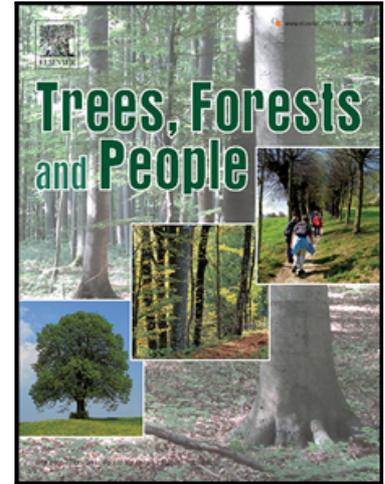


Journal Pre-proof

Factors influencing contact with professional foresters in small private forests



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Highlights

- Small private forest owners are in contact with professional foresters when management objectives require technical knowledge or are linked to public subsidy programmes.
- Management activities, demographic characteristics, information sources, economic factors and institutional support are significantly related to contact with professional foresters.
- Digital information sources offer flexible and location-independent opportunities to support forest owners, complementing traditional extension services.
- Customer-focused extension services are essential to reach different groups of forest owners.

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Factors influencing contact with professional foresters in small private forests

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Abstract

In Europe, approximately 60 % of forests are privately owned, with a significant proportion managed by small private forest owners (SPFOs) who face diverse management objectives and increasing societal demands for ecosystem services. This study examines the key factors influencing SPFOs in Germany to contact professional foresters, based on a dataset from a survey conducted by Feil et al. (2018). A mixed logistic regression model analyzes the relationship of forest management activities, demographic characteristics, information sources, economic factors and institutional support with the decision to contact professional foresters. The results show that SPFOs are in contact with professional foresters when management objectives require technical knowledge or are linked to public subsidy programmes. Demographic factors such as an increasing age, male gender, higher education and experience in the primary sector have a significant positive impact on the likelihood of contact. Economic considerations, such as perceived economic value of the forest and household income, also play an important role. The use of digital information sources is positively associated with contact with forest professionals. In addition, regional differences suggest that federal state-specific forestry structures also influence contact with professional foresters. The study highlights the need for targeted extension services to address the diverse needs of SPFOs.

Keywords: extension services, advisory, forest management, institutional support, digital information sources, Germany

1. Introduction

Approximately 60% of European forests are privately owned, corresponding to about 9.6 million individual forest owners. While the structure of the forests varies considerably

between different countries and regions, nearly 90 % of these private forests are smaller than 10 hectares (Mauser, 2021). Numerous studies have shown that these smaller private forest owners are a diverse group with different management objectives (Weiss et al., 2019). In addition to the different objectives that forest owners seek to achieve in their forests, society is increasingly demanding a range of ecosystem services from these forests (Winkel et al., 2022). Forest owners are expected to meet these demands by managing their forests (Lawrence et al., 2020). In addition to societal demands, the effects of ongoing climate change pose additional challenges to forest owners by increasing the effort and risks associated with forest management (Prins, 2022; Yousefpour and Gray, 2022).

Moreover, societal changes also influence how SPFOs interact with their forests. Many now live in urban areas and are less dependent on the income from their forests (Matilainen et al., 2023; Weiss et al., 2019; Westin et al., 2017). Additionally, a lack of time and insufficient knowledge about management options leads to limited or no management of their forests (BMEL, 2021; Follo, 2011; Matilainen et al., 2023; Matilainen and Lähdesmäki, 2023; Vedel et al., 2006).

To support SPFOs in managing their forests, there are different institutional forms of forest extension services. These can include direct communication with professional foresters on-site, digital information services, or different forms of forest owner associations (FAOs) (Lawrence et al., 2020; Pöllumäe et al., 2019; Pynnönen et al., 2021). These services can help to address the knowledge or structural deficits of SPFOs (BMEL, 2021). Numerous studies have shown that direct contact with professional foresters has a particularly positive impact on the forest management activities of private forest owners (Chhetri et al., 2018; Feil et al., 2018; Karppinen and Berghäll, 2015; Kilgore et al., 2015; Sagor et al., 2022; Snyder and Kilgore, 2018; Upton et al., 2019; Wild-Eck et al., 2006). Beyond institutional services, forest owners may also seek support from non-professional sources, such as family members,

neighbors, or other forest owners, who can provide practical assistance or shared experiences (Aguilar and Kelly, 2019; André et al., 2017; Hujala et al., 2013; Sagor and Becker, 2014).

Although the potential role and efficiency of institutional forest extension services has been well researched, there is little comprehensive literature on the decision-making processes of European private forest owners regarding the decision to use forest extension services or to get in contact with professional foresters. Studies on the determinants for the choice of forest extension services or communication with professional foresters are mainly found in the USA (Matilainen et al., 2023).

The aim of this study is to help fill the research gap in understanding the decision-making process of SPFOs in contacting professional foresters, using Germany as a case study. A regression analytical research approach is used to identify the key factors influencing this decision. The study uses the results of a North American metadata study by Floress et al. (2019) as an empirical framework to select potential influencing variables. The data for the regression analysis is drawn from the questionnaire study of Feil et al. (2018), which was conducted among private forest owners in Germany in 2017. The focus of the present study is on the following research question: What factors influence small private forest owners to contact professional foresters?

With the resulting better understanding of the decision-making process for contacting professional foresters, the study aims to provide indications for enhancing extension services to reach and support SPFOs in managing their forests.

2. Empirical Framework

The dataset analysed in this study originates from a nationally representative survey of German private forest owners by Feil et al. (2018), which was designed using the *Model for Explaining Human Decision-Making* by Pregernig (1999) based on (Langenheder, 1975). However, the original survey was designed with a different target variable than the one considered in this study. Consequently, Pregernig's (1999) theoretical model could not be

directly applied to the conceptualization of this research. To ensure a suitable analytical framework, this study instead relies on an empirical framework derived from the findings of Floress et al. (2019). Floress et al. conducted a meta-analysis on various forest management measures of private forest owners in the USA and identified key factors influencing their management behaviors. This empirical framework is considered relevant to the present research, as it highlights determinants that may also be important for management behavior of private forest owners in European respectively German contexts. Despite the contextual differences between the USA and parts of Europe, there are substantial similarities in the ownership structure, management objectives and structural challenges and the use of forestry support services.

In both regions, private forest owners own a significant proportion of the total forest area. In the USA, private forest owners account for about 39 % of the forest area, with much of this land located in the eastern states of the country (Butler et al., 2021). In Europe, around 60 % of forests are privately owned, with similar proportions in Germany (48 %), Belgium (52 %), Sweden (48 %) and Finland (63 %) (Živojinović et al., 2015).

In the USA, smaller private forest owners are increasingly pursuing differentiated objectives in managing their forests. While traditional silvicultural activities are becoming less important, many forest owners are prioritising non-financial aspects such as recreation, aesthetics and nature conservation (Butler et al., 2021; Sass et al., 2023). This trend is also evident in Central Europe: in Germany and Austria, many SPFOs manage their land primarily for non-monetary reasons, comparable to Sweden and Finland, where management for ecological and social values plays a central role (Feil et al., 2018; Weiss et al., 2019; Westin et al., 2023; Živojinović et al., 2015).

Although private forest ownership in Europe and North America is still strongly characterised by family ownership, the importance of the forest as an economic livelihood has declined. Fewer private forest owners are using their forests for livelihoods, and a growing proportion

are living in urban rather than rural areas (Matilainen et al., 2023; Weiss et al., 2019; Westin et al., 2017). This increasing pluralisation and urbanisation is also affecting the structure of Germany's private forests and poses new challenges for forest policy (Feil et al., 2018).

