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RESEARCH ARTICLE

Understanding small-scale private forest owners is a basis for transformative change towards integrative conservation

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Abstract

1. Balancing societal demands on forests is a major challenge in current forest management. Small-scale private forest owners are an important ownership group that is rarely addressed directly in this discussion. Our study aims to identify and differentiate between private forest owner groups. Based on this, we take a systemic approach and determine leverage points that can be used to foster transformative change towards integrative conservation-oriented forest management.
2. We conducted a survey of 1656 small-scale private forest owners in northwest Germany within a typical European multi-ownership landscape and formed three clusters based on their activities.
3. While all groups generally perceived nature conservation as important, they differed with regard to their forest management activities. Multiple-use-oriented forest owners (45%) were most active, including in terms of conservation measures. Conservation-oriented owners (25%) mainly focused on passive measures, and conventional owners (30%) showed only a little engagement with conservation-related activities. Despite the differences, common instruments promoting conservation activities were identified. They included, for example on-site consultation, information about legal regulations and financial incentives.
4. Based on four system characteristics (parameters, feedback, design and intent), we identified leverage points towards transformative change. The deep and thus effective leverage points are changing the discourse, accounting for the heterogeneity of private forest owners as well as for uncertainty related to climate change and adapting measures to local contexts. Furthermore, working towards increasing awareness, knowledge and interest as well as accounting for the desire for autonomy and control are promising pathways for change.
5. A holistic transformation of forest policy and management towards integrative conservation is urgently needed to meet the current challenges of climate change, biodiversity loss and timber demand. This transformation has to go beyond the adaptation of existing policy instruments and instead focus on systematic and cross-sectoral changes in the underlying policy orientation, its design and its implementation.

KEYWORDS
forest management objectives, integrative forest management, forest owner typology, small-scale private forests

1 | INTRODUCTION

Today's forest management is facing major challenges related to the growth of diverse and simultaneous societal demands on forests (Krumm et al., 2020), such as wood and energy supply (Lawrence, 2018), biodiversity conservation (Joa & Schraml, 2020), outdoor recreation (Derks et al., 2020) and climate change mitigation (Sousa-Silva et al., 2018). While the importance of semi-natural forest ecosystems and their biodiversity has been highlighted (Biró et al., 2022), many European forests are lacking the stand structures (e.g. sufficient amounts of coarse woody debris) necessary to support forest biodiversity (Thorn et al., 2020). At the same time, demand for wood is growing, leading to an increase in harvested forest area, biomass reduction and larger harvesting units (Ceccherini et al., 2020). This trend is expected to continue as a consequence of the EU's aim to achieve a climate neutral economy by 2050 (Blattert et al., 2020; European Commission, 2018). Especially the demand for fuelwood is reinforced by the current energy crisis and the associated high demand for domestic firewood (Booth, 2022).

Climate change contributes to an increase in the occurrence and severity of forest disturbances such as storms, bark beetle infestations and wildfires (Seidl et al., 2017). These disturbances have substantial impacts on forest biodiversity (Kortmann et al., 2021) and the provision of ecosystem services (Reyer et al., 2017), such as wood production, water quality and erosion control (Anderegg et al., 2013). Both in Europe and across the globe, drought and heat-induced stress are thus heightening the vulnerability of forest ecosystems (Allen et al., 2010).

As the concurrent challenges of biodiversity loss, growing resource demands and climate change are likely to intensify in the future (Stjernquist & Schlyter, 2022), an intensive debate about future forest management in Europe has evolved. Some experts see high potential in natural forest development and reduced silvicultural activities to create diverse and resilient forest ecosystems that are able to cope with extreme events in the future (Jandl et al., 2019; Popkin, 2021; Thorn et al., 2019). A contrasting view suggests that adaptive forest management, including the cultivation of non-native tree species (Bolte, Ammer, Löf, Nabuurs, et al., 2009; Pötzelsberger et al., 2020), active reforestation after disturbances (Bolte, Ammer, Löf, Madsen, et al., 2009) and assisted migration of tree species or populations (Benito-Garzón & Fernández-Manjarrés, 2015), is needed to adapt forest ecosystems to climate change. This view argues that the speed of climate change differs from that of natural adaptation processes (Bauhus et al., 2021; Jandl et al., 2019; Popkin, 2021).

While the suitable pathways for managing forests in the future are still debated, most scientists and forest practitioners agree that forests have to be resilient and adaptive to provide ecosystem services in the future (Bauhus et al., 2021; Milad et al., 2013; Seidl et al., 2017). Improved management of existing protected areas, ecological restoration (Mawdsley et al., 2009), a refined perspective on disturbances (Thom et al., 2017), the preservation of ecological continuity (von Oheimb et al., 2014), the establishment of multi-aged (O'Hara & Ramage, 2013) and mixed stands (Pardos et al., 2021), fostering genetic diversity and increasing tree species and structural diversity (Thompson et al., 2009) are all recommended to enhance ecosystem resilience while also contributing to forest biodiversity. Incremental modifications of current forest management are unlikely to tackle the magnitude of the described challenges. Rather, radical shifts and a substantial ecological and economic transition appear necessary (von Detten, 2022). Such 'transformative change' has been most comprehensively promoted by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), calling for: 'A fundamental, system-wide reorganization across technological, economic and social factors, including paradigms, goals and values' (IPBES, 2019, XVIII). We argue that within the context of forest management, the term transformative change is suitable to describe the holistic transition required to convert current forestry to an integrative conservation-oriented forest management approach (from here on: integrative conservation). Thereby, the term 'integrative' implies the provision of multiple forest ecosystem services within the same area (Borrass et al., 2017). As forests, their owners and subsequently the management are embedded in a social–ecological system, four basic system characteristics have to be addressed to enable and foster the process of transformative change. According to Abson et al. (2017), the system consists of (1) *parameters*, which are defined as 'modifiable, mechanistic characteristics such as taxes, incentives, and standards'. This is followed by (2) *feedback*, which can be understood as 'the interactions between elements within a system [...] that drive internal dynamics'. Third, the system is characterized by its (3) *design*, which includes the 'structure of information flows, rules, power and self-organisation'. The last attribute, (4) *intent*, consists of 'norms, values and goals embodied within the system of interest and the underpinning paradigms out of which they arise'. The order of these terms refers to the increasing potential of their respective leverage points. Policy instruments mainly address (1) parameters and (2) feedback and, thus, shallow leverage points. However, approaches aiming at (3) design or (4) intent, called deep leverage points, may be of larger influence (Abson et al., 2017). Due to its holistic nature, transformative change in forest management should focus on all ownership types, including public and privately owned forests. However, both innovative concepts

for integrative forest management and research on integrative conservation are largely missing for private forests and even for mixed-ownership landscapes. This is particularly true for small-scale private forests with holdings of less than 20 hectares that are characterized by fragmented structures, a mix of management approaches and various cultural landscape habitats of conservation concern (Loeb & D'Amato, 2020; Mölder et al., 2021; Schaich & Plieninger, 2013). This is a relevant research gap since the heterogeneous group of private forest owners (Häggqvist et al., 2014; Tiebel et al., 2021a) comprises a particularly important set of stakeholders to consider. Their importance is illustrated by the fact that, collectively, they possess 56% of the forest area in Europe (UNECE & FAO, 2020). In consequence, effective conservation strongly depends on management decisions taken by small-scale private forest owners (Mayer, 2019; Paloniemi & Tikka, 2008). Although private forest ownership has long been investigated (Weiss, Lawrence, Lidestav, et al., 2019), knowledge of how small-scale private forest owners perceive and react to recent forest challenges is limited (de Groot et al., 2021), as is expertise in how to design appropriate management approaches that account for current environmental changes (Weiss, Lawrence, Hujala, et al., 2019). This is particularly true when looking at transformative change towards integrative conservation.

