite statistically significant differences between the groups, forest owners in each group considered on-site consultation to be the most helpful tool for implementing more conservation activities, followed by information about legal regulations, and financial incentives. In contrast, computer-based visualizations and telephone consultations were regarded as least helpful by all groups. Forest stakeholders such as foresters, forest management associations [Forstbetriebsgemeinschaften], and the forest owners' association [Waldbesitzerverband] had the highest influence on management decisions across all three groups. On the other end of the spectrum, digital media and the daily press or television were considered as being of low influence. Lack of time and lack of family labor were among the three most frequently mentioned obstacles in all groups, while uncertainty about the location of forest parcels was least often considered a barrier. More than 40% of the respondents in all groups desired more information on support and funding schemes in the forestry sector, as well as on silvicultural forest restructuring, forest maintenance, and legal regulations. Information about timber marketing and wood harvesting was generally least needed, with a share between 12 and 30% depending on the forest owner group.

Table 4: Comparison of the ranking of the helpfulness of policy instruments, the influence of stakeholders, the presence of obstacles, and the desire for information across owner groups (In brackets: values for multiple-use-oriented / conventional / conservation-oriented owner groups).

| | | Helpfulness of policy instruments [average on 1-5 scale] | Influence of stakeholders on decisions [average on 1-5 scale] | Obstacles [%] | Information desires [%] |
|--|--------------------------------------|---|--|--|--|
|  | <i>Ranked highest</i> | On-site consultation (4.1/4.0/4.0) | Forester (4.1/3.9/3.8) | Different order, but occurring for all three groups: Lack of time (43/37/41), lack of family labor force (34/31/30) | Different order, but occurring for all three groups: Support/funding schemes in the forestry sector (64/51/46), forest maintenance (45/47/49) |
| | <i>Ranked 2nd highest</i> | Information about legal regulations / financial implications (4.1/3.9/3.9) | Forest owners' association [Forstbetriebs-gemeinschaft] (3.6/3.3/3.2) | | |
| | <i>Ranked 3rd highest</i> | Financial incentives (4.0/3.8/3.9) | Forestry associations [Waldbesitzer-verband] (3.5/3.3/3.0) | | |
| [...] | [...] | | | | |
|  | <i>Ranked 3rd lowest</i> | Different rankings | Different rankings | Different rankings | Different order, but occurring for all three groups: Timber marketing (30/18/13), wood harvesting (20/23/12) |
| | <i>Ranked 2nd lowest</i> | Computer-aided visualizations (3.2/3.1/3.1) | Digital media (2.3/2.1/2.3) | Different rankings | |
| | <i>Ranked lowest</i> | Telephone consultation (2.9/2.9/2.9) | Daily press or television (2.2/2.0/2.2) | Uncertainty about the location of the forest (0.4/2.9/2.5) | |

Key finding 13: The most important leverage points promoting transformative change towards integrative conservation are increasing awareness, knowledge, and interest as well as accounting for autonomy and control.

As modifications to the current system of forest policy are unlikely to be sufficient in meeting the challenges forests are facing today, a radical shift and a substantial economic and ecological transition are necessary (von Detten, 2022). Such a process of transformative change and thus, a holistic transition towards integrative conservation requires the identification of cross-cutting leverage points (The central leverage points are written in italics and summarized in Fig. 9). Following Abson et al. (2017), the focus is on the four basic system characteristics: 1) parameters, 2) feedback, 3) design, and 4) intention (rectangles in Fig. 9). The order of these terms relates to their increasing potential in promoting transformative change. Policy instruments are mainly concerned with 1) parameters and 2) feedback, and thus with shallow leverage points. However, approaches that target design or intention, so-called deep leverage points (arrows in Fig. 9), can be more influential (Abson et al., 2017).