In European countries such as Germany, forestry support is provided through EU programmes and national funding schemes. The *European Agricultural Fund for Rural Development* (EAFRD) and the German joint task for the *Improvement of Agricultural Structures and Coastal Protection* (GAK) provide financial incentives for sustainable forest management and nature conservation. The concrete implementation is carried out by the member states (Nichiforel et al., 2018) respectively federal states in Germany.

In the USA, forestry support is provided through federal and state programmes, with property tax programmes are the most important support instruments for private forest owners. There are also cost-share programmes and, for example, conservation easements (Butler et al., 2021). While tax incentives for private forest owners exist in both the United States and Europe, their implementation differs: In the United States, they are primarily part of voluntary, incentive-based programmes, whereas in Europe, financial support mechanisms often include regulatory elements that define management requirements (Poudel et al., 2024).

Despite these different approaches, the participation rates in forestry funding programmes remain low in both regions. In Germany, for example, only about 12 % of private forest owners use public funding (Feil et al., 2018), and participation rates are also low in other European countries (Aggestam and Pülzl, 2018). In the USA, less than 5 % of private forest owners use programmes such as cost-share initiatives or conservation easements (Butler et al., 2021; Chhetri et al., 2018; Feil et al., 2018; Sass et al., 2023). SPFOs rarely take advantage of financing opportunities. The main reasons for this are a lack of information about the programmes, bureaucratic hurdles and a perceived unattractive cost-benefit ratio (Butler et al., 2021; Feil et al., 2018; Haeler et al., 2023). Haeler et al. (2023) for Finland, Sweden and

Austria and Feil et al. (2018) for Germany show that many forest owners find the programmes too complicated or inappropriate to implement the support.

Furthermore, only about 18 % of forest owners in the USA have used forest extension services in the last five years (Butler et al., 2021). In Germany, this figure is much higher at 56%, but refers to a ten-year period (Feil et al., 2018). In the USA, professional extension services are provided by government service foresters and private consulting foresters, with the former often advising smaller forest owners (Chhetri et al., 2018). In Central and Western Europe, forest owners have a wide range of public, semi-public and private extension services to choose from. Particularly in Western Europe, the importance of private extension services is increasing, while the traditional public extension services are losing influence (Lawrence et al., 2020). In several European countries, including Sweden, Finland, Germany, France, and Belgium, extension services are increasingly shifting from government institutions to private providers and forest owner cooperatives (Lawrence et al., 2020; N-ForB, 2023)

Given these parallels, it appears plausible to hypothesize that the drivers of forest management behavior identified by Floress et al. (Floress et al., 2019) may also be relevant in the context of Central Europe, with Germany serving as case study.

The independent variables identified by Floress et al. for the dependent variable category 'Policy tool participation' are particularly important for this study. Policy tools are understood as instruments through which governments attempt to influence citizen behavior and achieve policy goals, as described by Schneider and Ingram (1990), on whose study Floress et al. (2019) rely. A subcategory of the dependent variable category 'Policy tool participation' is 'Capacity - Networking with professional' (included in Floress et al. (2019), Table 3). Floress et al. (2019) describe this subcategory as 'Communicated with forester or other land management professional'. This description is consistent with the content of the variable in focus of this study, which is SPFOs' contact with professional foresters. The independent variables identified by Floress et al. as relevant to this dependent variable category 'Policy

tool participation’ (included in Floress et al. (2019), Table 8) are listed in Table 1. For the study, these independent variables were divided into five groups.

Table 1

Identified independent variables for the dependent variable category ‘Policy tool participation’ acc. to Floress et al. (2019).

Thematic group	Independent variable	Description
Forest management activities and objectives	Ownership objective (all)	Includes ownership objectives such as protecting nature or diversity, using wood from land, using land for recreational activities, owning land for beauty or non-timber products
Demographic and personal attributes	Absentee landowner	Owner does not reside on land
	Age	Owners age
	Education	Years of education or level of education
	Gender – male	Male gender of owners
	Resides on land	Whether owner resides on land
	Retired	Whether owner is retired
	Years in family	Number of years property has been in a family
Information resources	Policy tools capacity - Received/used information	Owner sought or received marketing/communication about land/forest management
Economic aspects	Management plan	Landowner has forest management plan; refers to management plan
	Land value	Land value
	Parcel size	Total size of parcel or total forested acres
Institutional support	Policy tool participation - Incentive – inducement	Participates in cost-share or tax incentive programs, including programs that apply to their non-forested land

(1) *Forest management activities and objectives*: The ‘Ownership objective’ includes the goals and priorities of a forest owner. These objectives, and corresponding management activities required to achieve them, could influence the type of advice and support needed,

especially if specific objectives require forestry expertise, such as reforestation or applying for subsidies, thereby potentially increasing the likelihood of consulting professional foresters.

(2) *Demographic and personal attributes*: ‘Absentee Landowner’ and ‘Resides on Land’ indicate whether the forest owner lives on the forest property or not. An ‘Absentee Landowner,’ in particular, might reduce interest in active forest management due to the greater physical and psychological distance. However, greater distance could also necessitate professional support due to the challenges of remote management, increasing the likelihood of contacting professional foresters.

Sociodemographic characteristics like ‘Age,’ ‘Education,’ ‘Gender,’ and ‘Retired’ shape a forest owner’s attitudes, knowledge, and behavior. For example, more educated SPFOs might be more informed and open to external expertise, which could increase their propensity to seek professional advice.

‘Years in family’ indicates how long the forest has been owned by the family. A longer ownership period might suggest a deeper emotional bond and greater responsibility, which could lead to a higher likelihood of seeking advice and support from professional foresters to maintain the forest over the long term.

(3) *Information resources*: ‘Policy tool capacity’ reflects the extent to which SPFOs have accessed information about land and forest management. This engagement might increase the likelihood of consulting professional foresters to apply acquired knowledge and optimize management.

(4) *Economic aspects*: The variable ‘Management plan’ indicates the planning basis for sustainable forest management and serves as an indicator of the level of professionalization in forest ownership. Higher professionalization and a structured planning basis could increase the likelihood of forest owners contacting professional foresters for planning and implementation.

'Land value' is an economic factor that represents the monetary worth of the forest to the owner. A higher land value might indicate a greater financial stake in the property, which could increase the likelihood of seeking professional foresters' advice to maximize and possibly enhance that value.

'Parcel size' is another economic factor that impacts management requirements. Larger parcels might require more effort to manage effectively, which could increase the need for professional forester involvement.

(5) *Institutional support*: Involvement in support and incentive programs (referred to as 'Policy tool participation') may be facilitated by professional foresters who assist SPFOs in identifying and applying for suitable programs, which could increase the likelihood of engaging with foresters.

3. Material and methods

3.1. Survey

As a survey instrument for the former study, a standardised questionnaire with closed response categories was developed by Feil et al. (2018), which was derived from the research questions and the *Model for Explaining Human Decision-Making* by Pregernig (1999) based on (Langenheder, 1975). In developing the questions, the main aim was to present sometimes complex forestry and forest policy relationships in generally understandable formulations for private forest owners and the rest of society (which was also surveyed in the course of the previous study) with little knowledge of forests. Questionnaires and response categories from earlier studies (where available) were also taken into account and compatibility checked. The questionnaire was designed to adequately cover all variable groups of the Pregernig (1999) model. Questions were asked with nominal, ordinal or interval response categories. In addition to yes-no questions, Likert scale questions were also used. The final questionnaire for private forest owners consisted of more than 70 questions. The questions related to their own forest ownership, as it was assumed that the majority did not (or could not) recognise and

differentiate between different types of ownership. A version of the questionnaire in English language can be found in Stockmann et al. (2024).

