ForestPaths

Co-designing holistic forest-based policy pathways for climate change mitigation

D1.3 Decision rules, parameters, and narratives for modelling

20/01/2025

Authors: Diana Feliciano, Florencia Franzini, Mart-Jan Schelhaas, Emmi Haltia, Valentina Bacciu, Silvester Boonen, Sara Filipek, Liina Häyrinen, Marcus Lindner, Alessio Menini, Nieberg, M., Chidiebere Ofoegbu, Mikko Peltoniemi, Tudor Stancioiu, Igor Staritsky, Sara Uzquiano, Hinke Wiersma

Contributors: Thomas Nord-Larsen, Vivian Kvist-Johanssen, Leen Govaere, John Redmond, Rasmus Astrup, Andrzej Talarczyk, Neroj Bozydar, Emil Cienciala, Brigitte Rohner, Golo Stadelmann, Jonas Fridman

Funded by the European Union

This project receives funding from the European Union's Horizon Europe Research and Innovation Programme (ID No 101056755), as well as from the United Kingdom Research and Innovation Council (UKRI). Views and opinions expressed are those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the EU nor the EC can be held responsible for them

Prepared under contract from the European Commission and the United Kingdom Research and Innovation Council.
Grant agreement No. 101056755
EU Horizon Europe Research and Innovation Action

Project acronym:	**ForestPaths**
Project full title:	**Co-designing Holistic Forest-based Policy Pathways for Climate Change Mitigation**
Project duration:	01.09.2022 – 28.02.2027 (54 months)
Project coordinator:	Dr. Hans Verkerk, European Forest Institute (EFI)
Call:	HORIZON-CL5-2021-D1-01
Deliverable title:	Decision rules, parameters, and narratives for modelling
Deliverable n°:	D1.3
WP responsible:	WP1
Nature of the deliverable:	Report
Dissemination level:	Public
Lead partner:	TEES
Recommended citation:	Feliciano, D., Franzini, F., Schelhaas, M.J., Haltia, E., Bacciu, V., Boonen, S., Filipek, S, Häyrinen, L., Lindner, M., Menini, A., Nieberg, M., Ofoegbu, C., Peltoniemi, M., Stancioiu, T., Staritsky, I., Uzquiano, S., Wiersma, H. (2025). Decision rules, parameters, and narratives for modelling. ForestPaths project deliverable D1.3.
Due date of deliverable:	Month n°22
Actual submission date:	Month n° 27

Deliverable status:

Version	Status	Date	Author
1.0	First version	18 November 2024	Diana Feliciano, TEES
	Review		Thomas Pugh and Hans Verkerk
2.0	Final version	20 January 2025	

Contents

Key take-away messages

- Analysis of repeated National Forest Inventory data reveals three broad harvesting types in Europe. The first type is connected to the dominant clearcut system in Scandinavia and the intensive plantations along the Atlantic coast. The second type is characterized by low management intensity in areas with severe restrictions due to climate and/or topography, such as Alpine and Mediterranean regions. The third type contains a variety of silvicultural systems in the Atlantic and Continental zones in Western and Central Europe, like multi-purpose forests in densely populated areas as well as production forests with long rotations. Within these broad types, there is considerable country-by-country variation.

- Analysis of a large-scale survey in 13 European countries resulted in the development of a forest practitioner typology that classify owners based on their values towards different forest management objectives. The typology resulted in five distinct groups dubbed *environmentally conscious passives*, *environmental implementers*, *traditionalist*, *maximisers*, and *societal satisfiers*.

- *Environmentally conscious passives* place importance on RES objectives *Environmental implementers* place importance on RES objectives, the opinion of forestry networks, and the usefulness of market mechanisms. *Traditionalist* place importance on RES objectives and the opinions of society. *Maximisers* place importance on income objectives and the usefulness of market mechanisms. Lastly, *societal satisfiers* place importance on amenity objectives, the opinions of forestry networks, and the opinions of society.

- According to the survey findings, country differences explain most of the variations in earlier CBS activities applied by forest owners. Forest practitioner typology or other explanatory variables included in the models were mainly unable to explain differences in the past implementation of the presented activities. These country differences may be related, for example, to geographical conditions, traditions, management guidelines, or differences in forest product markets.

- Forest practitioners participating in the workshops in the 4 Demo cases agreed that increasing mixed tree species, leaving deadwood in the forest, reduce deer/moose population were the suitable climate and biodiversity forest management practices. Other CBS forest management practices highlighted include planting fast-growing species such as Douglas fir (The Netherlands), the use of the principle of sustained yield to ensure continuous presence of all stages of development (Romania), active management and implementation of fire breaks (Sardinia, Italy), or continuous cover forestry for forest regeneration (Finland).

- Unique factors found in the Demo Cases reemphasise the need to consider context when designing policies and schemes to promote the implementation in CBS forest management. For example, the role of traditional knowledge in adaptation to fire risk was highlighted as very important in Sardinia (Italy), while in Finland tradition was seen as a barrier for climate change adaptation.

- Current policies were unanimously considered as the main factor constraining the implementation of CBS forest management by participants in workshops in the 4 Demo Cases.

Summary

This deliverable reports the findings from three activities undertaken in WP1, namely a large-scale survey (T1.2.3), workshops in 4 Demo cases to exchange knowledge and co-design climate and biodiversity forest management practices (T1.2.2), and the analysis of repeated NFI data to derive forest management approaches (T1.1.2). In this deliverable the summaries of findings for narratives, decision rules and parameters for modelling are described.

The survey targeted forest practitioners across Europe to elicit information about (i) forest holdings, (ii) ongoing forest management activities, (iii) forest practitioners' views on forest management activities, and (iv) forest owners' views on financial compensation towards alternative climate and biodiversity smart forestry practices. In this survey research, forest practitioners were defined as individuals who either own a forest or manage a forest or segment of a forest on behalf of a public or private entity. The survey was deployed through a polling agency across thirteen European countries: Croatia, Czechia, Finland, France, Germany, Italy, Latvia, the Netherlands, Romania, Spain, Switzerland, Sweden, and the United Kingdom (n=2151). The survey responses were analysed by developing five forest practitioner typologies through K-means clustering. The resulting groups were profiled using multivariate statistics, chi-squares, and descriptive statistics. Analysis of a large-scale survey in 13 European countries resulted in the development of a forest practitioner typology that classify owners based on their values towards different forest management objectives. The typology resulted in five distinct groups dubbed environmentally conscious passives, environmental implementers, traditionalist, maximisers, and societal satisfiers.

This deliverable reports findings from the workshops with forest owners, managers, and local forestry experts conducted in the four Demo Cases, namely Italy, Finland, Romania, and The Netherlands, to exchange knowledge about their perceptions on suitable Climate and Biodiversity (CBS) forest management practices and on climate change risks and impacts for the forest sector, as well as to better understand the factors constraining and enabling the implementation of CBS forest management in specific contexts. Forest

practitioners participating in the workshops in the 4 Demo cases considered that increasing mixed tree species, leaving deadwood in the forest, reduce deer/moose population were suitable climate and biodiversity forest management practices for their regions because these are already being implemented and less implementation barriers exist. Other CBS forest management practices include planting fast-growing species such as Douglas fir (The Netherlands), the use of the principle of sustained yield to ensure continuous presence of all stages of development (the shifting steady-state mosaic) (Romania), active management and implementation of fire breaks (Sardinia, Italy), or continuous cover forestry for forest regeneration (Finland). There was a consensus among the workshop participants about the increasing risks of climate change and about the observed impacts of climate change in the forest. Current policies were considered as the main factor constraining the implementation of CBS forest management by workshop participants.

Finally, the deliverable reports on the annual probability of thinning and clear-felling by country and biogeographic region. This was estimated by analysing repeated NFI data in more detail aiming at extracting the required parameters for the rule-based harvesting module of EFISCEN-Space. The analysis reveals three broad harvesting types in Europe. The first type is connected to the dominant clearcut system in Scandinavia and the intensive plantations along the Atlantic coast. The second type is characterized by low management intensity in areas with severe restrictions due to climate and/or topography, such as Alpine and Mediterranean regions. The third type contains a variety of silvicultural systems in the Atlantic and Continental zones in Western and Central Europe, like multi-purpose forests in densely populated areas as well as production forests with long rotations. Within these broad types, there is considerable country-by-country variation. In this deliverable the summaries of findings for narratives, decision rules and parameters for modelling are described.

List of abbreviations

CBS	Climate and biodiversity smart
EU	European Union
NFI	National Forest Inventory
SEM	Structural equation model
TRA	Theory of Reasoned Action
TPB	Theory of Planned Behaviour
QMD	Quadratic mean diameter

1 Introduction

WP1 investigates current and alternative Climate and Biodiversity-Smart (CBS) forest management approaches across Europe and what factors influence forest owners and practitioners' (e.g., managers on behalf of someone else) decisions. This deliverable report is the output of Task 1.3 *Synthesizing forest management narratives for modelling*, which integrates results from Task 1.1 and 1.2 and builds on the two previous deliverables D1.1 Forest management approaches across Europe and D1.2 Key factors influencing forest practitioners' decisions. It describes parameters for the forest practitioners' management objectives, developed in Task 1.2. It also reports on forest owners and practitioners' decision-making behaviour and the willingness to adopt improved CBS management based on information from survey results. Contextual barriers and enablers for CBS forest management were assessed through workshops with forest owners, managers, and local forestry experts conducted in the four demo cases: Italy, Finland, Romania, and The Netherlands. The typology and the results on decision making behaviour informs agent-based modelling in WP3 and outline narratives and management parameters for the analysis of improved CBS forest management scenarios in WP5 and WP6.