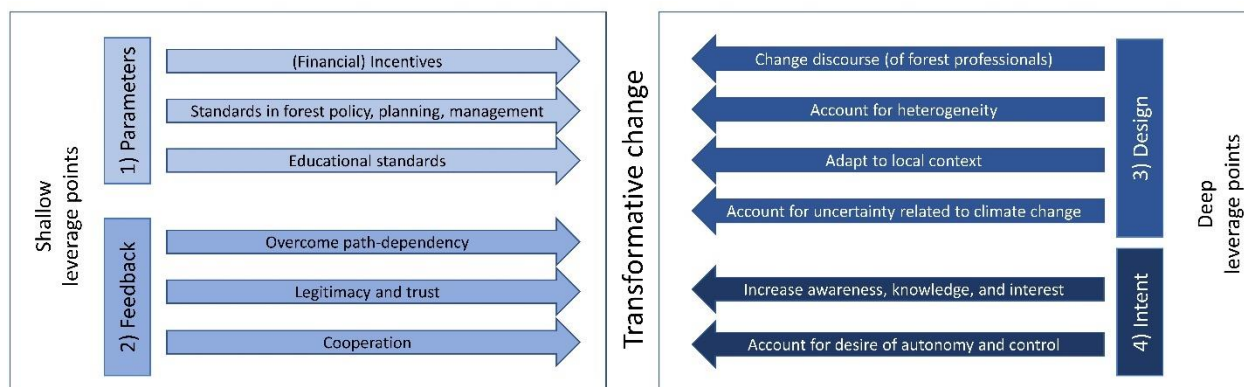


Figure 9: System characteristics (rectangles) and their leverage points (arrows) in fostering a process of transformative change towards integrative conservation in the realm of small-scale private forest owners.

Parameters are defined as "modifiable, mechanistic characteristics such as taxes, incentives, and standards" (Abson et al., 2017, S. 32). Survey respondents ranked *financial incentives* as useful. However, this instrument is controversially discussed (Rode et al., 2015). Incentivizing resilience (Bauhus et al., 2021) or conservation value (Demant et al., 2020) may be more effective than aiming at single activities. Societal appreciation might further promote conservation practices (Bieling, 2004). Another leverage point is to change the underlying *standards in forest policy, planning, and management* by strengthening the focus on regulating ecosystem services (Hernández-Morcillo et al., 2022). This is supported by adapting the *educational standards* for influential stakeholders such as foresters to enable them, e.g., to understand and reduce trade-offs in integrated forest management (Aggestam et al., 2020).

The term feedback encompasses "the interactions between elements within a system" (Abson et al., 2017, S. 32). An important leverage point in this category is to overcome *path dependencies* (Stjernquist & Schlyter, 2022). Thereby, participation can contribute to change the current system and existing power relations and thus, contribute to legitimacy and trust (Pöllumäe et al., 2016), which is a prerequisite for transformative change. Also, *cooperation* between stakeholders from different sectors (Atmadja et al., 2021), the consideration of local knowledge (IPBES, 2019), and mutual learning (Korhonen et al., 2013) are important. Thereby, committed individuals, also referred to as change agents, may inspire actions contributing to transformative change (Priebe et al., 2022).

The third system characteristic, 3) design, involves the "structure of information flows, rules, power, and self-organization" (Abson et al., 2017, S. 32). In this realm, *changing the discourse* towards giving greater weight to biodiversity by private forest owners and other stakeholder groups is crucial (Takala et al., 2019) and may be achieved by using different lines of argumentation to reach people with varying perspectives (Tinch et al., 2018). The *heterogeneity* amongst private forest owners needs to be considered by taking into account individual values (IPBES, 2019), goals (Joa & Schraml, 2020), and needs (Bieling, 2004). Further, an *adaptation to local conditions* is useful and might be supported by collective social learning (Garmendia & Stagl, 2010). The use of flexible approaches, consisting of different short- and long-term strategies (Bauhus et al., 2021) at a landscape level (Mölder et al., 2021), is required to *account for uncertainty*.

Leverage points that address the last characteristic, 4) intention, have the highest potential influence. Intention is defined as "norms, values, and goals embodied within the system of interest and the underpinning paradigms out of which they arise" (Abson et al., 2017, S. 32). A central leverage point is *to increase awareness, knowledge, and interest* in forests and nature conservation by engaging diverse

stakeholders such as forest advisors, the public, or the social network of the private forest owners. Current reluctance towards conservation instruments should be avoided by considering the *desire for autonomy and control*. Voluntary nature conservation agreements with compensation payments are a promising approach here.

3.5 Summary of key findings

Describing and discussing the results, I identified key findings (KF) for each article and categorized them into those which focus on the state of research, those that display social-ecological insights, and those which provide recommendations (Tab. 4).

The first literature review focused on the linkages between forest ownership, forest structure, biodiversity, and conservation. The author team found that agrarian individualism, the demand for efficient management, and the subsequent parcellation influence the structure of private forest ownership today (KF1, social-ecological insights). Further, we were able to demonstrate that private forests harbor important conservation values, especially related to cultural landscapes (KF2, social-ecological insights). We recommend using cross-boundary, integrative forest management, and systematic conservation planning as guiding principles for conservation in a mixed-ownership landscape (KF3, recommendations).