3.2. Sample

The data of Feil et al. (2018) was carried out in 2017 by *Forsa marplan Markt- und Mediaforschungsgesellschaft mbH* (Frankfurt am Main, Germany) in cooperation with *Sinus Markt- und Sozialforschung GmbH*. In order to ensure a systematic and comparable coverage of the target group, a two-stage survey procedure using computer-assisted telephone interviews (CATI) was used. A total of 1,202 private forest owners were interviewed.

Sampling was carried out using the telephone master sample of the *Arbeitsgemeinschaft Deutscher Markt- und Sozialforschungsinstitute* (ADM, 2014). Both simple and multi-stage random samples were used. Private forest owners were defined as persons who are listed as owners or co-owners (e.g. in a community of heirs) of a forest area with a corresponding land register entry in Germany. As this group is comparatively rare in the general population, it was also recruited via the population-representative multi-topic survey *forsa.Omnitel* in order to ensure a sufficiently large sample.

The data were weighted by age, gender, region and education to compensate for bias in the sample and to ensure that the distribution of respondents was as realistic as possible. The weighting was based on the official population update (key date: 31 December 2015) and the 2015 micro-census. For the present analysis, a sub-sample of 1,009 SPFOs with less than 20 ha of forest was selected. Missing information from respondents was systematically coded and taken into account in the analysis. Responses such as 'don't know' or 'no answer' were not included in the statistical calculations to minimise bias. Additional information on the population, sampling procedure, selection plan and sampling can be found in Feil et al. (2018) and Neitzel and Wachenfeld-Schell (2018).

The average age of SPFOs in the subsample of 1,009 respondents is 53 years, with a gender ratio of 63 % men and 37 % women. 85 % of the SPFOs live in rural areas and 65 % are not

employed in the agricultural or forestry sector. Most SPFOs share their forest property with one or two other co-owners. The average size of the forest property is about 3.5 hectares, often fragmented into several plots. The distance between home and forest varies considerably, but is on average 46 km (median: 2.5 km). About 80 % of SPFOs manage their forest themselves or with the help of family members. Only 29 % are members of a FOA and only 12.8 % have taken advantage of public subsidies.

3.3. Variable selection and data transformation

Table 2 provides an overview of the variables selected from the extensive Feil et al. survey, which correspond to the independent variables identified by Floress et al. (2019). In addition to these independent variables, the analysis focuses on the central dependent variable CONTACT, which measures whether or not SPFOs choose to contact professional foresters when making decisions about their forest. The variable is based on responses about whom SPFOs typically consult when faced with various forest management decisions. ‘Professional foresters’ in this context refers to public or private foresters and forest service providers. This is contrasted with contact options such as family members, other forest owners, or management associations who were contacted, as well as the possibility of not seeking contact at all.

To improve the numerical stability of the calculation of the regression coefficients and to ensure that the models can be reliably estimated, the variables AGE, SIZE, DISTANCE, VISIT and DURATION were standardised.

Table 2

Assignment of the survey variables from Feil et al. (2018) to the independent variables according to Floress et al. (2019).

Thematic group	Variable in Floress et al. (2019)	Variable in Feil et al. (2018)	Description
	Policy tool participation	CONTACT	Contact professional foresters when making decisions about the forest
Forest management activities and objectives	Ownership objective	FORESTFUNCTION	Attitude to public vs. private forest function

		CONVERSION	Planted more deciduous trees species in the past 10 years to make the forest more pristine
		ALIENPLANT	Planted alien tree species in the past 10 years to make the forest more diverse
		MAINTENANCE	Cut down single trees (maintain fellings) in the past 10 years to allow other trees to grow
		ZEROLOGGING	Refrained from logging in the past 10 years to preserve the forest for plants and animals only
		KEEPOFF	Kept off the forest in certain areas in the past 10 years to preserve them for plants and animals only
		TIMBERLOGGING	Logged wood for firewood use or furniture production in the past 10 years
		HABITATTREENOTUSE	Not used habitat trees in the past 10 years to permanently preserve them for animals and plants
		TRACKCLEAR	Cleared forest tracks in the past 10 years to make them specifically available to forest visitors
Demographic and personal attributes	Absentee landowner / Resides on land	RESIDENCE	Rural vs. urban residence
		DISTANCE	Distance between forest ownership and owners' residence (in km)
Information resources	Age / Retired Education Gender – male Years in family Policy tools capacity – Received/used information	VISIT	Frequency of forest visits
		AGE	Age
		EDUCATION	Level of education
		PRIMARYSECTOR	(Past) employment in the primary sector
		GENDER	Male gender
		DURATION	Years of forest ownership of the owner
		INTERNET	Internet as a source of information about forests
		MEETING	Internet as a source of information about forests
		JOURNAL	Meetings as a source of information about forests
		TV	Television as a source of information about forests
		RADIO	Radio as a source of information about forests

Economic aspects	Management plan	n.a.	n.a.
	Land value	CASHRELEVANCE	Attitude to the economic relevance of forest ownership
		INCOME	Household income of forest owner
Parcel size		COMPOSITION	Predominant forest type in forest ownership
		SIZE	Size of forest ownership
		FRAGMENTATION	Number of forests parcels of ownership
Institutional support	Policy tool participation	SUBSIDIES	Use of public subsidies in the past 10 years
	Incentive – inducement	FOA	Membership in a forest owner association

(1) *Forest management activities and objectives*: The ‘Ownership objectives’ and associated management activities are represented by the forest management activities collected by Feil et al. (2018). These include objectives such as increasing forest diversity (ALIENPLANT, CONVERSION), protecting and preserving the forest for flora and fauna (ZEROLOGGING, KEEPOFF, HABITATTREENOTUSE), maintaining forest health through selective felling to promote growth of other trees (MAINTENANCE), and timber and recreational usage (TIMBERLOGGING, TRACKCLEAR). These activities support key aspects of sustainable forest management such as wood supply, biodiversity, climate change mitigation and adaptation. Some of these activities are supported by public subsidies. The variable FORESTFUNCTION indicates whether the forest serves a private or public function. The values of FORESTFUNCTION were transformed from Likert scale questions into dimensionless indices on a continuous scale using Principal Component Analysis. This procedure serves two purposes: first, it reduces the number of dummy variables available, and second, it adds more variability to the dataset because the dimensionless index has a continuous scale (Stockmann et al., 2024).

(2) *Demographic and personal attributes*: Since living in the forest in Germany is only possible under certain conditions, the exact variables ‘Absentee landowner’ and ‘Resides on land’ cannot be directly operationalized in this analysis. However, the underlying concepts

that these variables represent can be approximated using data on the place of residence of the SPFOs (RESIDENCE), the distance to the forest property (DISTANCE), and the frequency of forest visits (VISIT). Information on the place of residence of SPFOs as recorded in the municipal register (Destatis, 2017) was used to determine the Degree of Urbanization (European Statistical Office, 2011) and to distinguish between urban, town and rural residences in each location. In addition to the physical distance data (RESIDENCE, DISTANCE), the VISIT variable provides insight into the emotional proximity of the SPFOs to their forest.

The sociodemographic characteristics (AGE, EDUCATION, GENDER) are operationalized in this study exactly as presented in the results by Floress et al. (2019). However, since there is no information about the retirement status of the SPFOs in the dataset, the variable 'Retired' is approximated by AGE to capture this aspect. In addition to the general education of the SPFOs, PRIMARYSECTOR includes the level of agricultural or forestry education. This additional dimension provides a more detailed understanding of how specialized education might influence the likelihood of SPFOs contacting professional foresters.

The variable 'Years in Family' has been adjusted to DURATION in this study to reflect the number of years the current owner has owned the forest property, rather than the time it has been in the family's possession, as the Feil survey does not explicitly provide information on the original content of the variable 'Years in Family'. It is assumed that the relationship between 'Years in Family' and the focus variable of the study remains the same.