Moreover, studies frequently observed a discrepancy between private forest owners' stated perspectives and their behaviour, for example regarding climate adaptation (Sousa-Silva et al., 2018) or nature conservation (Tiebel et al., 2021b). This deviation is referred to as the 'attitude–behaviour gap' (Goodarzi et al., 2021) and is attributed to socio-economic conditions (Blanco et al., 2015) as well as to structural, demographic and personal factors (Deuffic et al., 2018). Thus, further insights into the perspectives, behaviours and forest characteristics of small-scale forest owners and particularly their societal groups (Ficko et al., 2019; Urquhart & Courtney, 2011; Weiss, Lawrence, Lidestav, et al., 2019) are required to initiate a process of transformative change towards integrative conservation.

Against this background, the overall objective of our study is to identify and differentiate between small-scale private forest owner groups and thereby determine leverage points that can be used to foster a process of transformative change towards integrative conservation. We created a typology based on the cluster analysis approach. This method has been successfully applied to gain an overview and understanding of private forest owners (Boon & Meilby, 2007; Howley, 2013), to design forest policy measures (Blanco et al., 2015), communication strategies (Boon & Meilby, 2007) and activities for advisory services (Ingemarson et al., 2006) aiming at biodiversity conservation (Husa & Kosenius, 2021) or carbon sequestration (Khanal et al., 2017). Thereby, most forest owners' typology studies are based on objectives, values or attitudes, and only a minority provides specific policy recommendations (Ficko et al., 2019). Employing a novel approach, we differentiate between groups of small-scale private forest owners based on their forest management activities and use the insights gained to provide recommendations on transformative change.

More specifically, we are aiming to:

- Elicit differences and similarities between the groups of forest owners, as differentiated by management activities regarding their objectives and perspectives on nature conservation.
- Analyse the socio-demographic and forest structural characteristics of each owner type.
- Identify the factors promoting and inhibiting transformative change towards integrative conservation.

Based on these findings, we propose ownership group-specific recommendations and cross-cutting leverage points towards transformative change. For practitioners, we developed profile handouts for each ownership type (Appendix 5). They include an overview of their main characteristics, a SWOT (i.e. strengths, weaknesses, opportunities and threats) analysis and policy recommendations.

2 | METHODS

2.1 | Data collection

We conducted a quantitative mail survey in the German federal state of Lower Saxony in 2020. More specifically, our study area was the landscape unit of the Lower Saxon Hills and adjacent administrative districts (Figure 1). This study area is suitable for empirical research because of its consistent legal situation and uniform forest administration. With 43% of the forest area being privately owned (ML Niedersachsen, 2014) and, according to the survey, 91% of the private land being smaller than 20 ha, the fragmented and small-scaled ownership structure can be compared to many (western) European countries. Further details on the representativeness of our data can be found in Appendix 1.

Before distributing the survey, a self-assesment tool from the University of Kassel was employed to evaluate whether an appraisal by the ethics committee was required. This was not the case. Participants were informed about the voluntariness of participation, the anonymity of responses and data security. By participating in the survey, the respondents agreed to be part of the research. The mail survey was designed and distributed according to Dillman's Total Design Method (Dillman, 1991). It included 26 questions regarding the owners' relation to their forest, framework conditions and socio-demographic as well as forest stand characteristics (Appendix 2). After performing a pre-test, we sent the survey to 4204 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, 1671 responses (39.8%) were usable for the subsequent analysis.

Even though a comparable ownership structure can be found in many other European countries, our results are based on a certain region within Germany. They cannot be directly transferred to other

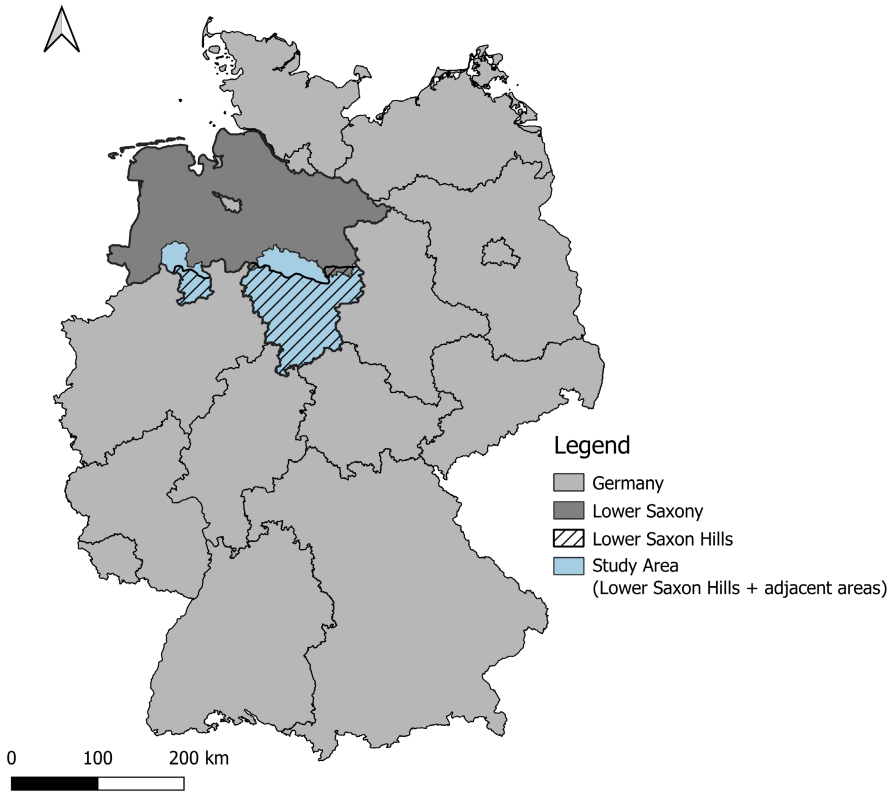

FIGURE 1 Study area in the context of Germany, Lower Saxony and the Lower Saxon Hills. Geodata: Germany and federal states (GeoBasis-DE and BKG, 2021), administrative borders of the study area (LGLN, 2021), Lower Saxon Hills (Gauer, 2005, slightly modified according to ML Niedersachsen, 2014).

areas but should be adapted to the specific context. Further, our data quality might be impacted by a non-response bias, as certain individuals might have had a higher likelihood to participate, especially if they have an interest in the topic, are particularly knowledgeable or have enough time (Stockemer, 2019).