A second literature review centered around conservation perspectives of small-scale forest owners. An analysis of the current state of research identified gaps regarding Mediterranean and Eastern European countries, national or international research approaches, qualitative or mixed methods, and small-scale forest owners (KF4, state of research). Across the reviewed core studies, social-ecological factors influenced conservation perspectives (KF5, social-ecological insights). In a summary of recommendations, I identified the need to improve conservation policy regarding the design of its instruments (substance), the conservation process and implementation (procedure), and the relation between the stakeholders (relationship) (KF6, recommendations).

In the next step, the analysis of qualitative survey data of small-scale private forest owners in my study area provided detailed insights. Thus, the third article concentrated on the relationship between Natura 2000 and small-scale forest owners' objectives, management activities, and attitudes. In general, the sampled forest owners show a gap between strong conservation objectives and lower conservation action (KF7, social-ecological insights). Further, I showed that Natura 2000 is not adapted towards small-scale forest owners which results in low effectiveness and acceptability in the study area (KF8, social-ecological insights). Consequently, participation, a stronger consideration of private forest owners, and an adaptation of the current payment schemes are needed to improve the Natura 2000 scheme (KF9, recommendations).

The fourth article focused on differences and similarities between groups of small-scale private forest owners and identified a pathway to transformative change. Within our study area, private forest owners can be differentiated into multiple-use oriented, conventional, and conservation-oriented forest owners with varying conservation focus (KF 10, social-ecological insights). The three groups of private forest owners differ regarding their needs, perspectives, and affinity with conservation approaches (KF11, social-ecological insights). However, there also is a high agreement regarding their perceptions of conservation instruments, influential stakeholders, obstacles, and information desires (KF12, social-ecological insights). The most important leverage points promoting transformative

change toward integrative conservation are increasing awareness, knowledge, and interest and accounting for autonomy and control (KF13, recommendations).

Table 5: Summary and categorization of key findings (KF = key finding).

| | Article | State of research | Social-ecological insights | Recommendations |
|--|---------|--|--|--|
| Theoretical research: Literature review | 1 | | <p>KF1: Historical agrarian individualism, the demand for efficient management, and subsequent parcellation still influence today's structure of private forest ownership.</p> <p>KF2: Private forests frequently harbor important conservation values which are especially related to cultural landscapes.</p> | <p>KF3: Cross-boundary, integrative forest management and systematic conservation planning are guiding principles for conservation in mixed-ownership landscapes.</p> |
| | 2 | <p>KF4: The scientific literature on private forest owners has national and international research gaps.</p> | <p>KF5: Various social-ecological factors drive conservation perspectives.</p> | <p>KF 6: Effective conservation policy needs to improve its substance, procedures, and stakeholder relationship.</p> |
| Empirical research: Quantitative data analysis | 3 | | <p>KF7: There is a gap between forest owners' strong conservation objectives and their actual management activities.</p> <p>KF8: Natura 2000 is not well-adapted towards small-scale forest owners resulting in low effectiveness and acceptability.</p> | <p>KF9: Participation, stronger consideration of private forest owners, and effective payment models are needed to improve the Natura 2000 scheme.</p> |
| | 4 | | <p>KF 10: Within the study area, private forest owners can be differentiated into 1.) multiple-use oriented, 2.) conventional, and 3.) conservation-oriented forest owners with varying conservation focus.</p> <p>KF11: The three groups of private forest owners differ regarding their needs, perspectives, and affinity with conservation approaches.</p> <p>KF12: The three forest owner groups concur regarding their perceptions of conservation instruments, influential stakeholders, obstacles, and information desires.</p> | <p>KF13: The most important leverage points promoting transformative change towards integrative conservation are increasing awareness, knowledge, and interest as well as accounting for autonomy and control.</p> |

4. Conclusions and wider implications

“[We are] confronted [...] with new challenges due to the increasing importance of nature conservation and other interests of the public (recreational function) and [have to] [...] analyze possibilities, how forest owners can use the forest in a reasonable and conserving way”.