(3) *Information resources*: 'Policy Tool Capacity' is represented by variables representing different sources from which SPFOs can obtain information about land and forest management (INTERNET, MEETING, JOURNAL, TV, RADIO).

(4) *Economic aspects*: Information on the variable 'Management plan' could not be extracted from the dataset by Feil et al. (2018), as it was not collected in the survey and therefore cannot be represented in this study.

The variable 'Land value' is represented by three analysis variables: the subjective perception of the economic importance of the forest resource (CASHRELEVANCE), the actual household income of the SPFOs (INCOME) and the predominant tree species in the forest property (COMPOSITION). These variables are included to approximate the economic factor that represents the monetary value of the forest to the owner, as it is assumed that, based on the context of these variables, they can serve as a close representation of the original variable. CASHRELEVANCE is a dimensionless index value constructed using Principal Component Analysis in the same way as FORESTFUNCTION, based on responses to three Likert scale questions. The originally categorical variable INCOME, which includes twelve different income classes, is treated as a continuous variable in the analysis and is therefore descriptively listed accordingly in Table 3.

The variable 'Parcel Size' is represented by the two variables SIZE and FRAGMENTATION. SIZE refers to the total size of the forest ownership, while FRAGMENTATION indicates the number of separate forest parcels under ownership. This dual approach allows for a more nuanced analysis of the economic factors that may influence management requirements.

(5) *Institutional support*: The variable 'Policy tool participation' is represented using public subsidies in the last 10 years (SUBSIDIES) and the membership in a FOA. These variables are used to indicate the propensity of SPFOs to use institutional support services.

3.4. Statistical analysis

To address the research question, a mixed logistic regression model was used to analyze the data set. This model incorporates both fixed and random effects to estimate the probability of a binary outcome, making it particularly useful for accounting for variability between groups in which the survey data is clustered, which might otherwise bias the estimates.

The clustering of data is due to Germany's decentralised political system. As a federal republic, Germany delegates political and administrative responsibilities to its 16 federal states. This also applies to forest extension services, which are under the jurisdiction of the

individual federal states. As a result, there are differences in the structure, financing and implementation of these services for private forest owners. Although forest extension services exist in every federal state, their institutional framework and organisational structure vary. In some states, extension services are provided by the public forest administration, while in others they are provided by private extension service providers or FOAs. These differences have an impact on private forest owners, as access to extension services, quality and public funding schemes vary from state to state.

Including a random effect for each federal state in the mixed logistic regression model helps to account for these structural differences. The use of the random effect is justified because a likelihood ratio test confirmed that the likelihood of contacting a professional forester varied significantly across the federal states. Overall, it shows that these state-specific differences need to be taken into account to avoid biased estimates of coefficients, standard deviations and confidence intervals (Snijders and Bosker, 2012).

Due to the small number of SPFOs who replied in the survey that they had not contacted anyone for extension services ($n = 85$), 'contact no one' could not be included as a separate response category of the variable CONTACT, as the random effect requires a sufficient number of data points for each of the 16 federal states. For this reason, the dependent variable CONTACT distinguishes binary between SPFOs who have contacted professional public or private foresters ('yes') and those who have not ('no'). The response category 'no' includes both SPFOs who have not contacted anyone for extension services at all and those who have contacted non-professional extension providers, such as family members or other forest owners.

All statistical analyses were conducted using RStudio version 4.4.0 (R Core Team, 2021). The mixed logistic regression model, utilizing a cumulative probability function, estimates the likelihood of specific actions based on multiple influencing variables:

$$\text{logit}(P(Y_{ij} = 1)) = \alpha_j + \beta_1 X_{1ij} + \beta_2 X_{2ij} + \dots + \beta_p X_{pij}$$

In this model Y_{ij} represents the binary outcome for small owner i in federal state j , $P(Y_{ij}=1)$ is the probability that a small owner contacts professional foresters, α_j denotes the random intercept for the j -th federal state and $\beta_1, \beta_2, \dots, \beta_p$ are the fixed effect coefficients corresponding to the influencing variables $X_{1ij}, X_{2ij}, \dots, X_{pij}$.

The model parameters were estimated using the maximum likelihood method. A forward procedure using the Akaike Information Criterion (AIC) was used for model selection. For each independent variable the Variance Inflation Factor (VIF) was calculated as a diagnostic statistic to check for possible multicollinearity (Allison et al., 2012).

Different diagnostic statistics were calculated to assess the quality of the model. The marginal R^2 and the conditional R^2 according to Nakagawa and Schielzeth (2013) were used to assess the explained variance. The marginal R^2 indicates the proportion of variance that is explained exclusively by fixed effects, while the conditional R^2 takes into account both fixed and random effects and thus describing the total variance explained by the model.

In addition, the Intraclass Correlation Coefficient (ICC) was calculated to assess what proportion of the total variance is explained by differences between the states. The ICC is a direct measure of the significance of random effects by relating the proportion of variance explained by the grouping to the total variance. Higher ICC values indicate that a relevant proportion of the total variance is due to differences between federal states, suggesting that federal state-specific effects play a role in the likelihood of contacting professional foresters.

The Correct Classification Rate (CCR) was also calculated to assess the predictive performance of the model. It provides an insight into how well the model discriminates between the two categories of the dependent variable - whether SPFOs contact professional foresters or not.

Incomplete data series ($n = 283$) were removed from the sample of 1,009 SPFOs. To ensure this reduction did not introduce bias, the reduced and complete datasets were compared using the Kolmogorov-Smirnov test, revealing no significant differences.

4. Results

This section presents the descriptive and inferential statistical results of the study, focusing on the factors influencing SPFOs' likelihood of contacting professional foresters. Almost two-thirds of SPFOs have contacted professional foresters when making decisions about their forest (CONTACT), while the remaining 36 % have contacted other persons such as family members, other forest owners, or FOA chairs, or contacted no one.

The results are structured according to the five thematic groups introduced with the empirical framework: (1) *forest management activities and objectives*, (2) *demographic and personal attributes*, (3) *information resources*, (4) *economic aspects*, (5) *institutional support*. Within each group, descriptive statistics (Table 3) provide an overview of the distribution of the relevant variables, followed by inferential statistical results (Table 4) that present the key influencing factors within each thematic category.

In addition to these individual determinants, the results also show the (6) *federal state-specific differences* in contacting professional foresters, as determined by the random effects of the mixed logistic regression model. While the five thematic groups mentioned above focus on the different determinants influencing contact with professional foresters, the last section of the results analyses the differences between the federal states.

Table 3

Summary statistics on the variables of the dataset of SPFOs in Germany. Reference categories are underlined. Percentages for categorical variables are based on the number of available responses, with missing values excluded.