In this report, the data collection and analysis methods used in the survey are presented as well as the results from the survey, including the updated forest practitioner typology and the behavioural models for the forest practitioner typologies derived from survey results are presented in Chapter 2. Chapter 3 presents synthesized information on management decisions derived from NFI data. Findings from workshops carried out in the demo cases, including options for improved CBS management identified by local stakeholders as well as contextual barriers and enablers for implementation are presented in Chapter 4. Finally, Chapter 5, summarises the information to provide narratives for the modelling exercises in WP3 and scenario design in WPs 5 and 6.

2 Parameters for factor shaping forest management behaviour

A cross-country survey targeting forest practitioners was designed in collaboration between three EU Horizon projects: Forwards, ForestPaths, and HoliSoils. As all three projects included tasks related to surveying forest practitioners to better understand their perceptions towards forest management practices, a strategic decision was made to combine the efforts of the projects. As a result, this collaboration permitted the ForestPaths project to cover additional countries besides the four demo countries and thereby improving the coverage and diversity of forest practitioners (includes forest owners and managers on behalf of someone else) across Europe.

This chapter describes the survey objectives, survey design, and survey data analysis relevant to the ForestPaths project. The ForestPaths objectives for the survey were threefold: 1) to test and measure drivers underpinning forest management behaviours of European forest practitioners identified in ForestPaths Deliverable 1.2 (Franzini et al. 2023), 2) to test whether the forest practitioner typologies proposed in ForestPaths Deliverable 1.1 (Feliciano et al., 2024) were a suitable framework for classifying respondents, and 3) to develop rules, narratives, or parameters to support model development in WP4.

2.1 Survey design

The forest practitioner survey was partitioned into five sections designed to elicit information about (i) the forest practitioners and their forest holdings, (ii) ongoing forest management activities across Europe, (iii) forest practitioners' perceptions towards their forest management practices, (iv) forest practitioners' views on CBS forest management practices, and (v) basic demographic questions. The forest practitioner questionnaire is available in Annex A. Forest practitioners include forest owners and forest managers on behalf of someone else.

2.1.1 Theoretical framework

Section (iii) of the survey included questions measuring various behavioural factors underpinning the forest management behaviours of European forest practitioners. There are a variety of competing behavioural theories positing which behavioural factors lead individuals to engage in behaviour. This study employs the theory of planned behaviour (TPB), an extension of the theory of reasoned action (TRA)[1] (see: Fishbein and Ajzen, 2010). TPB was selected given its extensive empirical validation and use across multiple disciplines (e.g., see Bosnjak et al., 2020) including forestry (Karppinen and Berghäll, 2015).

The TPB posits that an individual's *intention* to engage in a behaviour is directly driven by three dimensions: *attitude*, *subjective norm*, and *perceived behavioural control*. *Attitude* measures whether the individual perceives the behaviour as positive or negative. A positive attitude towards a behaviour means the individual is more likely to engage in the behaviour (and vice versa if the attitude is negative). *Subjective norm* measures whether the individual perceives that other societal groups are in Favor of the behaviour. If the individual perceives that societal groups view the behaviour favourably, then the individual is more likely to engage in the behaviour. *Perceived behavioural control* measures whether the individual believes they can carry out the behaviour in question.

[1] For further discussion on differences between TPB and TRA see: Ajzen (2020)

All three dimensions are formed according to an individual's salient beliefs. Salient beliefs represent the underlying reasons as to why an individual may or may not intend to engage in a behaviour. *Attitude* is determined by *behavioural beliefs* (b_ie_i), the individual's positive or negative evaluation (e_i) of different outcomes associated with the behaviour (b_i). For example, if a forest practitioner believes their forest management objectives will result in climate change mitigation, and climate change mitigation perceived as a positive outcome, then this outcome contributes to the formation of a positive attitude. *Subjective norm* is determined by *normative beliefs (*n_im_i*)*, the individual's beliefs about whether different societal groups (m_i) would evaluate the behaviour positively or negatively (n_i). For example, if family members are important to the forest practitioner and the family members are perceived to disapprove of the behaviour, then the individual's intention to perform the behaviour is weakened (and vice versa). *Perceived behavioural control* is determined by *control beliefs* (c_ip_i), the individual's evaluation of access (p_i) to resources (c_i) required to carry out the behaviour in question. For example, if a forest practitioner requires skilled labourers to implement their management objectives but believes they will not have access to this resource, then the intention to perform the behaviour is weakened (and vice versa).

2.1.2 Measurement scale development

2.1.2.1 Theory of planned behavior

In this study, the behaviour in question is "the implementation of the forest practitioner's forest management objectives". Establishing the behaviour is critical towards question formulation and achieving *Intention* is measured by a three Likert-scale statements asking the respondent about their intention to the implement their forest management objectives.

Behavioural beliefs (b_ie_i), normative beliefs (n_im_i), and control beliefs (c_ip_i) are each measured through a composite multiplying two belief factors (see equation: [1], [2], [3]). There are six belief measures: strengths of a belief (b_i), belief evaluation (e_i), strength of normative beliefs (n_i), referent's significance to the individual (mi), strength of control beliefs (c_i), perceived power of control beliefs (p_i). These belief factors are operationalized in the survey through a series of questions. Table 2.1 describes how intention and each belief factors was formulated into a question in the survey, the scale used to measure the question, and the response choice when answering the question (for more information on developing a TPB Questionnaire, see Fishbein and Ajzen, 2010: Appendix).

$$b_i \times e_i = b_ie_i \quad \text{[eq. 1]}$$
$$n_i \times m_i = n_im_i \quad \text{[eq. 2]}$$
$$c_i \times p_i = c_ip_i \quad \text{[eq. 3]}$$

Table 2.1. Formulation of the belief factor questions in the survey. For more information on developing a TPB Questionnaire see (Fishbein and Ajzen 2010: Appendix).

Belief Factors	Measurement Question	Scale	Response choices
b_i	How important do you find the following forest management objectives?	1 to 6	Extremely important / Not at all important
e_i	To what extent do you believe that implementing your forest management objectives will lead to the following outcomes?	-3 to 3	Highly likely / Highly unlikely
n_i	To what extend do you think that the following individuals would approve or disapprove of the implementation of your forest management objectives?	-3 to 3	Strongly approve / Strongly disapprove
m_i	How important are the opinions of the following individuals regarding your decision to implement your forest management objectives?	1 to 6	Extremely important / Not at all important
c_i	How important would access to the following resources be for implementing your forest management objectives?	1 to 6	Extremely important / Not at all important
p_i	What do you think is the likelihood that you will have sufficient access to the following resources?	-3 to 3	Highly likely / Highly unlikely
Int_1	I anticipate I will implement my forest management objectives.	-3 to 3	Strongly agree / Strongly disagree
Int_2	I intend to implement my forest management objectives.	-3 to 3	Strongly agree / Strongly disagree
Int_3	I want to implement my forest management objectives.	-3 to 3	Strongly agree / Strongly disagree

While Table 2.1 describes how the belief factors were operationalized in the survey, what is not displayed is the content following each question. For example, take question b_i which asks, "*How important do you find the following forest management objectives?*". This question cannot be answered without a follow up statement. Hence, following the questions presented in Table 2.1, a list of follow up statements are provided to the respondent. The follow up statements represent salient beliefs (i.e., the underlying reasons as to why an individual may or may not intend to engage in a behaviour).

Fishbein and Ajzen (2010) argue that only "salient beliefs" should be included in a survey. Saliency is achieved by searching for the topics that most readily come to mind to the largest number of respondents in the target population (ibid, pg. 98). As per Fishbein and Ajzen (2010), determination of salient topics was established through an elicitation interview study described in ForestPaths Deliverable 1.2 (Franzini et al., 2024). The study included 19 interviews with forest practitioners across 6 different countries. Beliefs about total of 17 behavioural outcomes, 8 referent societal groups, and 8 resources were selected for measurement in the survey. Table 2.2 describes the salient beliefs selected for developing the different statements in the questionnaire. The full list of statements is available in Annex A: Q22, Q23, Q35, Q26, Q28, Q29.

Table 2.2. Salient beliefs established in the elicitation study according to their respective belief measurement.

Behavioural belief topics (b_ie_i) – different types of key outcomes associated with implementing the behaviour (i)					
1	Timber income	7	Forest access	13	Climate change mitigation
2	WFP income	8	Forest safety	14	Biotic disturbances
3	Service income	9	Forest beauty	15	Abiotic disturbances
4	WFP production	10	Biodiversity habitats	16	Cultural heritage
5	Timber production	11	Soil quality	17	Traditional knowledge
6	Recreation	12	Water quality		
Normative belief topics (n_im_i) – different types of key referent groups (i)					
1	Family	4	Public	7	Local forest authority
2	Friends	5	Other owners	8	National forest authority
3	Neighbours	6	Forest owner association		
Control beliefs topics (c_ip_i) – different types of resources (i)					
1	Manual labour	4	Credit or loans	7	Market schemes
2	Technology	5	Advisory services	8	Voluntary agreements
3	Infrastructure	6	Subsidies or grants		

2.1.2.2 CBS forest management questions

The survey included questions about the implementation of certain forest management activities that were, together with experts, defined to be CBS forest activities that could be implemented in most European countries. These activities included: leaving deadwood in the forest, continuous cover forestry, retention trees, implementing buffer strips adjacent to water bodies, lengthening the rotation period, leaving logging residues, and applying continuous cover forestry on peatlands (activity asked only in Finland, Latvia and Sweden) (see Annex A: Q32). Earlier studies have used similar question types to analyse the use of a large set of different forest management activities in several European countries (Westin et al., 2023) or forest owners' willingness to manage their forest for climate change and biodiversity in Finland (Husa and Kosenius, 2021).The CBS management questions were presented only for those respondents who had indicated that they were forest owners, not practitioners managing forests owned by someone else. The questionnaire described the activity, and the question was if the respondent had ever intentionally implemented the CBS activity described in their forest. The response options were "Yes", "No", "This activity cannot be implemented in my forest", and "I don't know".