2.2 | Data analysis

We used cluster analysis to distinguish between different groups of forest owners based on their management activities, as stated in the survey. Before starting the clustering approach, we analysed the correlations among the variables on which the clustering approach is based (here: stated activities; question 2 in Appendix 2). The correlations showed a maximum of 0.47, which is below the critical value of 0.9 given by Mooi et al. (2018). Based on the literature, we grouped the stated activities into five forest management categories, which formed the foundation for our cluster analysis (Table 1, Appendix 3). In the first category, conventional silvicultural management (a), we summarized the activities related to a standard, production-oriented management focused on planting, thinning and harvesting. Close-to-nature silvicultural management (b) includes measures that ensure low impact on the forest ecosystem (e.g. use of logging horses, avoiding pesticides) or foster semi-natural forest structures (e.g. promoting broadleaf trees, natural tree regeneration). Historical forest management (c) comprises techniques such as coppicing or wood pasture. All conservation activities focused on letting nature take its course belong to the category of passive conservation management (d), while those that are based on active interventions are summarized in the category of active conservation management (e).

We developed the number of clusters inductively out of the data using hierarchical clustering. As we based our cluster analysis on stated activities, missing values (i.e. cases in which a question was skipped) were omitted. This explains the lower number of answers ($n = 1656$) in our analysis. We decided on a suitable agglomerative hierarchical clustering approach by comparing the agglomerative coefficients. Using Ward's linkage method, the coefficient showed the highest value (0.9976). Ward's linkage method minimizes the within-cluster variance (Boehmke & Greenwell, 2019). We gained three clusters, with 500, 737 and 419 forest owners, respectively. We tested the stability of our clustering approach using the average proportion of non-overlap (APN, Brock et al., 2021). This measure performs clustering for the full data set and smaller sets resulting from the omission of single columns (here: forest management categories). APN is calculated as the average proportion of forest owners that are placed into different clusters in the smaller sets in comparison to the full set. For our data, APN amounted to 0.07, meaning that on average, only 7% of the forest owners were assigned to different clusters in the reduced data sets. We thus received highly consistent clustering results.

A Kruskal–Wallis test was used to determine differences between the owner groups in ordinally scaled dependent variables (survey answers based on a Likert scale). When we found a significant difference, inter-group differences were determined by a Conover–Iman test (Ostertagova et al., 2014), and the effect size

TABLE 1 Categories of forest management and their components.

Category	Components
(a) Conventional silvicultural management	• Thinning • Protection of young trees against browsing • Timber sale • Planting/promotion of native tree species • Planting/promotion of introduced tree species • Harvesting single mature trees • Pruning
(b) Close-to-nature silvicultural management	• Reduction of damage created by logging • Avoidance of chemical pesticides • Promotion of broadleaf trees in coniferous forests • Use of logging horses • Promotion of natural tree regeneration • Avoiding clear-cuts
(c) Historical forest management	• Coppicing/coppicing with standards • Forest grazing/wood pasturing
(d) Passive conservation management	• Protection of habitat trees • Protection of dead wood • Non-use of parts of the stand • No measures
(e) Active conservation management	• Promotion of a shrub layer • Protection/restoration of more open stand structures • Protection/maintenance of special structures (e.g. bizarre growth forms) • Promotion of rare native tree and shrub species • Species protection measures • Habitat restoration • Removal of introduced species

(H^2) was calculated and interpreted according to Cohen (1988). As the majority of survey questions relating to socio-demographic and structural information resulted in categorical data, Pearson's Chi-square test was utilized. If a significant difference was found, inter-group-specific differences were calculated using a post hoc analysis. Subsequently, the effect size was analysed using the phi-coefficient. Both tests determining inter-group differences used the Bonferroni correction. We only described differences when a group significantly differed from both other owner groups.

This analysis enabled us to identify common patterns as well as unique characteristics of each ownership group. Based on our findings and the literature, we identified leverage points and classified them into the four basic system characteristics described by Abson et al. (2017): (1) parameters, (2) feedback, (3) design and (4) intent.

3 | RESULTS

3.1 | Activity-based typology of small-scale private forest owners

We distinguished three groups of forest owners based on their management activities (Figure 2). Further, we compared the three groups based on their share [%] of performing a certain measure.

Multiple-use-oriented forest owners ($n = 737$, 45%) performed all conventional silvicultural (Figure 2a) and historical measures as well as most close-to-nature (Figure 2b) and active conservation activities (Figure 2c) more often than the other two groups. The conventional silvicultural management options of thinning (97%), promoting native tree species (88%) and timber sale (84%) were the activities carried out most often by this group.

Conventional forest owners ($n = 500$, 30%) carried out most conservation measures (Figure 2c,d) and close-to-nature practices less frequently compared with the other groups. As for conventional silvicultural activities, this owner group mostly had intermediate shares, while they did not differ from conservation-oriented owners in three out of seven activities (Figure 2a). One conventional measure (pruning) was performed the least by this group in comparison to the other owner groups. Next to thinning (82%), conventional owners avoided chemical pesticides (56%) and sold timber (52%), the most frequently out of all management measures.

Conservation-oriented forest owners ($n = 419$, 25%) performed three out of seven conventional silvicultural activities (Figure 2a) less frequently, while they implemented half of the passive conservation practices (Figure 2d) more often than the other forest owner groups. With regards to close-to-nature management (Figure 2b) and active conservation (Figure 2c), they mostly showed an intermediate share of conducting these measures. The three activities performed most often within this group were avoidance of chemical pesticides (86%), protection of dead wood (80%) and thinning (75%).