Thematic group	Variable	N	Mean/Frequency in %	SD	Min/Max	Scale
	CONTACT	1.009	<u>no</u> : 36.9 % yes: 63.1 %			nominal
Forest management activities and	FORESTFUNCTION	974	-0.02	1.34	-1.96/1.69	interval

objectives	CONVERSION	1.000	<u>no</u> : 56.4 % yes: 42.8 %			nominal
	ALIENPLANT	1.000	<u>no</u> : 85.8 % yes: 13.3 %			nominal
	MAINTENANCE	1.006	<u>no</u> : 25.6 % yes: 74.1 %			nominal
	ZEROLOGGING	1.007	<u>no</u> : 57.8 % yes: 41.1 %			nominal
	KEEPOFF	998	<u>no</u> : 82.5 % yes: 16.4 %			nominal
	TIMBERLOGGING	1.007	<u>no</u> : 31.2 % yes: 68.7 %			nominal
	HABITATTREENOTUSE	989	<u>no</u> : 54.7 % yes: 43.3 %			nominal
	TRACKCLEAR	999	<u>no</u> : 57.4 % yes: 41.4 %			nominal
Demographic and personal attributes	RESIDENCE	1.001	<u>city</u> : 14.7 % town: 32.5 % rural: 51.9 %			nominal
	DISTANCE (km)	984	46.02	131.40	< 0/860	ratio
	VISIT	1.009	4.16	1.90	0/7	ratio
	AGE (Years)	994	52.49	15.08	19/87	ratio
	EDUCATION	1.005	3.21	1.47	1/6	ratio
	PRIMARYSECTOR	986	<u>no</u> : 63.5 % yes: 34.2 %			nominal
	GENDER	1.009	<u>female</u> : 36.6 % male: 63.4 %			nominal
	DURATION (Years)	972	20.30	17.94	0/100	ratio
Information resources	INTERNET	1.004	<u>no</u> : 71.2 % yes: 28.8 %			nominal
	MEETING	1.004	<u>no</u> : 91.1 % yes: 8.9 %			nominal
	JOURNAL	1.004	<u>no</u> : 76.7 % yes: 23.3 %			nominal
	TV	1.004	<u>no</u> : 77.7 % yes: 22.3 %			nominal
	RADIO	1.004	<u>no</u> : 92.3 % yes: 7.7 %			nominal
	Economic aspects	CASHRELEVANCE	991	-0.03	1.18	-1.57/3.82
INCOME		863	7.00	2.69	1/12	ratio
COMPOSITION			<u>mix</u> : 49.8 % deciduous: 26.0 % coniferous: 24.0 %			nominal
SIZE (ha)		1.009	3.47	4.52	0.01/20	ratio
Institutional support	FRAGMENTATION	993	<u>no</u> : 62.5 % yes: 36.6 %			nominal
	SUBSIDIES	992	<u>no</u> : 85.7 % yes: 12.6 %			nominal
	FOA	1.007	<u>no</u> : 70.9 % yes: 28.9 %			nominal

The analysis shows that SPFOs are engaged in various (1) *forest management activities and objectives*. More than half (56.4 %) have planted deciduous instead of coniferous trees

(CONVERSION) to make the forest more pristine. A smaller proportion (13.3 %) had planted alien tree species (ALIENPLANT) to diversify the forest ecosystem. A large proportion (74.1 %) have carried out maintenance activities such as selective felling of individual trees (MAINTENANCE) to encourage the growth of other trees. In addition, 41.1 % have refrained from logging (ZEROLOGGING) to preserve forest areas for wildlife, while 43.3 % have focused on preserving habitat trees (HABITATTREENOTUSE) to protect them for animals and plants. Some SPFOs have restricted access to certain areas (KEEPOFF) to protect nature and support wildlife recovery. 68.7 % harvested timber for furniture and firewood (TIMBERLOGGING) and 41.4 % maintained forest tracks for forest visitors (TRACKCLEAR).

However, the variables TIMBERLOGGING and TRACKCLEAR do not significantly influence the likelihood of contacting professional foresters. The other forest management activities are associated to varying degrees with the likelihood of contacting professional foresters. In contrast, activities such as planting non-native tree species (ALIENPLANT) and planting deciduous trees instead of conifers (CONVERSION) reduce the likelihood of contacting professional foresters. On the other hand, SPFOs who refrain from harvesting trees (ZEROLOGGING) or restrict access to certain forest areas (KEEPOFF) and preserve habitat trees (HABITATTREENOTUSE) show a higher likelihood of contacting professional foresters. Owners who emphasise the social function of their forests (FORESTFUNCTION) are more likely to contact professional foresters.

Table 4

Estimates of the forward selected mixed logistic regression modes on SPFOs' decision to contact professional foresters; SE = standard error. Reference categories are underlined. Significance levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Thematic group	Variable	Coefficient	SE	p-Wert
	Intercept	-2.349	0.704	0.001***
Forest management and objectives	CONVERSION	-0.965	0.278	0.001***
	ALIENPLANT	-2.474	0.394	0.000***
	MAINTENANCE	0.828	0.291	0.004**

	ZEROLOGGING		-0.945	0.271	0.000***
	KEEPOFF		0.967	0.322	0.003**
	HABITATTREENOTUSE		1.024	0.270	0.000***
	FORESTFUNCTION		0.426	0.102	0.000***
Demografic and personal attributes	DISTANCE		-0.201	0.142	0.155
	VISIT		-0.193	0.147	0.190
	AGE		0.608	0.134	0.000***
	EDUCATION		0.239	0.116	0.040*
	PRIMARYSECTOR		0.844	0.270	0.002**
	GENDER	<i>female</i>			
		<i>male</i>	1.190	0.241	0.000***
	DURATION		0.093	0.134	0.485
Information resources	INTERNET		0.767	0.286	0.007**
	MEETING		1.526	0.626	0.015*
	RADIO		-1.064	0.498	0.033*
Economic aspects	CASHRELEVANCE		0.380	0.112	0.001***
	INCOME		0.150	0.052	0.004**
	COMPOSITION	<i>mix</i>			
		<i>coniferous</i>	-0.772	0.285	0.007**
		<i>decidous</i>	-0.409	0.307	0.183
	FRAGMENTATION		0.540	0.250	0.031*
Institutional support	SUBSIDIES		1.146	0.464	0.014*
	FOA		1.010	0.292	0.001***
N			726		
Conditional R ²			0.586		
Marginal R ²			0.427		
ICC			0.278		
CCR			0.693		

SPFOs are characterized by different (2) *demographic and personal attributes*. On average, SPFOs have a secondary education (EDUCATION), with 34 % working or having worked in the primary sector (PRIMARYSECTOR). About 35 % have owned their forest for less than ten years (DURATION), reflecting a mix of newer and more established owners. The majority live in rural or small-town areas (RESIDENCE), with an average distance of 46 km (median: 2.5 km) from their forest property (DISTANCE) and typically visit their forest about every three months (VISIT).

Older SPFOs (AGE) and those with a higher level of education (EDUCATION) are more likely to contact professional foresters. Men (GENDER) and those who have worked or are working in the primary sector (PRIMARYSECTOR) are also more likely to contact professional foresters. The duration of ownership (DURATION), place of residence (RESIDENCE), distance to the forest (DISTANCE), and frequency of visits to the forest (VISIT) have no significant effect on the likelihood of contacting professional foresters.

The internet has a special importance as a (3) *information resource* for SPFOs. Almost one third use the internet (INTERNET) as a source of information about forests ‘every three to six months’ and ‘every six months’, which is more often than any other media. The internet and attending meetings as a source of information about forests (MEETINGS) are shown to be positive predictors of increased contact with professional foresters. In contrast, the use of traditional media such as radio (RADIO) is associated with a lower probability of contacting professional foresters.

The (4) *economic aspects* of forest ownership among forest owners show variability in several areas. The average household income of the owners ranges between EUR 3,000 and EUR 3,500 (INCOME). The subjective perception of the economic importance of the forest (CASHRELEVANCE) shows a balanced view among SPFOs, with some considering the forest economically important and others not. The composition of the owned forests is

diverse, with almost half of the SPFOs having mixed forests, 26 % having deciduous forests and 24 % having coniferous forests (COMPOSITION).

Economic factors influence the likelihood of SPFOs contacting professional foresters. Higher household income (INCOME) and perceived economic importance of the forest (CASHRELEVANCE) are associated with an increased likelihood of contacting professional foresters. Forest owners with mixed forests (COMPOSITION) are more likely to contact professional foresters than those with coniferous forests. The total size of the forest property (SIZE) does not significantly affect the likelihood of contact. In contrast, the number of separate forest parcels (FRAGMENTATION) positively influences this likelihood.

The use of (5) *institutional support* by SPFOs is very limited. Only 29 % of the SPFOs are members of a FOA and only 12 % have used public subsidies (SUBSIDIES). However, both variables are positively related to the decision to contact professional foresters. Thus, those who are members of a FOA or who have received public subsidies are more likely to be in contact with professional foresters.