2.2 Survey deployment

The survey was distributed by a polling agency to panellist located across thirteen European countries: Croatia, Czechia, Finland, France, Germany, Italy, Latvia, the Netherlands, Romania, Spain, Switzerland, Sweden, and the United Kingdom. Countries were selected on the basis that they represent the demo-case countries in the ForestPaths, Forwards, and Holisoils project – in addition, the combined surveying efforts among the projects also allowed the inclusion of Croatia, Czechia, and France. It was impossible to guarantee that the panellist would represent the views of forest practitioners, therefore the survey required panellist to identify whether they (i) own a forest, (ii) manage a forest on behalf of a public or private entity, (iii) both, or (iv) none of the above. Respondents classified as "both" were routed to complete the survey from the perspective of a forest owner. Respondents that selected "none" were not classified as forest practitioners and omitted from taking the survey. The breakdown of respondents by country and forest practitioner type is found in Table 2.3.

Table 2.3: Country breakdown of respondents according to forest practitioner type and country where forest is located.

Forest location	Private owner		Public Manager		Private Manager		Manager and Owner		Total
	n	%	n	%	n	%	n	%	
Croatia	230	0.70	31	0.09	49	0.15	18	0.05	328
Czechia	106	0.59	29	0.16	27	0.15	19	0.10	181
Finland	179	0.62	7	0.02	45	0.15	60	0.21	291
France	62	0.60	17	0.17	15	0.15	9	0.09	103
Germany	61	0.51	17	0.14	21	0.18	20	0.17	119
Italy	36	0.56	8	0.13	13	0.20	7	0.11	64
Latvia	189	0.51	63	0.17	95	0.25	26	0.07	373
The Netherlands	4	0.16	9	0.36	10	0.40	2	0.08	25
Romania	187	0.70	35	0.13	27	0.10	17	0.06	266
Spain	29	0.39	22	0.30	15	0.20	8	0.11	74
Sweden	106	0.75	5	0.04	22	0.15	9	0.06	142
Switzerland	57	0.52	16	0.15	22	0.20	14	0.13	109
United Kingdom	22	0.29	20	0.26	25	0.33	9	0.12	76
Total	1268	0.59	279	0.13	386	0.18	218	0.10	2151

2.3 Survey data analysis

The analysis undertaken in the survey research consisted of various statistical techniques for the purpose of i) developing a forest practitioner typology, ii) characterizing differences between members of the forest practitioner typology, and iii) assessing how respondent characteristics influence the likelihood of engaging in CBS forest management activities.

2.3.1 Forest practitioner typology development

There are a various methods for segmenting and classifying forest practitioners into typologies (see: Ficko et al. 2019: Table 2, Ekström et al., 2023). One approach is using survey data measuring the forest practitioner's perceived importance towards different forest management objectives as a clustering variable for creating the typological groupings (e.g., Kuuluvainen et al., 1996, 2014; Karppinen, 1998; Wiersum et al., 2005; Ingemarson et al. 2006; Danley, 2019). When taking such an approach, the typology represents a system for grouping individuals according to their forest management objectives. Through this process, researcher can explore whether the "forest management objective typology" play a role in impacting forest management behaviours.

The methodology for developing a typology based on forest management objectives follows a two-step process. In the first step, survey item responses are typically reduced using factor analysis to a minimal set of standardized, continuous variables known as factor scores (see: Hair et al., 2019: Chapter 3). In the second step, the derived factor scores are used as clustering variables in a cluster analysis (i.e., the typology development) (see: Hair et al., 2019: Chapter 4). The cluster analysis produces a new, discreet categorical variable where each survey observation (i.e., respondent) is assigned to one discreet group. Follow-up multivariate techniques are used to profile and test differences between the groups in the typology (e.g., ANOVA).

In this survey research, a forest practitioner typology was developed using measures of importance. Specifically, the s*trength of a belief* (b_i), *motivation to comply with referent groups* (m_i), and *control power* (c_i) dimensions. Respectively, these dimensions represent the forest practitioner's assignation of importance towards different forest management objectives, different referent groups, and different resources, respectively (see: Annex A: Q22, Q26, Q28). These dimensions were selected because they represent internal values (i.e., *strength of a belief* (bi) measures the respondent's assignation of importance, or value, towards different management objectives). This contrasts with those measurements that considers subjective evaluations of external factors. For example, *belief evaluations* (e_i) measure the respondent's beliefs about whether their forest contribute to the forest management objective, meaning this is a subjective assessment about external world. In other words, *belief evaluations* measure the individual's subjective evaluation of an externalities rather than measuring the individual's own internal values towards the question.

Following the examples provided in the literature on cluster analysis, first an Exploratory Factor Analysis (EFA) (see: Hair et al. (2019: Chapter 3) of the 33 evaluative items was conducted using the maximum likelihood estimator and varimax rotation. Following the methods for EFA, items with poor reliability were discarded during the analysis due to poor construct reliability criteria. The final EFA resulted in a meaningful six-factor solution of 20 items (for full details of the analysis, see: Annex B). The Bartlett factor scores of the resulting EFA were saved as new continuous variables for use in further analysis.

Following the EFA, a K-means cluster analysis was performed using the six behavioural factor scores obtained from the EFA as clustering variables. As the K-means analysis does not inherently identify the optimal number of clusters in a solution, a mixed *a priori* and *a posteriori* approach was taken to reach an informed decision on the final solution. Previous literature finds between 4-6 forest typology groups when using forest owner objectives as a clustering variable (e.g., Kuuluvainen et al., 1996, 2014; Karppinen, 1998; Wiersum et al., 2005; Ingemarson et al. 2006; Danley, 2019). Based on the dataset at hand, however, a hierarchical clustering analysis using Ward Linkage produced a dendrogram illustrating a potential range of cluster solutions (see: Annex C). Interpretation of the dendrogram suggested that a clustering solution of either five or six groups was feasible. Based on this information from the previous literature and the hierarchical clustering analysis, the study implemented the k-means cluster analysis with a five-group solution.

2.3.2 Describing typology groups and testing group differences

Following the development of the five groups, the forest practitioner typology was profiled based on statistical differences found between the groups. One-way analysis of variance (ANOVA) testing was used to determine whether there are statistically significant differences between the groups with respect to the six behavioural factors scores derived from the EFA. Tamhane's post-hoc test was applied to explicitly identify which groups showed significant differences between each other. The Tamhane's post-hoc test was selected given equal variance could not be assumed from the data (see: Annex D).

A multiple causes, multiple indices (MIMIC, see: Jöreskog and Goldberger, 1975) structural equation model (SEM, see: Hair et al., 2019, Chapter 11-12) was developed to validate the suitability of the TPB as a theoretical framework for describing the relationship between the variables measured in the survey (see: Chapter 2.1.1) Figure 2.1 shows the hypothesized relationship between the measures collected in the survey. A multigroup analysis was employed to compare different sub-models produced from estimating the model using the cluster groups (see: Jöreskog, 1971; Bagozzi and Yi, 2012). In other words, respondents are split into their typological groups and the SEM is estimated for each group to evaluate differences between the models for each group.

The SEMs were validated using goodness-of-fit indicators and cutoff values (Table 2.4) recommended by Hair et al. (2019: Chapter 12). Essentially, a good model fit suggests that the data fits the proposed relationship described in the SEM. In addition to confirming the validity of the theoretical model, the SEM tests whether the hypothesized relationships between the behavioural factor variables in the model are significant while also providing a standardized weight for the relationships between these variables. In essence, the SEM indicates the relative strength of the relationships between variables in the SEM. The significance of relationships between variables is reported through p-values. The standardized relationship between variables is reported on a scale from -1 to 1.

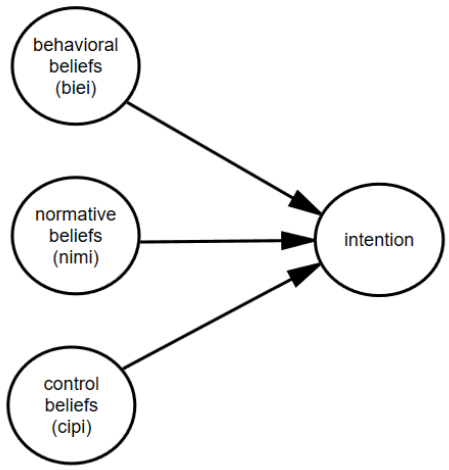


Figure 2.1 – Theorized relationship between the measurement dimensions collected in the survey. Adapted from Fishbein and Ajzen (2010: Figure 1.1, pg. 22). The full measurement model is available in Annex F.

Table 2.4 Fitness indices used to report goodness of fit of structural equation models, as per Hair et al. (2019: Chapter 11-12).