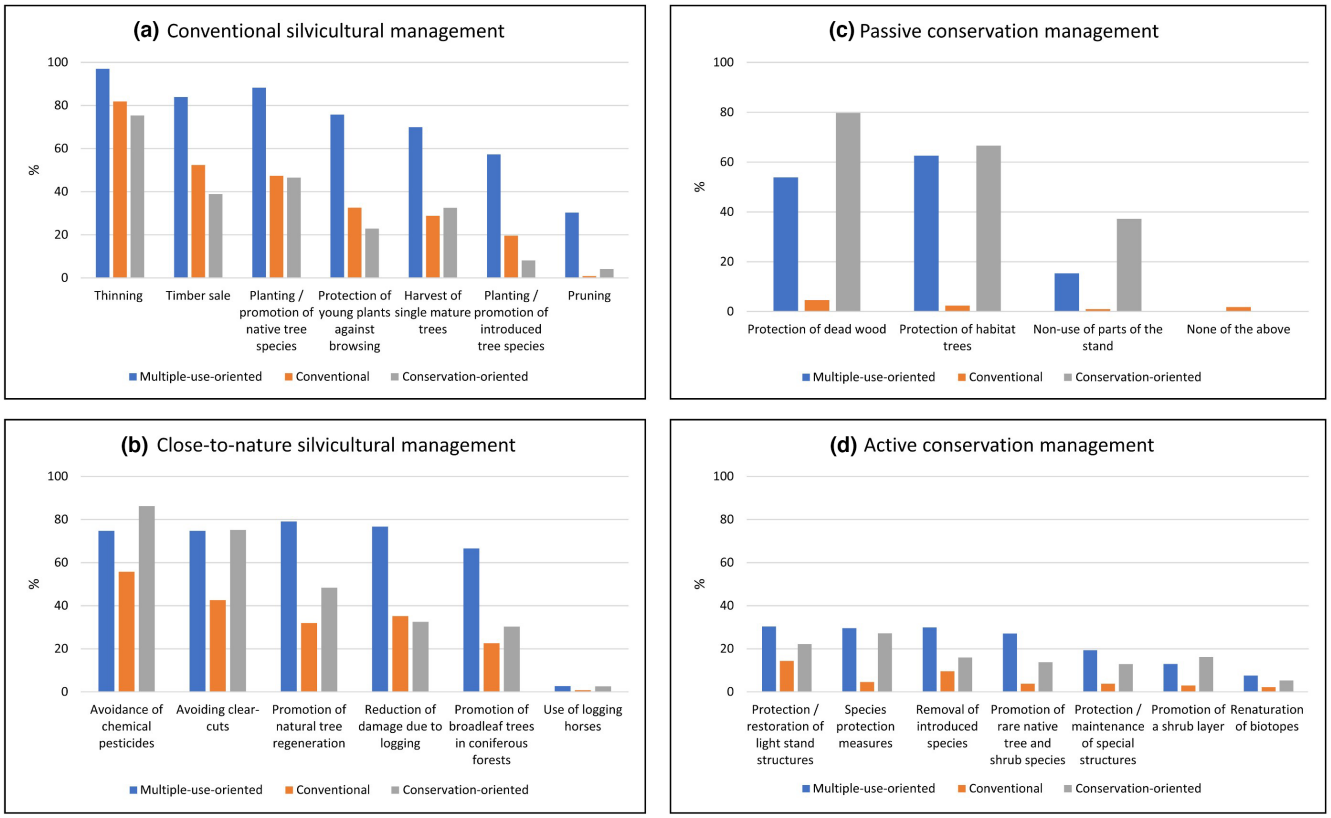

FIGURE 2 Average share (%) of forest owners who stated they performed certain forest management activities in each category (a) conventional silvicultural management, (b) close-to-nature silvicultural management, (d) passive conservation management, (e) active conservation management, differentiated by owner type. (c) Historical forest management is not depicted as it was only carried out by multiple-use-oriented forest owners.

3.2 | Objectives of small-scale forest owner groups and their perspectives on nature conservation

Survey recipients were asked to rate the importance of forest objectives, which were classified within the ecosystem services framework. Ecosystem services describe the benefits that people receive from ecosystems. The concept distinguishes between 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). Furthermore, they were asked about their opinion on certain conservation perspectives (Table 2).

Multiple-use-oriented forest owners rated provisioning ecosystem services as well as economic objectives on average as more important than the other two groups. They also valued half of the regulating services more highly. To a significantly greater degree, multiple-use-oriented forest owners wished for more involvement in decision-making processes about conservation.

Conventional forest owners perceived half of the regulating and most cultural ecosystem services as less important in comparison to both other groups. As for the provisioning services and economic objectives, they mainly assigned intermediate values. This owner type showed the weakest belief in the impact of their management on ensuring natural conditions and the presence of conservation structures in their forests. They also expressed the least agreement with promoting nature conservation in the absence of financial support.

Conservation-oriented forest owners valued half of the provisioning services and both economic objectives less in comparison to the other groups. For most regulating and all cultural services, this owner group did not show significant differences from both other owner groups. Conservation-oriented forest owners were willing to promote conservation without financial support significantly more often, while they less strongly believed that conservation creates high costs and threatenes their freedom to make decisions. They agreed most strongly with management cessation due to difficult stand conditions, as well as with the idea that their conservation activities are a consequence of their forest not providing other benefits.

The long-term preservation of a stable and healthy forest stand, followed by the preservation of soil, water and air quality and biodiversity conservation, were regarded as the most important regulating services across all groups. For conventional owners, biodiversity conservation was equally important as preserving family heritage. Across all groups, the collection of non-wood products, the opportunity for hunting and profit maximization were valued the least.

TABLE 2 Importance of ecosystem services among small-scale private forest owners, differentiated by owner group.