Statement received in the survey

Against the background of climate change, forests are increasingly the focus of political and public debates. Very different conclusions are being drawn, ranging from an active management with the introduction of new tree species and increased logging as part of the bioeconomy to the protection of natural processes and strict nature conservation. Amid this challenging debate are small-scale private forest owners. They are embedded in a complex environment shaped by socio-economic, institutional, natural, and historic conditions. Private forests provide a large variety of ecosystem services that positively affect the well-being of the wider society and their importance for forest conservation has been frequently highlighted. The conservation values in their stand, their heterogeneous objectives, activities, and perspectives, as well as current socio-demographic changes among private forest owners create a high potential for integrative conservation-oriented management. Therefore, and due to their quantitative share, small-scale private forest owners are an important ownership group within Europe. Yet, the current forest and conservation policy does not systematically concentrate on this group and research does not focus on private ownership with an average forest holding size smaller than 20 ha.

Therefore, this thesis shows that current conservation approaches are not adequately adapted for small-scale owners. Further, forest owners are a heterogeneous group and their conservation perspectives are influenced by social-ecological drivers. However, also universal factors exist which can promote nature conservation, such as on-site consultation by local foresters. Thus, an adaptation of the current conservation policy towards small-scale private forest owners is not only urgently needed but also has a lot of potential.

There is no single strategy to strengthen the implementation of conservation activities in forest management on private lands. Furthermore, private forest owners are only one part of a complex system determining the state of forests. Thus, the most promising and holistic approach to achieve integrative conservation is to change the whole system in a process of transformative change. Integrative conservation needs to be demanded and enabled across sectors, ranging from forestry and conservation, the energy and building sector, to the wider public. However, also a focus on conservation in forests by small-scale private forest owners is necessary to reduce the various conflicts and to implement local conservation action. I recommend that policy makers design conservation approaches in a way that makes them an attractive part of integrative forest management. Participatory processes and attractive voluntary approaches, such as contract-based conservation, are promising pathways as they create freedom of choice for the individual landowner. Complemented with practice-oriented consultation by forest stakeholders, this can form the basis of a successful integrative conservation strategy.

To summarize, conservation on private land is urgently needed in mixed-ownership landscapes. It is only successful if it considers the perspectives and needs of local landowners. Due to the great potential associated with the diverse groups of private forest owners, this may also be considered an opportunity instead of a problem.

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7. Appendix

7.1 On the interplay of ownership patterns, biodiversity, and conservation in past and present temperate forest landscapes of Europe and North America

Andreas Mölder, Malin Tiebel, Tobias Plieninger

Published in Current Forestry Reports 2021

<https://doi.org/10.1007/s40725-021-00143-w>



Figure 10: Diversity in the small private forest of the Osnabrück region, Lower Saxon Hills: "water pots" as small habitat structure, boundary markers, coppicing, oak planting. Photos: Andreas Mölder.

7.2 Conservation perspectives of small-scale private forest owners in Europe:
A systematic review

Malin Tiebel, Andreas Mölder, Tobias Plieninger

Published in *Ambio* 2021

<https://doi.org/10.1007/s13280-021-01615-w>



Figure 11: Nest boxes on a small private forest parcel in the Lower Saxon Hills. Photo: Peter Hansen.

7.3 Small-scale private forest owners and the European Natura 2000 conservation network: perceived ecosystem services, management practices, and nature conservation attitudes

Malin Tiebel, Andreas Mölder, Tobias Plieninger

Published in European Journal of Forest Research 2021

<https://doi.org/10.1007/s10342-021-01415-7>



Figure 12: Old coppice stool located in a small private forest stand, designated as Natura 2000 site, in the Teutoburg Forest close to Hilter (Lower Saxony). Photo: Andreas Mölder.

7.4 Engaging small-scale private forest owners for transformative change towards integrative conservation

Malin Tiebel, Andreas Mölder, Claudia Bieling, Peter Hansen, Tobias Plieninger

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Figure 13: Non-representative impressions from forest parcels, belonging to different forest owner groups. Photos on the left: multiple-use-oriented forest owners, in the middle: conventional owners, on the right: conservation-oriented owners. Photos: Peter Hansen.

8. Declaration

I, Malin Tiebel, hereby declare that this Ph.D. thesis titled “objectives, management practices, and perspectives of small-scale private forest owners” (examiners: Prof. Dr. Tobias Plieninger, Prof. Dr. Carsten Mann, Prof. Dr. Claudia Bieling) has not been presented to any other examining body in its present or similar form. I also affirm that I have not applied for a Ph.D. at any other higher school of education.

Furthermore, I declare that this thesis was prepared independently and without any unauthorized aid and that all aid has been appropriately acknowledged.

Göttingen, 26.05.2023

Malin Tiebel