Fitness indicator	Cutoff value (N<250)	Cutoff value (N>250)
Root mean square error of approximation (RMSEA)	<.09	<.07
Tucker-Lewins Lindex (TLI)	>.93	>.92
Comparative Fit Index (CFI)	>.93	>.92
Goodness of Fit Index (GFI)	>.90	>.90
Standardized Root Mean Square Residual (SRMR)	<.07	>.06
x2	Significant p-value	Significant p-value

Lastly, crosstabulations and chi-square test were used to examine differences between different typology groups (e.g., forest practitioner type, forest holdings, and forest management practices). Crosstabulation allow for a descriptive characterization of the groups and an assessment of when observed counts are lower or higher than expected. Meanwhile, the chi-square test examines for statistically significant relationships between variables (e.g., behavioural factors, forest management activities, and external factors).

2.3.3 Logistic regression models on CBS forest management

Logistic regression analyses were conducted to assess how various characteristics of respondents influence the likelihood of engaging in various CBS forest management activities. The binary dependent variable got value 1, if the respondent has responded “yes” to the question on implementing the described CBS activity, and the dependent variable got value 0, if the respondent had not implemented the activity, indicated that the activity was not possible in their forest, or had responded “I don’t know”. Thus, the models describe which factors increase the probability of a “yes” response in reference to other response options. In addition to the model coefficients, also average marginal effects were calculated. These analyses were performed using Stata 16.1 statistical software. The significance levels for the independent variables are reported at one, five, and ten percent thresholds. McFadden’s pseudo-R^2 was employed to indicate the explained variance of the model, as it provides a statistic that ranges from 0 to 1. Descriptive statistics for the explanatory variables can be found in Annex G.

2.4 Survey results

This chapter presents the results of analysis of survey data. This includes profiling the forest practitioner typology and identifying the factors influencing the implementation of CBS forest management across different countries.

2.4.1 The forest practitioner typology

The survey study implemented a k-means cluster analysis with a five-group solution to develop a forest practitioner typology from the survey data (for outline of methods see: Chapter 2.3.2). The five clusters produced from the analysis represents the five forest practitioner groups in the typology. The results of the statistical procedures use to profile the typologies are presented in the following sub-chapter.

2.4.1.1 Values across the forest practitioner typology

One objective of profiling the forest practitioner typology was to determine whether there are differences in the underlying importance each typology group places on different forest management objectives, referent groups, and resources. To reiterate, these dimensions are measured through the factors resulting from an EFA conducted on the *behavioural evaluations* (b_i), *motivation to comply with referent groups* (mi_i), and *control power* (c_i) survey items. Table 2.5 illustrates the results of the final six-factor solution, where the main belief items (b_i, mi_i, c_i) associated with each factor are found in bold. Ultimately, the six behavioural factors resulting from the EFA were named: Income Objectives, Regulating Ecosystem Service (RES) Objectives, Amenity Objectives, Society, Forestry Networks, and Market Mechanisms.

Table 2.5 – Rotated factor solution of 20 belief items using maximum likelihood and varimax rotation. Highest loading item in the factor are visible in bold.

Belief items (b_i, m_i, c_i)	Factor 1 RES Objectives	Factor 2 Forestry Networks	Factor 3 Society	Factor 4 Market Mechanisms	Factor 5 Income Objectives	Factor 6 Amenity Objectives
b_{12} Water quality	**0.662**	0.101	0.140	0.095	0.126	0.229
b_{12} Soil quality	**0.657**	0.150	0.153	0.150	0.192	0.189
b_{13} Climate change	**0.644**	0.147	0.124	0.106	0.046	0.171
b_{15} Abiotic disturbances	**0.641**	0.106	0.057	0.146	0.104	0.146
b_{14} Biotic disturbances	**0.629**	0.143	0.032	0.099	0.168	0.057
m_{i7} Local forest authority	0.221	**0.804**	0.259	0.202	0.127	0.082
m_{i8} National forest authority	0.211	**0.778**	0.229	0.220	0.13	0.097
m_{i6} FOA	0.218	**0.668**	0.368	0.223	0.119	0.110
m_3 Neighbours	0.121	0.224	**0.800**	0.130	0.125	0.116
m_2 Friends	0.175	0.226	**0.662**	0.152	0.087	0.143
m_4 General public	0.112	0.399	**0.611**	0.221	0.154	0.182
c_6 Subsidies or grants	0.227	0.232	0.103	**0.712**	0.16	0.090
c_7 Market schemes	0.244	0.219	0.193	**0.666**	0.221	0.120
c_4 Credit or loans	0.092	0.200	0.275	**0.596**	0.289	0.187
b_2 WFP income	0.264	0.100	0.149	0.187	**0.652**	0.273
b_1 Timber income	0.135	0.123	0.053	0.166	**0.629**	0.051
b_3 Services income	0.220	0.104	0.212	0.237	**0.585**	0.357
b_{i7} Forest access	0.366	0.101	0.198	0.157	0.263	**0.651**
b_8 Safety	0.442	0.141	0.173	0.163	0.208	**0.598**
b_9 Beauty	0.425	0.113	0.185	0.125	0.206	**0.598**

An ANOVA was run to test whether there are statistically significant differences between the forest practitioner typology groups and their importance towards the six factors derived from the EFA. The findings from the ANOVA conclude there are indeed significant differences (see: Annex D). This implies that each group in the typology prioritizes and values distinct forest management objectives (i.e., Regulating Ecosystem Services objectives, amenity objectives, income objectives), normative referent groups (i.e., society, forestry networks), and control factors (i.e., market mechanisms).

Table 2.6 provides a descriptive summary of how strongly each factor is valued according to each group by displaying the mean value, minimum value, maximum value, and standard deviation of factor score. Critically, the factor scores represent a standardized continuous scale that measures the degrees of importance towards the factor, with increasingly negative values signifying unimportance and increasingly positive values signifying importance. As values approach zero this indicates ambivalence.

Table 2.7 illustrates the findings of the ANOVA post-hoc test (see: Annex D) by indicating whether there are statistically significant differences between the mean factor score of the typology groups. For example, when looking at the Society factor, Table 2.7 shows that Group 4 and Group 1 do not have a statistically significant difference in their mean scores despite showing differences in their mean factor scores (-0.34 and -0.14, respectively). Therefore, the post-hoc test also works to ranks the groups from lowest to highest according to each factor score.

Table 2.6 –Summary of how strongly the five forest typology groups value the different factors (n=2259). Values represent factor score means. Negative values indicate the factor is unimportant to the group. Positive values indicate the factor is important. Values close to zero indicate the factors importance is ambivalent.

Behavioural Factors	Group 1	Group 2	Group 3	Group 4	Group 5
RES objectives	0.45	0.59	0.50	-1.07	0.02
Society	-0.14	-1.39	0.27	-0.34	0.79
Market mechanisms	-2.35	0.52	0.18	0.83	0.00
Income objectives	-0.03	-0.71	-0.15	0.57	0.07
Amenity objectives	-0.28	0.09	0.07	-0.92	0.55
Forestry networks	-0.06	0.80	-2.09	0.09	0.28

Table 2.7 – Ranking of factor score means per groups based on ANOVA post-hoc tests. A (<) indicates a significant difference between the groups. A (=) indicates there is no significant difference found between the groups.

Factor Scores	Group Ranking: Lowest to Highest							
RES objectives	4	<	5	<	1	=	3	=	2
Society	2	<	4	=	1	<	3	<	5
Market mechanisms	1	<	5	=	3	<	2	<	4
Income objectives	2	<	3	=	1	=	5	<	4
Amenity objectives	4	<	1	<	3	=	2	<	5
Forestry networks	3	<	1	=	4	<	5	<	2

The findings presented in Table 2.6 and Table 2.7 were used to name the five typology groups. Specifically, the findings were compared to the forest practitioner typology literature review presented in ForestPaths Deliverable 1.1 (Feliciano et al., 2024). Some of the typology groups ultimately shared similarities with typologies found across the literature.

Group 1: Environmentally Conscious Passives

Group 1 places importance on Regulating Ecosystem Services objectives (e.g., improving soil and water quality, mitigating climate change, mitigating forest disturbances) and is somewhat uninterested in amenity objectives (e.g., creating trails, ensuring safe and accessible spaces). The group is ambivalent towards opinions from both society and forestry networks when making choices related to their forest management objectives. The group appears to find market mechanisms (e.g., subsidies, grants, credits, loans, etc.) unimportant towards implementing their forest management objectives.

When comparing the group to typologies from the literature reviewed in ForestPaths Deliverable 1.1, the group is found to share similarities with the archetypical "*passive owner*", in that there is little interest in gaining personal utility from the forest or relying on social norms or market mechanisms to guide forest management decision making. However, Group 1 is distinct from the archetypical *passive owner* because Group 1 places a high value on RES objectives. Arguably, Group 1 can be classified as a sub-group of the *passive owner*. Matilainen and Lähdesmäki (2023) argue that passive ownership is a more complex phenomenon than the literature typically suggests and conclude by proposing a subgroup classification for passive owners. However, the subgroups proposed by Matilainen and Lähdesmäki (2023) do not entirely overlap with the values of Group 1, possibly because Matilainen and Lähdesmäki (2023) developed their subgrouping based on a Finnish dataset. Nevertheless, based on that fact that Group 1 is ambivalent to normative opinions (typical of *passives*), finds market instruments unimportant to implementing their forest management objectives (typical of *Environmentalist*), and places great importance on RES objectives the group was labelled *Environmentally Conscious Passives.*

Group 2: Environmental Implementers

Group 2 places importance on RES objectives, income objectives are deemed unimportant, and amenity objectives are seen ambivalently. With regards to norms, the group places high importance in forestry networks but societal opinions are unimportant. Market mechanisms are viewed as important for implementing forest management objectives.