Category	Ecosystem services/economic objectives	Activity-based clusters			*p* (Kruskal–Wallis)	Effect size (H^2)
		Multiple-use	Conventional	Conservation-oriented		
Regulating ecosystem services	Long-term preservation of a stable and healthy forest stand	4.9 (±0.4) (↑)	4.6[a] (±0.7)	4.7[a] (±0.6)	***	**0.23**
	Preservation of soil, water and air quality	4.6[a] (±0.6)	4.4[b] (±0.7)	4.5[ab] (±0.7)	***	**0.11**
	Biodiversity conservation	4.5 (±0.7) (↑)	4.2 (±0.9) (↓)	4.5 (±0.7)	***	**0.18**
	Carbon sequestration, conservation of carbon sinks	4.4[a] (±0.8)	4.1 (±0.9) (↓)	4.3[a] (±0.9)	***	**0.12**
Cultural ecosystem services	Protection as cultural heritage	4.3[a] (±0.8)	4.0 (±1.0) (↓)	4.3[a] (±0.9)	***	**0.13**
	Safeguarding or enhancement of landscape beauty	4.0[a] (±0.9)	3.7 (±1.0) (↓)	4.0[a] (±0.9)	***	**0.15**
	Possibility for nature observation	3.9[a] (±0.9)	3.4 (±1.1) (↓)	3.9[a] (±1.0)	***	**0.20**
	Possibility for own recreation	3.5[a] (±1.2)	3.1 (±1.3) (↓)	3.3[a] (±1.3)	***	**0.14**
	Preservation as an opportunity for education	3.5 (±1.1) (↑)	3.2[a] (±1.1)	3.3[a] (±1.1)	***	**0.10**
	Collection of non-wood products	2.2[a] (±1.1)	2.0 (±1.1) (↓)	2.2[a] (±1.1)	**	0.08
	Opportunity for hunting	2.9 (±1.5) (↑)	2.3[a] (±1.3)	2.3[a] (±1.4)	***	**0.23**
	Preservation of family heritage	4.4 (±0.9) (↑)	4.2[a] (±0.9)	4.0[a] (±1.1)	***	**0.13**
Provisioning ecosystem services	Wood production for personal consumption	4.0 (±1.2) (↑)	3.6[a] (±1.3)	3.5[a] (±1.3)	***	**0.19**
	Wood production for selling	4.1 (±1.1) (↑)	3.4 (±1.3)	2.8 (±1.3) (↓)	***	**0.44**
Economic objectives	Financial security	3.8 (±1.1) (↑)	3.2 (±1.2)	3.0 (±1.2) (↓)	***	**0.29**
	Profit maximization	3.2 (±1.2) (↑)	2.7 (±1.2)	2.2 (±1.1) (↓)	***	**0.34**
Perspectives on nature conservation						
Assessment of own management and conservation value	My management ensures natural forest conditions.	4 (±0.9)	3.7 (±0.9) (↓)	4.2 (±0.8) (↑)	***	0.07
	Structures with high conservation value are present in my forest.	3.4[a] (±1.0)	2.9 (±1.0) (↓)	3.5[a] (±1.0)	***	0.09
	I do not perform management due to difficult forest stand conditions.	2.1[a] (±1.2)	2.1[a] (±1.2)	2.5 (±1.3) (↑)	***	**0.14**
Views on nature conservation	I would like to see greater involvement in decision-making processes about conservation in my forest.	3.6 (1.4) (↑)	3.4[a] (±1.3)	3.3[a] (±1.3)	***	0.09
	Even without financial support, I am willing to promote nature conservation.	3.4 (±1.2)	3.1 (±1.1) (↓)	3.7 (±1.0) (↑)	***	**0.19**
	Conservation in my forest threatens my personal freedom of decision.	3.2[a] (±1.4)	3.1[a] (±1.4)	2.6 (1.4) (↓)	***	**0.17**
	Conservation in my forest creates high costs.	3.2[a] (±1.2)	3.1[a] (±1.2)	2.6 (±1.2) (↓)	***	**0.18**
	My forest provides no other benefit to me, which is why I promote nature conservation.	2.1 (±1.1) (↓)	2.5 (±1.2)	3 (±1.2) (↑)	***	**0.29**

Note: Values (mean values of five-scale assessment): 1 (not important at all) to 5 (very important), mean values without superscript letters are significantly different at the 0.05 level, values in brackets: standard deviation; *p*-value: * ≤ 0.05, ** ≤ 0.01, *** ≤ 0.001, n.s. not significant; effect size: bold if >0.1; colour coding: highest (↑) and lowest (↓) values, when significantly different from both other owner groups.

TABLE 3 Socio-demographic and structural characteristics of small-scale private forest owners differentiated by three clusters.

		Share [%] of private forest owners				
	Factors	**Multiple-use**	**Conventional**	**Conservation-oriented**	***p*** **(χ^2)**	**Effect size (Φ)**
(a) Socio-demographic	Female gender	14.6[a]	26.2[b]	19.8[ab]	***	**0.12**
	University degree	34.3[a]	26.8 (↓)	35.8[a]	***	0.08
	Agricultural profession	43.0 (↑)	26.3[a]	23.5[a]	***	**0.19**
	Centre of life: village	73.1[a]	68.3[ab]	64.7[b]	***	0.08
	Weekly visits	31.9 (↑)	14.1 (↓)	21.9	***	**0.18**
	Highly active (performance of >12 measures)	38.0 (↑)	0 (↓)	9.8	***	**0.43**
	Proximity to forest (≤10 km)	85.1[a]	79.3[b]	79.6[ab]	*	0.07
	No forestry knowledge	11.2 (↓)	32.6[a]	29.2[a]	***	**0.24**
	No knowledge about stand structure	2.8 (↓)	12.5 (↑)	7.1	***	**0.16**
	Connection to forest	79.8 (↑)	55.4[a]	61.7[a]	***	**0.23**
	(partly) Acquired by inheritance	79.4[ab]	82.5[a]	73.5[b]	***	0.08
	(partly) Acquired by purchase	33.5 (↑)	17.7 (↓)	27.5	***	**0.15**
(b) Structural	Average forest size ≤5 ha	53.9 (↓)	81.5[a]	80.9[a]	***	0.29
	Share of deciduous forest >75% of stocked area	33.8 (↓)	41.8	59.6 (↑)	***	**0.21**
	Forest age >100 year	5.3[a]	5.3[ab]	9.3[b]	*	0.07
		Mean (SD)			***p*** **(Kruskal–Wallis)**	**Effect size (H^2)**
	Average forest size [ha]	19.7 (±66.7) (↑)	4.4[a] (±10.5)	4.1[a] (±6.4)	***	**0.33**

Note: values without superscript letters are significantly different at the 0.05 level; *p*-value: * ≤ 0.05, ** ≤ 0.01, *** ≤ 0.001, n.s. not significant; effect size: bold if >0.1; colour coding: highest (↑) and lowest (↓) values are highlighted, when significant different from both other owner groups.

[Correction added on 24 January 2024, after first online publication: The values 12.5 and 59.6 have been corrected to 12.5↑ and 59.6↑.]

3.3 | Socio-demographic and forest structural characteristics of forest owner groups

Multiple-use-oriented forest owners were most active (>12 silvicultural or conservation activities), most frequently paid weekly visits to their property and most frequently reported a connection to their forests (Table 3a). They more often had an agricultural profession and had purchased their forest. They stated least frequently not to have forestry knowledge and not to be aware of their stand structures. Concerning their forest stand structures (Table 3b), owners within this group had the lowest share of their forests consisting mainly of deciduous trees. Multiple-use-oriented forest owners also had the lowest share of parcels with a size of ≤5 ha. With 19.7 ha, their average holding size was the largest.

Conventional forest owners had the lowest share of university degrees (Table 3a). Furthermore, this group did not include highly active forest owners and had a lower number of owners who visit their forest weekly or had (partly) purchased their stand. Also, they were unaware of the structures of their stands more often. As for structural characteristics (Table 3b), this group did not show any significant differences from the other groups, except for their intermediate levels of having a stand structure dominated by deciduous trees.

Conservation-oriented forest owners did not exhibit many significant differences from the other groups except for the following: As for their socio-demographic background (Table 3a), their intermediate values for weekly visits, being highly active and being unaware of their stand structure were significantly different from both other ownership groups. Considering the stand structures (Table 3b), the highest share of the forest consisting mainly of deciduous trees was found among members of this group.