At least the (6) *federal state-specific differences* in contacting professional foresters are evident, as shown by the results of the random effects of the mixed logistic regression model. The model has an intraclass correlation coefficient (ICC) of 0.278, which means that 27.8 % of the total variance can be explained by differences between the federal states.

5. Discussion

5.1. Factors influencing contact to professional foresters

Forest management activities and ownership objectives

Six of the eight forest management activities considered in this study show that ownership objectives are significantly associated with contact to professional foresters. The variables TIMBERLOGGING and TRACKCLEAR have no effect on the likelihood of contacting professional foresters when controlling for other factors included in the model, suggesting that objectives related to timber and recreational use are not relevant to contacting professional

foresters. This is contrast to previous findings indicating that SPFOs who are supported by foresters are more likely to harvest timber (Chhetri and Pelkki, 2022; Kilgore et al., 2015). The finding in this study could be due to the fact that 69 % of the private forest owners surveyed in the study of Feil et al. (2018) harvested (fire) wood for self-sufficiency, which does not require support from professional foresters. This also explains the lack of effect of the variable TRACKCLEAR: As forest roads are mainly used for firewood transport, major maintenance is rarely necessary. Forest owners could be able to carry out minor maintenance, such as clearing tracks, on their own without the need for professional foresters.

The forest management activities that are positively associated with contact to professional foresters (MAINTENANCE, KEEPOFF, HABITATTREENOTUSE) are those that may require technical knowledge and support or may be part of public subsidy programmes. The positive relationship with the selective felling of individual trees to promote the growth of others (MAINTENANCE) can thus be justified. Almost half of the SPFOs surveyed manage mixed forest enterprises where tree-specific management is crucial due to the high structural diversity and silvicultural complexity of the stands (del Río et al., 2021). This necessity is also underlined by the influence of the variable COMPOSITION, which possibly indicates that mixed forest forestry enterprises require more expertise and contact with foresters than those with pure stands. Furthermore, selective maintenance interventions may also indicate nature conservation objectives, which depend on the attitude of the forest owner and the advice given by the forester (Joa and Schraml, 2020). In this context, it seems unclear whether the forest owner undertakes selective maintenance on his own initiative or only after advice from the forester.

The positive relationship with restricting access to certain forest areas (KEEPOFF) could indicate the establishment of forest cultures that restrict access to the area, e.g. by fencing. This could explain why forest owners who implement such measures are more likely to contact professional foresters due to the technical effort involved. This assumption for the

establishment of fences is supported by the legal framework in Germany, as a general ban on entering the forest can only be imposed with official authorisation - a practice that is rarely used as a rule. Due to the high cost of erecting cultural fences, public funding plays a crucial role, which in turn can reinforce the need to consult professional foresters.

The preservation of habitat trees (HABITATTREENOTUSE) can be positively linked to contact with professional foresters, as public foresters in particular, who are responsible for the implementation of national forest policies and certification systems, emphasise the importance of habitat trees to SPFOs. The possibility of public funding could also play a role. Professional foresters - both public and private - can inform SPFOs about existing funding opportunities and assist them in the application process. However, it remains unclear whether the initiative to preserve habitat trees comes primarily from the SPFOs themselves or through the influence of professional foresters.

The negative relationship between planting deciduous trees instead of conifers (CONVERSION) and contacting professional foresters can be explained by the high proportion of mixed forest owners in the data set (49.8 %). In these stands, the regeneration of deciduous tree species often takes place naturally, so that there is no planting necessary. In general, artificial regeneration methods are cost-intensive and complex (Chudy et al., 2022; Guldin, 2019), which makes them less attractive, especially in small private forests. Karppinen (2005) shows that advice from foresters plays an important role in the choice of regeneration method. Therefore, in German small private forests, especially in mixed forests, professional advice could lead to foresters favouring natural regeneration methods, which would further explain the negative effect of CONVERSION.

The negative relationship between contacting professional foresters and the planting of non-native tree species (ALIENPLANT) could be due to the fact that the planting of non-native tree species instead of native tree species was not considered particularly relevant in small private forests at the time of the 2017 survey. For this reason, no professional foresters were

contacted for this purpose. With the increase in forest damage due to extreme weather events or insect outbreaks, the popularity of these tree species may have changed since then due to possible climate resilience, which could lead to different survey results (Konic et al., 2024; Pötzelsberger et al., 2020).

The decision to refrain from logging (ZEROLOGGING) can be interpreted as a passive measure within the framework of the forest management activities mentioned above. It does not require contact with professional foresters. This could explain the negative relationship between these two variables.

Finally, contact with foresters is primarily sought by SPFOs who highly value the social function of their forests (FORESTFUNCTION). These SPFOs may therefore seek contact with professional foresters to ensure sustainable management, as Hujala et al. (2009) also found for Finnish forest owners.

These results show that various forest management activities and objectives in small private forests are closely linked to contact with professional extension services. However, the analysis does not clearly show whether the forest owners carried out these activities on their own initiative or whether they were encouraged to do so through contact with forestry experts - either based on professional recommendations or to apply for subsidies.

Forest Owner Demographics and Personal Attributes

The positive influence of education level (EDUCATION), employment in the primary sector (PRIMARYSECTOR) and contact with professional foresters can be explained in different ways. Forest owners with a higher level of (forestry) education are more likely to be actively involved in forest management (Bashir et al., 2024; Westin et al., 2023). They are also more likely to favour sustainable management practices (Bashir et al., 2024; Côté et al., 2017; Westin et al., 2023). In addition, they show a greater interest in nature conservation and biodiversity (Bashir et al., 2024; Lidestav and Westin, 2023; Sadowska, 2024; Westin et al.,

2023), which can also be interpreted as pursuing objectives in the forest. Contact with professional foresters in turn leads to greater knowledge and understanding of forest management, which in turn may increase the willingness to such management activities (Eriksson and Fries, 2021; Wilson et al., 2022). This reciprocal relationship between knowledge acquisition and professional advice can thus promote sustainable forest management through the informed and active participation of SPFOs.

The relationship between age (AGE) and contact with professional foresters may be due to limited management capacity of older forest owners (Juutinen et al., 2022). Younger forest owners can be more active in managing their forests (Husa and Kosenius, 2021; Koskela and Karppinen, 2021), while older forest owners are less likely to carry out management activities and sell timber (Chhetri and Pelkki, 2022; Eriksson and Fries, 2020; Pezdevšek Malovrh et al., 2022). This suggests that they are more dependent on professional support due to declining physical capacity. As their ability to carry out forestry operations declines, they may increasingly seek advice and services from professional foresters to compensate for their limitations. On the other hand, this effect could also indicate that younger SPFOs may be less likely to contact professional foresters than older forest owners due to different forest management goals (Husa and Kosenius, 2021).

Regarding the significant positive relationship between male gender (GENDER) and contact with professional foresters, it is noted that a number of studies show that women are less often involved in forest management activities and have less forestry education than men, which, considering the PRIMARYSECTOR result from the previous paragraph, explains why the latter are more often in contact with professional foresters (Butler et al., 2018; Kuhlman et al., 2023). Men tend to have more knowledge and experience in traditional, economically oriented forest management and are more confident in their knowledge, which may make them feel more secure in their decisions (Butler et al., 2018; Eriksson and Fries, 2021; Kuuluvainen et al., 2014), which could lead them to be more likely to come into contact with

professional foresters. Women, on the other hand, show a greater interest in ecological, social and recreational aspects of forest management, such as nature conservation, biodiversity and alternative uses such as tourism or health/rehabilitation (Umaerus et al., 2017). This pattern suggests that existing extension structures do not take into account the preferences and objectives of female forest owners to the same extent, as forestry extension and support programmes are often not specifically tailored to this group (Kuhlman et al., 2023; Mook and Dwivedi, 2022).