When comparing the Group 2 to typologies from the literature reviewed in ForestPaths Deliverable 1.1, the group shares similarities with the archetypical "*environmentalist*" group, in that they highly value RES objectives, have no importance towards income objectives, and place low importance on norms from groups considered to be at odds with their objectives (e.g., see: Sotirov et al., 2019). From this perspective, Group 2 could be interpreted to see society largely at odds with their forestry objectives, given that they view societal opinions as unimportant.

Group 2 diverges from *Environmentalist*, given that Group 2 acknowledges a need for market mechanism and places importance on forestry networks, suggesting that there is a regard both for the knowledge and opinion of forestry networks, as well as the financial resources required to implement forest management activities. Arguably, it follows that the group truly wishes to operationalize their RES management objectives, acknowledging both the resources and skills to do this. As a result, the group was labelled *Environmental Implementers* rather than *Environmentalists.*

Group 3: Traditionalist

Group 3 places a large importance on RES objectives, while importance towards amenity objectives are ambivalent manner and income objectives remain somewhat unimportant. This group appears to find forestry network opinions unimportant but instead heeds opinions from society (e.g., friends, neighbours, society).

When comparing the group to typologies from the literature reviewed in ForestPaths Deliverable 1.1, Group 3 shares several similarities with the archetypical "traditionalist" group. *Traditionalists* are typically classified according to their low interest in income objectives but occasional interest in utility objectives. They are also found to place a high degree of value specifically on societal norms (e.g., local traditions) rather than other referent groups.

Group 4: Maximizer

Group 4 primarily places importance on income objectives, which appear to be at odds with the lack of importance placed on RES objectives and amenity objectives. As such, they also place a high importance on market mechanisms. Societal opinion appears unimportant, while forestry network opinions are viewed ambivalently.

When comparing the group to typologies from the literature reviewed in ForestPaths Deliverable 1.1, Group 4 shares many similarities with the archetypical "*maximizer*" group. *Maximizers* are described as being largely in favour of income objectives, to the point where other objectives become irrelevant or at odds with the pursuit of income. In the same vein, *maximizers* differ from the typical income-oriented "*optimizers*" group in that they hold little to no regard for societal and institutional norms (see e.g., Sotirov et al. 2019). Therefore, *maximizers* would be expected to find the opinions of society and institutions largely unimportant. In this sense, Group 4 differs somewhat from the archetypical *maximizer* because they are ambivalent to the opinions of forestry networks (i.e., local forest authorities, national forest authorities, forest owner associations) rather than finding them unimportant. This is significant because the forestry network factor includes a large institutional component, given the use of forest authorities as referent groups in the survey question used to develop the factor. However, rather than answering that these referents are unimportant, Group 5 views these referents neutrally. One possible explanation for the discrepancy could be due to social desirability bias – a form of response bias where respondents answer according to the expectations of society – where *maximizers* are aware of their disinclination towards institutional figures and abscond from admitting this openly.

Group 5: Societal Satisfiers

Group 5 primarily places a large emphasis on amenity objectives but is ambivalent towards income objectives and the RES objectives. Group 5 appears to place importance on norms, with especially high importance towards societal opinion, and to a lesser extent, also the opinions of forestry networks. Market mechanism are seen ambivalent. When comparing Group 5 to typologies from the literature reviewed in ForestPaths Deliverable 1.1, the group does not appear to share similarities with a singular typology group. Instead, Group 5 shares similarities with two different typology groups, the *traditionalist* group and the *recreational users* group. *Traditionalist* place large importance on societal norms (typically normative values instilled from close-knit social circles rather than society at large) and thereby take up management objectives according to those societal norms. However, *traditionalist* do not overemphasize amenity values and tend to have more multifunctional objectives, a trait missing from Group 5. Meanwhile, *recreational users* (a sub-class of passive owner) highly value amenities objectives while other objectives are discarded, with the occasional exception of forestry conservation objectives (e.g., set aside land).

Based on the lack of overlap between typologies described across the literature, it appears that Group 5 may represent a somewhat different group altogether. Because the main characteristic of the group was valuing societal opinions and fulfilling amenity objectives, the group was dubbed *Societal Satisfiers*. This comes from the acknowledgement that amenity objectives relate highly to public goods (e.g., access to forest via trails, safety in forest, forest beauty) and that the high emphasis on societal opinions appear to suggest that this group is largely interested in satisfying the utility and normative needs of society.

2.4.1.2 Behavioural intention across the forest practitioner typology

A structural model was developed following the TPB in order to test, confirm, and analyse the behavioural factors influencing forest management behavioural intention between the different forest practitioner typology groups. A confirmatory factor analysis of the full measurement model showed that behavioural factors measured through the survey held acceptable measures of fit (see: Annex F, Figure 8.1). This suggests that the items from the survey are appropriate measures for the factors.

Following, a SEM specifying causal relationships between the factor was specified according to the TPB (see: Annex F, Figure 8.2). The model was estimated for each of the forest practitioner typology groups. The SEM sub-models showed somewhat acceptable fitness indices, however, the SRMR was unacceptably high across all the sub-models (see: Annex F: Figure 8.3-8.8). The high SRMR value implies that the dataset does not fit the proposed theory. Given the adequate fit of the confirmatory factor model, this suggests that the causal relationships drawn between the behavioural factors are misspecified. In other words, while the TPB hypothesizes that the relationship between the belief factors relate linearly to intention, it is possible that some factors are mediating the relationship between intention. Finding a suitable alternative model presents itself as an area of future research. Ultimately, due to the poor fit of the TPB SEM model, the strength of the relationship between behavioural factors and intention cannot be interpreted.

2.4.1.3 Management behaviors across the forest practitioner typology

To test whether there is a link between the forest practitioner typology and their implemented management behaviours, a crosstabulation and chi-square test was implemented. The chi-square tested whether there was a signification relationship between the forest practitioner typology and forest management behaviours.

Various forest management behaviours were measured in the survey according to the practices the forest owner reported as being typical in their prevalent forest type (see: Annex A, Q12-21). Given the large number of management questions presented alongside the numerous response alternatives present under each management question; it was necessary to aggregate responses to meet the assumptions of the chi-square testing. To this end, “management classes” were created based on combinations of responses to management questions related to cutting activities and thinning activities. The cutting and thinning activities were selected due to the impacts that harvest and thinning regimes play on forest cover. Moreover, one key management activity identified as climate-and biodiversity smart is continuous cover forestry, defined by Pommerening and Murphy (2004) as “*silvicultural systems which involve continuous and uninterrupted maintenance of forest cover and which avoid clearcutting*.” Therefore, creating a management classification system that juxtaposes continuous cover forestry and clearcutting management regimes was deemed relevant to the study.

Respondents were classified into five management classes. The classes were defined as *inactive management* (no management activities employed whatsoever in the forest), *strong continuous cover forestry* (selective felling AND thinning from above OR thinning of all size classes), *weak continuous cover forestry* (selective felling AND thinning from below), *strong clearcutting* (clearcutting AND thinning from above OR of all size classes), or *weak clearcutting* (selective felling AND thinning from below).

The chi-square test resulted in a statistically significant p-value, indicating there is a relationship between the behavioural typologies and management behaviours. The findings from the crosstabulation show that *Environmentally Conscious Passives*, *Environmental Implementers*, and *Traditionalist* have observable differences in their expected versus observed management activities (Table 2.8). *Environmental*

Implementers were found to have less practitioners engaged in strong clearcutting than expected (6.4% observed versus 12.5 % expected) and more inactive management than expected (37.8% observed versus 20.90% expected). *Traditionalists* were found to have less practitioners engaged in strong clearcutting than expected (7.1% observed versus 12.5% expected) and more practitioners engaged in strong continuous cover forestry than expected (33.6% observed versus 26.2% expected). *Societal satisfiers* were observed to have less inactive management than expected (20.9% observed versus 29.1% expected) and observed stronger clearcutting than expected (18.1% observed versus 12.5% expected). Neither *Environmentally Conscious Passives* or *Maximizers* were found to engage in management behaviours that strongly deviate from expected (+/- 5% difference between expected and observed).

Table 2.8 – Overview of management practices implemented across the give typology groups. *% within* refers to percentage of observed respondents implementing each management practice within the typology group*. Expected % within* refers to the expected number of observations, on average, per management practice within the typology group if the relationship between practitioner typology and management practice was independent (n=2259).

	Environmentally Conscious Passive		Environmental Implementer		Traditionalist		Maximizer		Social Satisfier		Expected
	N	% within	N	% within	N	% within	N	% within	N	% within	% within
Inactive management	77	32.2%	124	37.8%	78	32.8%	143	33.9%	165	20.9%	29.1%
Strong CCF	54	22.6%	88	26.8%	80	33.6%	112	26.5%	195	24.7%	26.2%
Weak CCF	40	16.7%	61	18.6%	36	15.1%	73	17.3%	146	18.5%	17.7%
Strong clearcut	24	10.0%	21	6.4%	17	7.1%	47	11.1%	143	18.1%	12.5%
Weak clearcut	44	18.4%	34	10.4%	27	11.3%	47	11.1%	140	17.7%	14.5%

Cells overrepresented by >5% of the *Expected % within count* highlighted in red.
Cells underrepresented by >5% of the *Expected % within count* are highlighted in blue.