3.4 | Perspectives on factors promoting and inhibiting nature conservation

The three forest owner groups strongly agreed on the ranking of the usefulness of instruments promoting conservation activities, the

TABLE 4 Comparison of the ranking of the usefulness of policy instruments, the influence of stakeholders and the importance of obstacles/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 wishes (%)
	*Ranked highest*	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 labour 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)
	Ranked 2nd highest	Information about legal regulations/financial implications (4.1/3.9/3.9)	Forest owner association [Forstbetriebsgemeinschaft] (3.6)/3.3/3.2)		
	Ranked 3rd highest	Financial incentives (4.0/3.8/3.9)	Forestry associations [Waldbesitzerverband] (3.5/3.3/3.0)		
[…]	[…]				
	*Ranked 3rd lowest*	Different rankings	Different rankings	Different rankings	Different order, but occurring for all three groups: Timber marketing (30/18/13), wood harvesting (20/23/12)
	Ranked 2nd lowest	Computer-aided visualizations (3.2/3.1/3.1)	Digital media (2.3/2.1/2.3)	Different rankings	
	Ranked lowest	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)	

influence of stakeholders on forest management decisions, the presence of obstacles to implementing one's objectives and the wish for information (Table 4).

Forest owners from each group regarded on-site consultation as the most helpful tool for implementing more nature conservation activities, followed by information about legal regulations as well as financial incentives (partly rated the same, Table 4). In contrast, computer-aided visualizations and consultation by telephone were regarded as the least helpful across all owner groups. Forestry stakeholders such as foresters, forest owner associations [*Forstbetriebsgemeinschaften*] and the forestry association [*Waldbesitzerverband*] had the highest influence on forest management decisions in all three groups (partly rated the same, Table 4). On the other end of the spectrum, digital media and daily press or television were considered as being of low influence. Lack of time and shortage of family labour support were among the three most frequently mentioned obstacles to the implementation of their goals across all groups, while uncertainty about the location of the forest parcels was least often considered to be 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.

Despite these common patterns, differences between the forest owner groups also existed (Appendix 4):

Multiple-use-oriented forest owners perceived financial incentives, information about legal regulations, exchange of experience and visits to exemplary stands as more important in comparison to both other forest owner groups. Furthermore, they were more strongly influenced by family and friends, forestry stakeholders and agricultural media. Multiple-use-oriented forest owners stated six obstacles less often in comparison to the other groups, namely: small forest size, lack of knowledge, lack of skills, distance between forest and living place, lack of interest and unclear location. In comparison to both other owner groups, they were more interested in information on support schemes in the forestry sector and on wood marketing.

Conventional forest owners rated regular publications as less helpful compared to both other owner groups. Owners within this group were less strongly influenced by research institutes as well as daily press and television. They did not perceive obstacles as more or less prominent than the other groups and did not wish for any information more often.

Conservation-oriented forest owners perceived support in identifying structures worthy of protection and cooperation with neighbours and experts as more helpful than the other owner groups. This group rated the influence of conservation actors higher, while the forestry association [*Waldbesitzerverband*] was regarded as less influential. A lack of technical equipment was perceived as an obstacle more often. Conservation-oriented forest owners had a higher desire for information on conservation and forest restructuring, while they were less interested in wood harvesting.

4 | DISCUSSION

4.1 | Conservation-oriented objectives, activities and perspectives of small-scale forest owners

Transformative change towards integrative conservation requires assessing the degree to which conservation is currently considered and performed among small-scale private forest owners. Across the three identified owner groups, biodiversity conservation was perceived as important by a majority of survey respondents and rated higher than resource use or income generation. Similarly, in the wider European context, landscape and environment-related objectives, including biodiversity conservation, have been perceived as important by small-scale private forest owners (Wiersum et al., 2005). However, the situation differs regionally. In Estonia, for instance, income and self-consumption were rated as more important than conservation (Põllumäe et al., 2014). In Germany, this was the case for self-sufficiency (Joa & Schraml, 2020), and in Finland, for wood production and multiple uses (Hallikainen et al., 2010).

As a gap between attitude and behaviour is frequently observed (Ferreira & Klütsch, 2021), our study included a focus on management activities, objectives and perspectives. Alongside the high valuation of biodiversity conservation found in our study, conventional silvicultural management was carried out most frequently, while active conservation and historical forest management activities were performed only rarely. The implementation of conservation and close-to-nature activities varied between forest owner groups. While multiple-use-oriented forest owners generally performed most activities in each category, including conservation, conservation-oriented owners focused on passive measures and conventional owners showed only little engagement with conservation-related activities. As most studies focusing on both objectives and behaviour revolve around silviculture and harvesting (Ní Dhubháin et al., 2007), the comparability of our findings is currently limited. One potential explanation for the gap between the high valuation of biodiversity conservation and the lower performance of related activities may be related to our finding that foresters and forest owner associations had the biggest influence on decision-making across owner groups. Similarly, in the US, forestry professionals (Kittredge et al., 2013) but also timber buyers (Ruseva et al., 2014) were the most frequently occurring group in networks of private forest owners. However, objectives between forest stakeholders and private forest owners can differ. This might contribute to the gap between objectives and behaviour. For example, forest officials valued timber production higher than the owners (Kindstrand et al., 2008).

4.2 | Owner group-specific options to support transformative change towards integrative conservation

The described gap between objectives and behaviour raises the question of how the identified forest owner groups can be empowered

to act according to their objectives, which include their professed strong interest in regulating ecosystem services such as biodiversity conservation. We found universal patterns concerning their perspectives on influential stakeholders, obstacles and policy instruments. However, group-specific recommendations can be deducted based on their socio-demographic and stand characteristics as well as on their conservation view. Targeted approaches have been frequently recommended for strengthening conservation within small-scale private forests (Tiebel et al., 2021a) and are also required for an integrative approach to forest management (Aggestam et al., 2020). Inspired by Arnould et al. (2021), we developed group-specific profile handouts to be used by practitioners (Appendix 5).

Multiple-use-oriented forest owners were knowledgeable and actively engaged in their forests, for example through weekly visits, a high number of management measures and a reported connection to their forest. They had a variety of objectives and performed activities in different categories. Aspects of nature conservation were considered but not a major focus, which is also reported for Finland by Takala et al. (2022). Forestry stakeholders such as forest officials, forest owner associations and forestry associations most strongly influenced this owner group. As personal relationships are connected to trust (Hujala & Tikkanen, 2008), the provision of conservation-related and practice-oriented consultation by forestry stakeholders is a possible pathway for fostering conservation-related behaviour. Furthermore, contract-based conservation might be impactful. Such voluntary and individual contracts define the nature and extent of certain conservation measures, are terminable by either party, and include an appropriate payment (Demant et al., 2020). For this forest ownership group, the offered conservation activities have to be compatible with aspects of resource use to be attractive. As multiple-use-oriented forest owners were the largest group among our respondents and as they reported the largest average plot size, motivating this owner type for conservation action could be especially rewarding in terms of potential impact.