The missing or insignificant relationship between duration of forest ownership (DURATION), residence (RESIDENCE), distance to the forest (DISTANCE), and frequency of forest visits (VISIT) with contact to professional foresters suggests that these factors do not play a critical role in the decision to contact professional foresters. Côté et al. (2017) found that Canadian forest owners who have owned their forest for less than 10 years are more likely to live far from their forest, which seems to be consistent with the effect of RESIDENCE and DISTANCE. Long-standing forest owners tend to rely on traditional sources of information such as journals or magazines, while new forest owners are more likely to seek information through informal networks and the internet.

This underlines the importance of peer-to-peer networks and the development of the forestry extension structure via the internet, so that greater distance from the forest owner is not necessarily a barrier to contact with foresters on site. In particular, the internet and social media facilitate access to forestry information and allow forest owners to interact with experts and other forest owners (Lewoń and Pirożnikow, 2019). Peer-to-peer networks play a central role as they build trust and transfer practical knowledge in a practical way (Virkkula and Hujala, 2014). Particularly in forest management decision-making processes, these networks can provide important support by promoting the exchange of experiences and increasing participation in collaborative projects (Kittredge et al., 2013; Stoettner and Ní Dhubháin, 2019; Vainio et al., 2018).

Information Sources

Digital platforms and internet services (INTERNET) offer forest owners the possibility of flexible, location- and time-independent access to knowledge building, which in turn has a positive impact on sustainable forest management (Koliouška and Andreopoulou, 2019; Lewoń and Pirożnikow, 2019; Pynnönen et al., 2021; Słupińska et al., 2022) and thus also a positive effect on contacting professional foresters. The use of the internet and digital platforms for forest management is growing, but they are no substitute for face-to-face communication (Bettinger et al., 2022; Hujala and Tikkanen, 2008; Pynnönen et al., 2021). Government, private and NGO advisors are increasingly using digital tools such as web portals, smartphones and e-newsletters for advisory services (Lawrence et al. 2020). However, challenges exist in the user-friendliness and acceptance of such services, especially among older or less tech-savvy forest owners (Hartikainen, 2021).

However, non-digital information options are necessary for these forest owners, as shown by the preference of the older forest owners studied by Côté et al. (2017), who tend to obtain information from traditional sources such as magazines. These traditional sources may also include information events for forest owners (MEETINGS), which show a positive relationship with contact to professional foresters.

The negative relationship between obtaining information via the radio (RADIO) and contacting professional foresters could be due to the fact that the radio is primarily a passive medium for acquiring knowledge. In contrast to more active forms of information procurement, such as the Internet or participation in forestry meetings, SPFOs may use the radio more casually and do not use it specifically to find out about forestry topics.

Economic Aspects of Forest Ownership

Forest owners who rate the economic value of their forest higher (CASHRELEVANCE) may be more likely to contact professional foresters in order to use their forest in a potentially

economically profitable way. This economic use depends on investments such as reforestation, young stand maintenance or forest conversion, which need to be financed by a corresponding household income (INCOME). This positive relationship between higher income and the use of foresters is confirmed by Zhang and Sun (2013). Sufficient household income is therefore a prerequisite for investment management activities that can be supported by professional foresters. A coniferous dominated tree species composition (COMPOSITION) contributes to the economic profitability of forest management, as coniferous timber has a higher economic viability in many markets (Knoke et al., 2008). At the same time, a high degree of fragmentation (FRAGMENTATION) increases the need for extension services, as the organisational effort required for efficient management increases (Kumer and Slavič, 2016). This may explain the positive impact of fragmented forest ownership and contact with professional foresters. Overall, the results show that economic aspects of forest ownership are important framework conditions for the decision to contact professional foresters.

The missing effect of forest ownership size (SIZE) on contacting foresters is inconsistent with previous publications (Chhetri et al., 2018; Zhang and Sun, 2013). However, in private forests, which tend to be smaller than 20 ha, the size of the forest ownership appears to be too small to have a significant impact on the management activities of SPFOs or their contact with professional foresters (Stockmann et al., 2024).

Institutional support options

The positive relationship between institutional support services (FOA, SUBSIDIES) and contact with professional foresters is consistent with findings from previous studies. Membership in a FOA promotes forest management activities, which in turn are associated with advice from foresters (Khanal et al., 2020; Lidestav and Westin, 2023; Zhang and Sun,

2013). Similar to FOA, the use of public subsidies (SUBSIDIES) increases the likelihood of seeking professional advice and implementing sustainable management (Haeler et al., 2023).

Unfortunately, the cause and effect relationship between institutional support services and contact with professional foresters cannot be clearly identified. One reason for this is that many FOAs are managed by professional foresters. As a result, contact with a forester is often automatic, even if the forest owner does not actively seek one. Applications for public funding are also made through the forestry authorities. Contact with a forester is therefore inevitably made through the application for funding. Conversely, professional foresters can also specifically encourage forest owners to apply for funding, which increases the likelihood of an application.

Finally, it should be mentioned that despite the positive relationship between institutional support and contact with professional foresters, participation rates are low both for membership in an FOA and for the use of public subsidies. On the one hand, lack of information about the programmes, bureaucratic hurdles and a perceived unattractive cost-benefit ratio are barriers to uptake, as forest owners perceive the programmes as too complicated or unsuitable for implementing the subsidies (Feil et al., 2018; Haeler et al., 2023; Quiroga et al., 2019). On the other hand, FOAs mainly reach an economically oriented, traditional forestry clientele that is primarily focused on timber production and less on ecosystem goals (Stockmann et al., 2024). Many small forest owners, especially women and younger people, do not see their forest primarily as an economic resource, but rather have recreational, nature conservation or family motives, which do not coincide with the main goals of many forest owner associations or forestry extension services (Butler et al., 2018; Hrib et al., 2018; Umaerus et al., 2017).

Federal state-specific differences

The results of the analysis show significant state-specific differences in contact with professional foresters, which is confirmed by the random effects of the mixed logistic regression model. The calculated ICC of 0.278 shows that 27.8 % of the total variance can be explained by differences between the federal states. This underlines that, in addition to individual determinants, structural and institutional factors at the federal state level may play an important role in the probability of contact with professional foresters.

Possible explanations for these differences can be found in the structure of forest advisory services, the funding landscape and regionally specific framework conditions. The federal states differ considerably in their forestry infrastructure, the availability and organisation of extension services, and the support provided to private forest owners. In addition, financial support and funding programmes for extension may have an important impact. Differences in access to finance or dependency on specific memberships in forest owner associations could influence the likelihood of contacting professional foresters (N-ForB, 2023).

This study can only show that there are significant differences between the German federal states. Based on the data used, no conclusions can be drawn about the effects of different framework conditions within these federal states. This should be investigated in more detail in future studies.

5.2. Model validation

The quality of the model was assessed using several indicators. The marginal R^2 (0.427) indicates the proportion of variance explained by the fixed effects, while the conditional R^2 (0.586) also takes into account the variance explained by the random effects, in this case the federal states (Nakagawa and Schielzeth, 2013). These values show that a considerable part of the variance is explained by the model factors, although regional differences also play a role. The CCR of 69.4 % indicates how well the model distinguishes between the two characteristics of the dependent variable - contact or no contact with professional foresters (Cameron and Trivedi, 2005). The CCR is thus slightly below the level of comparable studies,

which reported values between 73 % and 78 % (Stockmann et al., 2024) and 77.4 % and 83 % (Joshi and Arano, 2009).