2.4.1.4 Characterizing the forest practitioner typology

While the *Environmentally Conscious Passives*, *Environmental Implementers*, and *Traditionalist* groups showed some observable differences in the management activities they implement in the forest, the results ultimately show that regardless of the practitioner typology all management activities are implemented across the typology groups. This suggests that internal values alone do not drive management behaviours, otherwise larger differences in observed versus expected behaviours would be visible. The literature often points to the role of external factors, (e.g., ecological factors) in shaping forest management decisions (e.g., Sotirov et al., 2019). For this reason, further exploration of the characteristics of typology group members was carried out through crosstabulation and chi-squares test. Attention was paid to whether there were outstanding observable differences within the typology groups according to forest country locations, size of forest holdings, or forest practitioner types.

A chi-squares test between the typology groups and forest country region, forest area, and forest practitioner type each resulted in a statistically significant p-value (<.001). This indicates a significant relationship between the forest practitioner typology and each of the respective three variables. Tables 2.9 - 2.11 display the results of the crosstabulations comparing the forest practitioner typology group against forest region, forest holding size, and forest practitioner type.

Table 2.9 – Crosstabulation comparing the European forest region where the respondent's forest is located against the typology group. *% within* refers to percentage of observed respondents per European forest region within the typology group. *Expected % within* refers to the expected number of observations that would be found on average per European forest region within the typology group if the relationship between practitioner typology and European forest region was independent (n=2259).

	Environmentally Conscious Passive		Environmental Implementer		Traditionalist		Maximiser		Social Satisfier		Expected
	N	% within	N	% within	N	% within	N	% within	N	% within	% within
North Europe	144	52.60%	110	28.10%	134	48.70%	175	36.80%	274	32.50%	37.10%
Central West Europe	51	18.60%	76	19.40%	43	15.60%	106	22.30%	187	22.20%	20.50%
Southwest Europe	4	1.50%	35	8.90%	7	2.50%	24	5.00%	72	8.60%	6.30%
Central East Europe	42	15.30%	85	21.70%	50	18.20%	95	20.00%	202	24.00%	21.00%
Southeast Europe	33	12.00%	86	21.90%	41	14.90%	76	16.00%	107	12.70%	15.20%

Cells overrepresented by >5% of the *Expected % within count* highlighted in red.
Cells underrepresented by >5% of the *Expected % within count* are highlighted in blue.

Table 2.10 – Crosstabulation comparing the forest holding size against each typology group. *% within* refers to percentage of observed respondents per forest holding size within the typology group. *Expected % within* refers to the expected number of observations that would be found on average per forest holding size within the typology group if the relationship between practitioner typology and forest holding size was independent (n=2259).

	Environmentally Conscious Passive		Environmental Implementer		Traditionalist		Maximiser		Social Satisfier		Expected
	N	% within	N	% within	N	% within	N	% within	N	% within	% within
≤ 1 ha	40	14.60%	86	21.90%	74	26.90%	82	17.20%	99	11.80%	16.90%
2 - 5 ha	99	36.10%	129	32.90%	85	30.90%	142	29.80%	225	26.70%	30.10%
6 - 19 ha	63	23.00%	64	16.30%	59	21.50%	89	18.70%	119	14.10%	17.40%
20 - 99 ha	51	18.60%	52	13.30%	30	10.90%	82	17.20%	163	19.40%	16.70%
100+ ha	21	7.70%	61	15.60%	27	9.80%	81	17.00%	236	28.00%	18.90%

Cells overrepresented by >5% of the *Expected % within count* highlighted in red.
Cells underrepresented by >5% of the *Expected % within count* are highlighted in blue.

Table 2.11 - Crosstabulation comparing the forest practitioner type against the typology groups. *% within* refers to percentage of observed respondents per forest practitioner type within the typology group displayed in the column. *Expected % within* refers to the expected average number of observations that would be found per forest practitioner type if the relationship between practitioner typology and forest region was independent (n=2259).

	Environmentally Conscious Passive		Environmental Implementer		Traditionalist		Maximiser		Social Satisfier		Expected
	N	% within	N	% within	N	% within	N	% within	N	% within	% within
Private owner	185	69.80%	242	63.40%	186	68.90%	271	60.60%	384	48.80%	58.90%
Public manager	14	5.30%	42	11.00%	15	5.60%	57	12.80%	151	19.20%	13.00%
Private manager	33	12.50%	69	18.10%	38	14.10%	76	17.00%	170	21.60%	17.90%
Owner and manager	33	12.50%	29	7.60%	31	11.50%	43	9.60%	82	10.40%	10.10%

Cells overrepresented by >5% of the *Expected % within count* highlighted in red.
Cells underrepresented by >5% of the *Expected % within count* are highlighted in blue.

A scan of the crosstabulation between typology groups and forest location (Table 2.9) shows that *Environmentally Conscious Passives* are overrepresented in North Europe (52.60% observed versus 37.10% expected) and underrepresented in Central East Europe (15.30% observed versus 21.00% expected). *Environmental Implementers* showed overrepresentation in Southeast Europe (21.90% observed versus 15.20% expected) and underrepresentation in North Europe (28.10% observed versus 37.10% expected). *Traditionalists* showed overrepresentation in North Europe (48.70% observed versus 37.10% expected) and overrepresentation in Central West Europe (15.60% observed versus 20.50% expected). *Maximisers* and *Societal Satisfiers* show no extreme divergences in expected versus observed, which can be interpreted in that they appear evenly distributed across the 13 European countries included in the survey.

A scan of the crosstabulation between typology groups and the size of forest holdings (Table 2.10) shows that *Environmentally Conscious Passives* are overrepresented in forest holdings of 2-5 hectares (36.10% observed versus 30.10% expected) and holdings of 6-19 ha (23% observed versus 17.4% expected) but underrepresented in shares of >100 ha holdings (7.70% observed versus 18.90% expected). *Environmental Implementers* hold an overrepresented share of forest holdings of ≤1 hectares (21.90% observed versus 16.90% expected). *Traditionalists* hold an overrepresented share of forest holdings of 0-1 ha (26.90% observed versus 16.90% expected) but underrepresentation of 20-99 ha (10.90% expected versus 16.70% observed) and >100 ha (9.80% observed versus 18.90% expected). *Maximisers* do not appear to hold over- or under-represented shares of any forest holding size. *Societal Satisfiers* hold an overrepresented share of forest holdings of 100+ ha (28% observed versus 18.90% expected) and an underrepresented share of ≤1 ha forest holdings (11.80% observed versus 16.90% expected).

A scan of the crosstabulation between typology groups and forest practitioner types (Table 2.11) shows that *Environmentally Conscious Passives* (69.80% observed versus 58.90% expected)*, Environmental Implementers* 63.40% observed versus 58.90% expected)*,* and *Traditionalist* (68.90% observed versus 58.90% expected) are all overrepresented in their composition of private forest owners. *Societal satisfiers* are overrepresented in their composition of public managers (19.20% versus 13.00%) and underrepresented in their representation of private forest owners (48.80% observed versus 58.90% expected). *Maximisers* do not appear over- or under- represented among any forest practitioner type.

2.4.2 Factors influencing CBS forest management

The survey included questions regarding the implementation of seven different CBS forest management activities (Table

Table 2.12 Forest owners' responses to the question: "Have you ever intentionally implemented any of the following forest management activities in any of your forest stands?". Percentage of respondents. (n=1486)2.12). These questions were presented only to respondents who identified as owning a forest at the start of the survey.

According to the survey results, 52% of respondents reported reserving at least 5% of trees as retention trees during final felling in even-aged stands. The next highest numbers were for leaving the undisturbed buffer strips adjacent to water bodies. The lowest share of yes-responses was for retaining deadwood in the forest and for lengthening the rotation period by at least 25% of the typical rotation. About 40% of the respondents implicated that they had not left logging residues in the forest, which was the highest share of no responses. A clearly lower number of no-responses were given to buffer strips and retention trees. 10–16% of the respondents replied *I do not know* to this implementation question depending on the presented forest management activity.

Table 2.132.13 summarizes the results (see Annex G) of the full logit models (see: Annex G: Model 4) on variables explaining the probability of having implemented the CBS management activities. Overall, the explanatory power of models was poor, with R2 values varying from 3% to 7%. Thus, the explanatory variables considered in the survey analysis do not entirely explain previous forest owner's behaviour regarding the proposed CBS scenarios. Nevertheless, the model results provide information on some variables that had a statistically significant impact on the probability of implementing the CBS scenarios, even though there are explanatory factors that are not included in these models.

Based on the results, the country differences explain most of the differences in forest owners' earlier activities. Of the respondent or forest estate characteristics, the small (below 1 hectare) forest size decreased the probability for several CBS activities, namely leaving retention trees, buffer strips, lengthened rotation, leaving logging residues, and applying CCF on peatland forests. Respondents belonging to the forest practitioner typology group 5 (societal satisfiers) had a 14 percent higher probability of having left deadwood in forest and a nine percent higher probability of having left retention trees, compared to the respondents in other clusters. Respondents from the forest typology group 2 (environmental implementers) had a 13 percent higher probability of having used a longer rotation period compared to others, and respondents in forest practitioner typology group 4 (maximizers) had a 17 percent higher probability of having applied CCF to spruce-dominated peatland forests.