Conventional forest owners were rather inactive, with comparably less interest in many forest objectives and management, the exception being wood production. Thus, the highest potential for conservation-related behaviour seems to be an increase in their interest, knowledge and awareness about their own forest and non-production aspects. As the provision of information is unlikely to change the underlying discourse (Takala et al., 2022) and as resource use is of importance for this owner group, it might be useful to focus on measures with relatively low trade-offs, even if they are not very ambitious. For example, this could imply leaving coarse woody debris in the forest or allowing individual trees to develop as habitat trees. Such measures should be compatible with wood production and allow for self-determination (Miljand et al., 2021). Financial incentives might further contribute to an uptake of conservation measures, as this ownership group rated this instrument as very helpful in promoting conservation activities.

Conservation-oriented forest owners highly valued conservation aspects but limited their conservation management activities mostly to passive measures. They reported to have high shares of deciduous forests as well as stand structures of conservation value, which is generally a good starting point for conservation. The continuation of their rather extensive management approach seems beneficial from a nature conservation perspective. The focus on passive measures might be due to a lack of knowledge and skills. Thus, the empowerment of those who want to implement their conservation objectives more actively can be achieved through the provision of knowledge (Miljand et al., 2021) in practice-oriented consultation programmes.

4.3 | Cross-cutting leverage points towards transformative change in small private forests

To identify cross-cutting leverage points that foster a process of transformative change in the realm of small-scale private forest owners, we focus on the four basic system characteristics described by Abson et al. (2017): (1) parameters, (2) feedback, (3) design and (4) intent. While we differentiate the leverage points (Figure 3, in italics in the text) according to the system characteristics, they are interconnected.

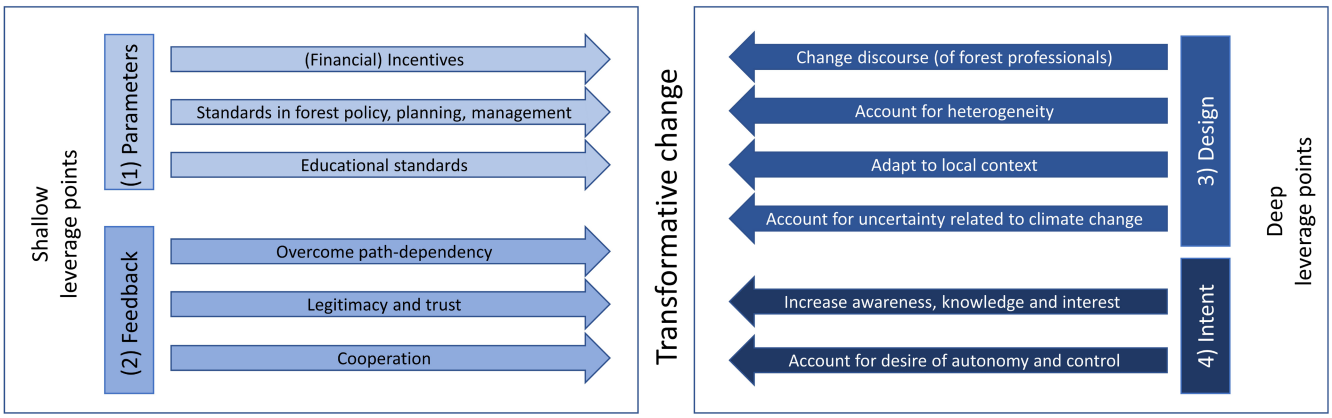

FIGURE 3 System characteristics and their leverage points in fostering a process of transformative change towards integrative conservation in the realm of small-scale private forest owners.

(1) Parameters: Within our study, *financial incentives* were among the most preferred policy instruments for increasing the implementation of conservation measures. However, this leverage point is controversially discussed, as economic incentives may result in adverse effects if a person has an intrinsic motivation to act in a certain way. On the other hand, it may also strengthen these motives (Rode et al., 2015). When designing and implementing a financial incentive scheme, one has to foster non-economic motivations, establish trust and support self-organization (Chan et al., 2017). Due to the uncertainty related to climate change, incentivizing resilience might be more effective than honouring single activities (Bauhus et al., 2021). Similarly, the conservation value could be rewarded (Demant et al., 2020), which was estimated as intermediate by our respondents. This way, their knowledge would also increase. Apart from financial incentives, social appreciation can contribute to the conservation process (Bieling, 2004). Within the realm of 'parameters', another leverage point is to change the underlying *standards in forest policy, planning and management* by stronger considering regulating ecosystem services throughout all decisions and activities (Hernández-Morcillo et al., 2022). This contributes to the leverage point of *changing the discourse* in (3) design. For example, by adapting the *educational standards* for stakeholders that were regarded as influential by our survey respondents (e.g. forester officials), this group is enabled to understand and address trade-offs in forest management (Aggestam et al., 2020). Furthermore, indicators for evaluating the ecological performance of forester officials may contribute to this process (Cosyns et al., 2020), including, for example the number of habitat trees, the composition of tree species and ages or the amount of deadwood.

(2) Feedback: In this context, the consideration of *path-dependency* is crucial as current forest conditions represent past objectives, states of knowledge, constraints and values (Stjernquist & Schlyter, 2022). Moreover, changing the current political system and existing power relations is challenging (Larson et al., 2021). The participation of external stakeholders (Bouriaud et al., 2015) as well as the establishment of trust (Põllumäe et al., 2016) may contribute to overcoming path-dependency and result in *legitimacy and trust*. The wish for involvement in the decision-making process was also frequently raised in our survey. Linking stakeholders from different sectors and governance levels can create coalitions fostering transformative change (Atmadja et al., 2021). Thereby, local knowledge is considered, legitimacy generated and compliance strengthened (Brondízio et al., 2019). *Cooperation*, for example through sharing experiences or peer-to-peer learning, may contribute to increasing conservation behaviour (Korhonen et al., 2013). The results of our study confirm that private forest owners perceived instruments focusing on cooperation, exchange and knowledge generation as helpful. In the context of private forests, the role of change agents (Korhonen et al., 2013), opinion leaders (Kittredge, 2004) and information disseminators (Bieling, 2004) has been frequently highlighted as they may inspire actions leading to transformative change in their local communities (Priebe et al., 2022).