5.3. Limitations

The present study shows a simultaneity in the relationship between contact with professional foresters and the implementation of forestry measures by forest owners. It remains unclear whether forest owners first plan measures and then contact foresters, or whether contact with foresters first initiates implementation. This interdependence makes it difficult to determine cause and effect. To better address this problem in future analyses using cross-sectional data, instrumental variable estimation models could be used. By choosing appropriate exogenous instruments that influence contact with foresters but are not directly related to forest management activities, the direction of causality may be more precisely examined and endogeneity bias reduced.

The analysis of this study is based on the influencing variables identified by Floress et al., which were derived from a meta-analysis of the literature on American forest owners. Many of the factors identified there were also confirmed to be relevant for German SPFOs. However, it should be noted that Floress et al. did not explicitly consider studies on forest owners with less than 20 ha, which corresponds to the definition of SPFOs in Germany. Therefore, it cannot be excluded that in addition to the variables identified by Floress et al. and confirmed in this study, there are other relevant factors influencing the contact with professional foresters in small private forests. For example, Hujala & Tikkanen (2008) show that trust in professional foresters has a significant impact on contact, which should be taken into account in future studies. In addition, the variable 'Management plan' was not considered in the present study because the data was taken from the dataset of Feil et al. (2018). Floress et al. (2019), however, found in two studies that this variable has a significant positive influence on 'Policy tool participation', such as communication with professional foresters. Future survey studies could be designed within a clearly defined theoretical framework to

systematically analyse the decision-making processes of SPFOs and to identify other factors influencing contact with professional foresters. One approach would be to apply the *Theory of Planned Behaviour* (Ajzen, 1993) as it explains how attitudes, subjective norms and perceived behavioural control influence behaviour. This theory may help to better understand the role of trust in foresters. In addition, variables that were represented by proxies in this study could be collected directly in future studies. For example, the variables 'Absentee landowner' and 'Retired' could be collected directly, and 'Management plan', based on the results of forest management planning, and 'Land value' could also be explicitly included in future surveys.

Due to the limited number of forest owners who indicated that they had not contacted anyone for extension services ($n = 85$), this category could not be included separately in the CONTACT variable, as the random effect requires a sufficient number of data points per federal state. Consequently, CONTACT was defined as a binary variable, distinguishing between those who have contacted professional public or private foresters ('yes') and those who have not ('no'). The 'no' category includes both forest owners who did not contact a professional forester and those who contacted non-professional advisors, such as family members or other forest owners. However, this aggregation can mask differences within the 'no' group, which could for example be explored in future studies using hierarchical Bayesian models or regularisation methods.

A significant part of the explainable variance in contact with professional foresters can be attributed to state-specific differences. However, as the data collection does not provide detailed information on structural and institutional differences between the federal states, it is not possible to interpret these effects further. This is an important limitation of the study, as factors such as the organisation and financing of forest extension, the institutional integration of foresters (e.g. public or private) and the use of public subsidy programmes may influence the use of professional advice. Future studies should therefore specifically examine how extension services differ between the federal states in terms of structure, financing and

accessibility, and what influence these factors have on the utilisation of extension services. It could be analysed whether different factors play a role in federal states with privately organised extension structures than in federal states with predominantly public extension services. It could also be investigated whether differences in the availability and use of public subsidies influence contact with foresters. At the time of data collection, no research findings on the differences between the federal states on a national level were available, so that the differences identified between the federal states, although they were found to be significant, could not be analysed in detail.

An important point when interpreting the results is the timeliness of the data collected by Feil et al. in 2017. Since then, the conditions for forest owners in Germany and large parts of Europe have changed considerably. Extreme weather events, such as droughts, storms and bark beetle outbreaks, have fundamentally changed the framework conditions for forestry and may also have changed the willingness of forest owners to contact professional foresters. In addition, awareness of climate change and its effects on forests has increased significantly in recent years, which could lead to new demands on forest management and changes in the demand for extension services. As these developments are not reflected in the data set, the results should be interpreted with caution. Regional differences in adaptation to these changing environmental conditions need to be taken into account, especially when comparing across Europe. A more recent survey could therefore lead to different conclusions, especially with regard to the importance of forest management extension services and the decision-making patterns of forest owners in the context of changing climatic and political conditions.

6. Conclusions

There is little research in Europe on extension services and their use by private forest owners. This study aims to contribute to filling this research gap. For the German case study, characteristics of SPFOS associated with contact with professional foresters were identified. The results show that in addition to the management activities of SPFOs, their demographics,

information sources, economic aspects and institutional support are significantly associated with contacting professional foresters. However, it was found that not all forest owner groups can be reached equally through contact with professional foresters.

The results show that SPFOs have heterogeneous objectives. However, it is not clear to what extent these objectives influence the contact with professional foresters, or whether the contact itself contributes to the formulation of certain objectives. There is an interaction between the forest management activities of forest owners and the and the contact with professional foresters. In order for forest owners to make informed decisions about the management of their forest, it is important that they are able to clearly formulate their own objectives. Forest extension services should therefore actively incorporate the owners' needs and motivate them to implement appropriate measures (Hokajärvi et al., 2011; Virkkula and Hujala, 2014).

The analysis shows age and gender differences in the use of forest extension services. Women and younger SPFOs are less likely to contact professional foresters and often have different forestry interests than male or older SPFOs. This suggests that existing extension structures should be better adapted to the needs of different target groups. The focus of many extension services is on sustainable timber production, while other ecosystem services such as recreation or carbon storage are often neglected (Winkel et al., 2022). This leads to a mismatch between the needs of forest owners and the services provided (Hujala and Tikkanen, 2008; Umaerus et al., 2017). More customer-oriented advice is therefore crucial to target different groups of forest owners, such as younger forest owners, women, and forest owners from different social backgrounds (Hujala et al., 2013; Kuhlman et al., 2023; Mook and Dwivedi, 2023; Stockmann et al., 2024).

The results highlight the importance of digital platforms and informal knowledge networks. For example, attending forestry events or using the internet as a source of information increases the likelihood of contacting professional foresters. This suggests that network

effects play a central role in the dissemination of advice and knowledge (Crowley et al., 2019). Younger forest owners and those with little previous forestry experience could be better reached through targeted online training or peer-to-peer platforms. Regional forest owner meetings could also make a valuable contribution to face-to-face dialogue between forest owners.

Institutional support, such as public subsidies or membership in a FOA, is intended to provide economic support to SPFOs, enabling them to manage forests. The study shows that economic factors have a significant and positive influence on contact with professional foresters and thus on the implementation of forestry measures. Against this background, it is all the more remarkable that institutional support plays a beneficial role but is actually used by only a small proportion of SPFOs. This points to structural barriers that make it difficult to access these support instruments. Complex application procedures and bureaucratic hurdles may deter many potential applicants. A simplification of procedures, a more targeted approach to forest owners and a better interlinking of advisory and funding programmes could help to increase the use of institutional offers and improve their effectiveness. In addition, FOAs should adapt their thematic focus and communication more to the different interests and information habits of non-classical forest clientele in order to enable broader participation (Stockmann and Franz, 2024).

The development of flexible, digital and target group-oriented extension services has the potential to improve the effectiveness of existing counselling services. However, there is a need for further research to validate and generalise national and international implications and to place the results on a broader empirical basis. As there is currently no comprehensive national data on regional differences in the extension services offered by the individual German federal states, further research should focus on systematically recording these differences to enable more precise research into extension services at state level. In addition,

further studies in (Central) Europe should be encouraged to validate the interpretation of the results beyond state borders.

CRedit authorship contribution statement

Johannes Stockmann: Conceptualization, Methodology, Software, Formal Analysis, Investigation, Data Curation, Writing - Original Draft, Writing - Review and Editing. **Kristin Franz:** Writing - Review and Editing, Supervision, Project Administration.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The data presented in this study can be found in Feil et al. (2018).

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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