Table 2.12 Forest owners' responses to the question: "Have you ever intentionally implemented any of the following forest management activities in any of your forest stands?". Percentage of respondents. (n=1486)

Forest management activities	YES	NO	This activity cannot be implemented in my forest	I do not know	
Deadwood: Retained at least 10 m3/ha of standing or fallen deadwood in a forest stand with low risk of forest fire? This equals roughly 15-20 stems of over 20 centimetres diameter per hectare.	38	33	16	12	100
Continuous cover forestry: Implemented continuous cover forestry in 20% or more of your total forest area? Continuous cover forestry refers to a silvicultural system that largely maintains the forest cover of a forest stand by cutting single trees, groups of trees, or using a shelterwood system, all of which all avoid clearcutting of the entire tree cover.	42	35	12	11	100
Retention trees: At final felling, reserved at least 5% of the trees in an even-aged stand as retention trees? This equals roughly 10 m3/ha (15-20 stems) when logging 200 m3/ha.	52	20	16	12	100
Buffer strips: Left undisturbed forest buffer strips of 20 meters or more adjacent to any body of water?	46	18	25	11	100
Longer rotation: Lengthened the rotation period of a forest stand at low risk of forest disturbances by at least 25% of the typical rotation period? For example, lengthening the rotation period in a stand from 80 to 100 years.	39	28	17	16	100
Logging residues: Left all the logging residues in a recently logged forest stand? For example, not harvesting logging residues for bioenergy.	40	41	10	10	100
Continuous cover forestry on peatland*: Applied continuous cover forestry in all spruce dominated peatland forest stands, by selecting single tree or group trees for felling, rather than clearcutting the entire stand.	35	29	22	15	100

*This forest management activity was presented only for the respondents from Finland, Sweden and Latvia (n=629).

Table 2.13 Summary of typologies and other factors that had a statistically significant effect in a logit model on probability the forest owner had carried out the mentioned CBS activity in their forest. Marginal effects as percentages in the parenthesis.

CBS activities	Characteristics	Typologies (reference: Group 1)	Behaviours (reference: unmanaged)	Country (reference: Croatia)
Deadwood		Group 5 (+14%)		Finland (+16%) France (+14%) Latvia (+14%) Sweden (-15%) Switzerland (+20%) United Kingdom (+25%)
Continuous cover forestry*,**			-	Czechia (+11%) Spain (-19%) Sweden (-22%) Switzerland (+14%)
Retention trees	Forest area below 1 ha (-12%) (reference: Forest Area: 100 ha or more)	Group 5 (+9%)	CCF Strong (+14%) Clear felling Strong (+11%)	Netherlands (-29%) Romania (+13%) Spain (-24%) Sweden (-11%)
Buffer strips	Forest area below 1 ha (-15%) (reference: Forest Area: 100 ha or more) Forestry income over 26% of annual income (-9%) (Reference: Forestry income 26% or less of annual income)		CCF Strong (+7%) CCF Weak (+8%) Clearfelling Strong (+9%) Clearfelling Weak (+11%)	France (-15%) Italy (-21%) Latvia (-14%) Spain (-17%)
Longer rotation	Gender Male (-5%) (Reference: female) Forest area below 1 ha (-14%) (reference: Forest Area: 100 ha or more)	Group 2 (+13%)	CCF Weak (+9%)	Finland (-14%) France (-20%) Germany (-19%) Latvia (-13%) Spain (-35%) Sweden (-29%)
Logging residues	Forest area below 1 ha (-11%) (reference: Forest Area: 100 ha or more) Forest area 20-99 ha (-12%) (reference: Forest Area: 100 ha or more)			France (+17%) Germany (-14%) Switzerland (+14%) United Kingdom (+35%)
Continuous cover forestry on peatland,*****		Group 4 (+18%)	-	Sweden (-21%)

* Finland was excluded from this model due to slightly different question version in the survey questionnaire.

** Grouping based on current forest management behaviours were excluded from the CCF models due to endogeneity issues.

***This forest management activity was presented only for the respondents from Finland, Sweden and Latvia (n=629). In the logit model, the reference country was Latvia.

2.5 Parameters for an agent classification system

The purpose of this sub-chapter is to develop parameters for an agent classification system that can be operationalized into an agent-based model. The agent classification system categorizes agents based on their values, according to the Forest Practitioner Typology developed in Chapter 2.4.1. In this context, parameters for modelling constitute numerical variables that either describe the distribution of values, characteristics, and behaviours found between agent classes or the probabilities of implementing behaviours between agent classes. Table 2.14 displays the parameters for modelling for each agent class. The parameters are developed by synthesizing the results presented in Chapter 2.4.

Table 2.14 – Summary of parameters for modelling each agent class.

Typology / Agent Classes	Values	Characteristics	Behaviour
1. Environmentally conscious passives	• **RES objectives** + • **Income objective** +/- • **Amenity objectives** - • **Forestry network** +/- • **Society** +/- • **Market mechanism** --	• **North Europe** overrepresented 15% • **Southwest Europe** underrepresented **5%** • **Central East Europe** underrepresented 6% • **2-5 ha holders** overrepresented 6% • **6-19 ha holders** overrepresented 6% • **>100 ha holders** underrepresented 11% • **Private forest owner** overrepresented 11% • **Public managers** underrepresented 8% • **Private managers** underrepresented 5%	• **No under- or over-representation**
2. Environmental implementers	• **RES objectives** + • **Income objectives** -- • **Amenity objectives** +/- • **Forestry network** ++ • **Society** -- • **Market mechanism** +	• **Southeast Europe** overrepresented 7% • **North Europe** underrepresented 9% • **<1 ha holders** overrepresented 5% • **Private forest owner** overrepresented 5%	• **Inactive management** overrepresented 8.5% • **Strong clearcutting** underrepresented 6% • **Longer rotation** (13% higher probability)
3. Traditionalist	• **RES objectives** + • **Income objective** +/- • **Amenity objectives** +/- • **Forestry network** -- • **Society +** • **Market mechanism** +/-	• **North Europe** overrepresented 12% • **Central West Europe** underrepresented 5% • **<1 ha holders** overrepresented 10% • **20-99 ha holders** underrepresented **6%** • **>100 ha holders** underrepresented 9% • **Private forest owner** overrepresented **10%** • **Public managers** underrepresented **7%**	• **Strong CCF** overrepresented • **Strong clearcutting** underrepresented
4. Maximisers	• **RES objectives** -- • **Income objective** + • **Amenity objectives** -- • **Forestry network** +/- • **Society** - • **Market mechanisms** ++	• Ownership neither over/underrepresented • Localities neither over/underrepresented	• **No under- or over-representation** • **Continuous cover forestry on peatland*** (18% higher probability)
5. Societal satisfiers	• **RES objective** +/- • **Income objective** +/- • **Amenity objectives** + • **Forestry network** + • **Society +** • **Market mechanism** +/-	• **North Europe** underrepresented 5% • **<1 ha holders** underrepresented 5% • **>100 ha holders** overrepresented 9% • **Private forest owners** underrepresented 10% • **Public managers** overrepresented 6%	• **Inactive management** underrepresented • **Strong clearcutting** overrepresented • **Deadwood** (14% higher probability) • **Retention trees** (9% higher probability)

* This forest management activity was presented only for the respondents from Finland, Sweden and Latvia.

2.6 Limitations to the survey study

The limitations to the survey study include inability to assess the generalizability of the survey findings resulting from the use of a non-probabilistic sampling approach. The inability to employ random sampling is primarily due to limited available information about the target population, in particular the lack of forestland registries across Europe.

Random sampling[2] is the only method for ensuring probabilistic sampling that is limited in bias and produced results generalizable to the target population. To give an example of random sampling, take a country such as Finland, where the National Land Survey of Finland hosts a Land Register with contact information of forestland owners across Finland. This register can be used by researchers to create a randomly sampled list of individuals and send the survey study to the random sample. In addition, the researcher can effectively track response rates and nonresponse rates – figures that are critical towards ensuring that the minimum sample size required to meet confidence intervals for statistical testing are achieved.

Once surveying of the population group is no longer random, it is referred to as non-probability sampling[3]. Some methods include convenience sampling, quota sampling, network sampling, and web panels. Non-probabilistic sampling opens the window for multitudes of survey bias, such as noncoverage of groups or response biases (e.g., nonresponse, voluntary response sampling). Furthermore, confidence intervals are not implementable in non-probabilistic sampling, meaning that the representativeness of the sample and generalizability of results is highly at risk. Despite these pitfalls, Baker et al. (2013) argue extensively that these caveats alone should not result in the exclusion of nonprobability sampling from research, but approaches should be taken to mitigate biases and ensure appropriate interpretation of results.

As a reminder, this survey study collected data through a web panel. Given the limited number of forestland registries found across the 13 European countries targeted in the study, random sampling was highly unfeasible, if not outright impossible. Certain data analysis techniques employed in the research study are therefore especially vulnerable to sampling biases, the main technique being cluster analysis. Clusters analysis is an inherently data-driven technique, where biases in sampling can cause conflated or biased formation of clusters. Underrepresented groups may be agglomerated into a larger cluster and thereby skew clustering results rather than forming an independent cluster as would be expected. For this reason, care should be taken in the interpretation of findings from this survey study. And indeed, care should also be taken when interpreting any research

[2] For more information about survey sampling, see: Wolf et al. (2016: Chapter 21)
[3] For an extensive discussion on non-probabilistic sampling and see Baker et al. (2013)

study aiming to develop a forest practitioner typology that cannot properly ascertain the representativeness of their sample.

3 Decision rules and parameters for harvesting

3.1 Background

In ForestPaths Deliverable 1.1 (Feliciano et al., 2024), we analysed available repeated National Forest Inventory (NFI) plot data from 12 countries using a variety of European-scale maps using different harvest predictors (like elevation, species, distance to ports) to find groups of plots that are managed (more specifically: harvested) using a similar management style. We found a clear effect of constraining external factors on the harvest rate that work in a similar way all over Europe. Overall, these constraints seemed to be summarized best by biogeographic regions and species. However, within these constraints, we also found very clear differences between countries, in line with earlier work by Levers et al. (2014) and parallel work by Suvanto et al (submitted).