(3) Design: In this realm, *changing the discourse* towards the acceptance of and concern for biodiversity loss by private forest owners and influential stakeholders is crucial (Takala et al., 2022), especially for the group of conventional forest owners. Professional forest stakeholders are important for this, since this stakeholder group is considered most influential by forest owners in our study as well as by owners with a production-oriented discourse in Finland (Takala et al., 2021). This can partly be achieved by adapting educational standards as elaborated in (1) parameters. Including different lines of argumentation for biodiversity conservation, ranging from intrinsic to material components, would have the potential to reach individuals with varying perspectives (Tinch et al., 2018). Recognizing and considering the different values and activities of private forest owners (Brondízio et al., 2019) is important for changing the discourse. As discussed earlier, certain conservation instruments may only be attractive for a certain group of forest owners, and thus, measures should be designed to *account for their heterogeneity*, their objectives (Joa & Schraml, 2020) and specific needs (Bieling, 2004). As lack of time and labour support were frequently mentioned as obstacles and as many survey recipients owned small and fragmented parcels, conservation measures must be easy to understand and fast to implement, containing low entry points (for owner-specific recommendations, see Section 4.2). Thereby, an *adaptation to the local context* is useful. A simultaneous implementation of different approaches aiming to strengthen conservation distributes the risk of ineffective measures (Bauhus et al., 2021). The landscape scale seems to be an appropriate level here, as certain factors, such as forests belonging to mixed-ownership structures, can be considered (Mölder et al., 2021). The area-specific knowledge gained by local stakeholders through past changes and experiences may further contribute to transformative change (Priebe et al., 2022). In combination with the leverage point *cooperation* in (2) feedback, this local knowledge can be used during collective social learning, which describes an approach in which stakeholders with diverse backgrounds develop answers to challenges in social–ecological systems in a process of mutual learning (Garmendia & Stagl, 2010). Including social learning in forest management has the potential to adequately address the complexity and uncertainty of the current challenges (Didham & Ofei-Manu, 2015). It is recommended to use a flexible approach consisting of different short- and long-term strategies and enabling continuous learning to adapt plans according to new insights (Millar et al., 2007). Additionally, the use of different approaches on a landscape scale distributes the risk of ineffective measures (Bauhus et al., 2021), which is especially important when *accounting for the uncertainty related to climate change*.

(4) Intent: Leverage points that address the last system characteristic, (4) intent, have the highest potential influence. Conservation action requires forest owners to recognize the importance of biodiversity conservation as well as to act accordingly. Thus, an influential leverage point is to *increase awareness, knowledge and interest* in forests and biodiversity conservation. Our

results indicate a relationship between a rather low active connection to the forest and the reduced performance of conservation-oriented management. Thus, deepening the relationship between owners and their forests may be promising. This can be achieved by increasing their knowledge of forest ecology (Takala et al., 2022) to broaden their view on forest management (Hernández-Morcillo et al., 2022). In our study, information on conservation was not found to be of central interest to most forest owners. Thus, it seems to be more promising to increase the interest and knowledge of private forest owners by considering other stakeholders such as forest advisers (Salomaa et al., 2016), the forest owners' social network (Vainio et al., 2018) and the public (Jakobsson et al., 2021) as important information sources contributing to the leverage point *change the discourse* in (3) design. This is especially important as new forest owners are less experienced in forest management (Urquhart & Courtney, 2011) and might rely on advice from forest professionals (Hujala et al., 2007). Taking into account the reasons that partly justify the reluctance to conservation instruments, accounting for the *desire for autonomy and control* is important as this factor influences forest owners' behaviour (Miljand et al., 2021). The Finnish METSO programme accounts for this by focusing on voluntary conservation agreements while providing a compensation payment based on the timber value of the stand (Ministry of the Environment & Ministry of Agriculture and Forestry, 2015). However, mere voluntary changes in management action may not be sufficient to ensure large-scale improvements to conservation. Additionally, structural reforms of the current forest policy are required (Danley et al., 2021), as discussed in all system characteristics. The comprehensive list of leverage points (Figure 3), targeting different system characteristics, groups of people and sectors, makes it clear that substantial changes to the existing system are needed.

While we focus on private forest owners, their forest holdings are frequently embedded into a mosaic of different ownership types at the landscape scale. Therefore, in a process of transformative change, it is important to systematically consider linkages between different types of ownership that can be implemented in cross-boundary ecosystem management (Loeb & D'Amato, 2020; Mölder et al., 2021; Thompson et al., 2004). Globally, the identified leverage points have great chances to be adapted to small-scale private forests under different socio-economic and natural conditions. This is particularly important given recent findings that emphasize the conservation value of even small habitat patches, such as those found in small-scale private forests. As Riva and Fahrig (2022) highlight, acknowledging the conservation value of small or even very small habitat patches will be a necessary step for halting biodiversity loss in the Anthropocene.

5 | CONCLUSIONS

Balancing societal demands towards forests is a major challenge in present times. Small-scale private forest owners must increasingly be included in analyses and addressed in discussions. We provide a first approach to identify leverage points that can be used to foster transformative change towards future-proof, integrative conservation-oriented forest management. Focusing on four system characteristics (parameters, feedback, design and intent), we show that adapting policy instruments such as standards or incentives is not sufficient. Instead, systematic changes to the underlying policy orientation, its design and its implementation are needed. The leverage points that have the largest potential include changing the discourse, adapting strategies to local conditions and uncertainty related to climate change, accounting for owners' heterogeneity and desires as well as increasing awareness, knowledge and interest.

More specifically, we differentiated three small-scale private forest owner groups within a typical European multi-ownership landscape. We found that they varied regarding their approach to conservation measures and perspectives, despite a high general valuation of biodiversity conservation. Through our analysis, we identified group-specific approaches to foster integrative conservation. At the same time, common patterns promoting and inhibiting conservation action were found. For example, on-site consultation, information about legal regulations as well as financial incentives were perceived as helpful, while a lack of time and a shortage of family labour were most frequently mentioned as obstacles.

Engaging small-scale private forest owners in transformative change towards integrative conservation has high potential due to the large proportion of total forest area they possess, their generally high valuation of biodiversity conservation and their heterogeneity that results in a diverse mosaic of management approaches and forest stand structures. However, there are several challenges related to small-scale private forest owners. To enable transformative change, political stakeholders need to develop an understanding of this group, their backgrounds, demands and needs. We showed that especially the system characteristics 'design' and 'intent' have to be adapted accordingly. Furthermore, the political environment, related institutions and the wider society should be included in a cross-cutting process.

AUTHOR CONTRIBUTIONS

All authors contributed to the idea for this article and its implementation. Malin Tiebel was responsible for the survey design and its implementation. Malin Tiebel performed the data analysis, which was supported by Peter Hansen. Malin Tiebel wrote the manuscript together with Andreas Mölder and Peter Hansen and received constant feedback from Tobias Plieninger and Claudia Bieling. All authors critically contributed to the draft and approved the final version for publication.

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CONFLICT OF INTEREST STATEMENT

Tobias Plieninger is an Associate Editor for People and Nature but was not involved in the peer-review and decision-making process. The authors do not have any conflicts of interest regarding the article.

DATA AVAILABILITY STATEMENT

The data on which this review is based can be found on the platform Zenodo by using the following link https://doi.org/10.5281/zenodo.6572661.

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SUPPORTING INFORMATION

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

Appendix 1. Representativeness of the survey sample.

Appendix 2. Translated version of our survey.

Appendix 3. Categories of forest management, their components and references.

Appendix 4. Survey data.

Appendix 5. Owner group-specific recommendations towards an integrative conservation-oriented forest management.

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