As a characterization of harvesting style and for application in the models, a simple average harvest rate is not sufficient. Therefore, we re-analysed the repeated NFI data in more detail, with the aim to extract harvest decision rules and parameters, applicable for use in EFISCEN-Space and other models.

3.2 Method

A single harvesting rule consists of: 1) the time interval between consecutive harvest events, 2) the minimum and maximum threshold of a certain action variable (e.g., minimum or maximum tree density, basal area, diameter or standing volume) that triggers the rule, 3) the probability the harvest event is carried out, 4) the intensity of the harvest (% of basal area removed), and 5) the shape of the harvest (thinning from above or below, or uniform).

For all NFI plots with repeated assessment, we calculated the basal area at census 1, the quadratic mean diameter (qmd) at census 1, the basal area removed during thinning (for those trees labelled as being harvested at census 2 and using their basal areas at the first census), the quadratic mean diameter of the trees that were harvested and the interval between census 1 and census 2. We calculated the harvest intensity as the fraction of the basal area removed during the harvest event. Plots with a harvest intensity greater than 0 were labelled as being harvested, and plots with a harvest intensity greater than 0.9 were labelled as clearfelled. Clearfell should be understood here as final felling or regeneration felling, since the plots are rather small. We calculated the qmd ratio of the harvest as:

$$\text{qmd ratio} = \text{qmd harvest} / \text{qmd plot} - 1 \quad \text{[eq 4]}$$

A qmd ratio of 0 indicates that the harvested trees have the same qmd as the stand before harvest, and the harvest was uniformly distributed over the diameter at breast height (dbh) classes. A negative value indicates that there was a preference to harvest trees that were smaller than average (thinning from below), while a positive value indicates that the trees harvested were larger than average (thinning from above). This qmd ratio is translated into a shape parameter in the harvest module of EFISCEN-Space. A shape parameter of zero means a uniform thinning, while the more positive (negative) the shape parameter, the more the thinning is targeting the largest (smallest) trees.

In addition, we labelled all plots according to their country, biogeographic region (Metzger et al. 2005) and dominant species in the plot. The latter was done by determining the species with the highest basal area share at census 1. We also assigned each plot to a basal area class, using classes with a width of 5 m^2 ha^{-1}, and to a qmd class, using classes with a width of 5 cm.

All repeated plot censuses were used as independent observations. A plot that was measured 3 times would thus yield two observations, once for the period between census 1 and 2, and once for the period between census 2 and 3. For each combination of country and biogeographic region we determined how much plots were available for each species, and aggregated the data to species groups if too few observations were available for a meaningful analysis. As a rule of thumb, we used a minimum of 100 observations but deviated where deemed necessary. This was done for example in the case of poplar plantations that clearly have a different harvesting regime from other broadleaved forests, but in most countries only had a limited data coverage. The species groupings were classified on an expert-based basis, taking into account the specifics of both the species and the country situation. For example, other indigenous pines are usually quite rare in Central and Northern Europe and were merged with Scots pine, while in the Mediterranean region sufficient data was available to create separate harvest rules for both groups.

For every combination of country, biogeographic region, and species, we analysed the clearfell (regeneration felling) pattern in relation to the qmd and the thinning pattern (harvested but not clearfelled) in relation to the basal area. We hereby assumed that clearfelling/regeneration felling is carried out if the trees reach a certain size (target diameter), and a thinning is carried out if a stand is (too) dense. For each of the respective qmd or basal area classes we calculated the average probability as the number of plots receiving the treatment divided by the total number of plots in that class, the average intensity as the average of the intensities of the plots receiving that treatment, and the average qmd ratio as the average of the individual qmd ratios of the plots receiving that treatment. After plotting the result, we chose one threshold that separated the resulting patterns of probability, intensity and qmd ratio into two groups with maximum differences and created rules for both groups. For each combination of country, biogeographic region, and species, we thus ended up with 4 sets of rules, 2 for clearfelling and 2 for thinning.

Figure and Figure 1 show an example of the procedure for Germany, Atlantic + Continental region, Norway spruce-dominated forests, resulting in the rules shown in Table . In addition, we calculated the average probabilities of thinning and clearcutting and the intensity of thinning for all country-biogeographic region combinations for a broad characterization of the observed differences within Europe.

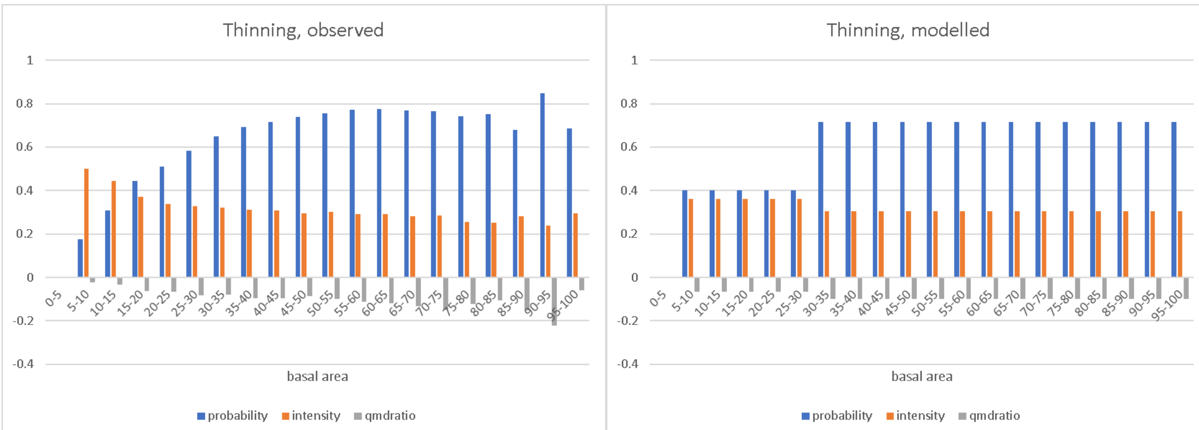


Figure 3.1 Example of thinning rules as derived for Germany, Atlantic + Continental, Norway spruce-dominated forests. Left the pattern as derived from the raw data, right the resulting rules, using a basal area threshold of 30 m^2 ha^{-1}. The probability shows the probability of a harvest event being carried out (unitless) with interval 12 years in the case of Germany, the intensity is the fraction of basal area removed during the event (unitless) and the qmd shows the ratio between the mean dbh of the trees removed and the mean dbh of the stand before harvesting (unitless) according to equation 1.

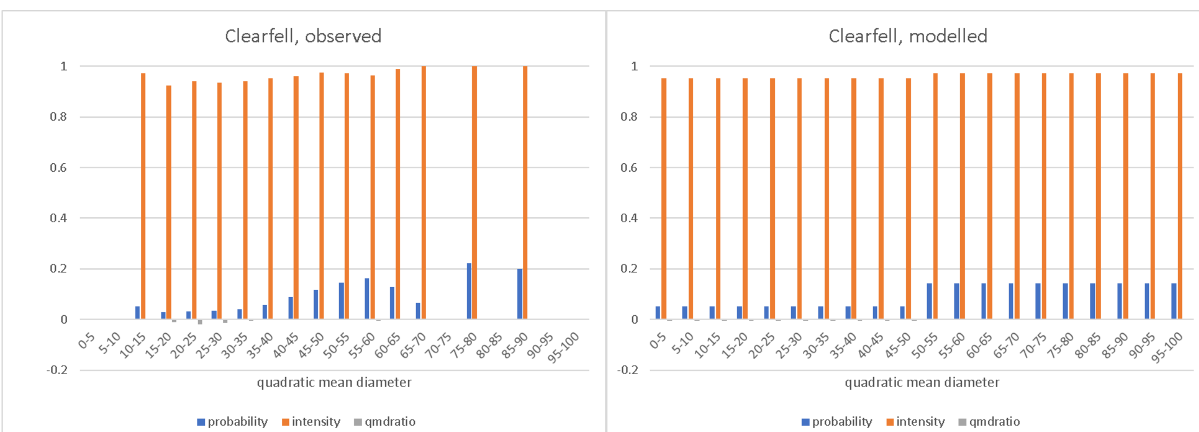


Figure 1.2 Example of clearfelling rules as derived for Germany, Atlantic + Continental, Norway spruce-dominated forests. Left the pattern as derived from the raw data, right the resulting rules, using a qmd threshold of 50 cm. The probability shows the probability of a harvest event being carried out (unitless) with interval 12 years in the case of Germany, the intensity is the fraction of basal area removed during the event (unitless) and the qmd

shows the ratio between the mean dbh of the trees removed and the mean dbh of the stand before harvesting (unitless) according to equation 1.

Table 3.1 Example of thinning and clearfelling rules for Germany, Atlantic + Continental, Norway spruce-dominated forests, as derived from Figure 3.1 and 3.2. The probability shows the probability of a harvest event being carried out (unitless) given the interval specified, the intensity is the fraction of basal area removed during the event (unitless). A shape parameter of zero means a uniform thinning, while the more positive (negative) the shape parameter, the more the thinning is targeting the largest (smallest) trees.

Rule	Interval (years)	Action variable	Minimum value	Maximum value	Probability	Intensity	Shape
Clearfell 1	12	Qmd	0 cm	50 cm	5%	95%	0
Clearfell 2	12	Qmd	50 cm	1000 cm	14%	97%	0
Thinning 1	12	Basal area	0 m^2/ha	30 m^2/ha	40%	36%	-1
Thinning 2	12	Basal area	30 m^2/ha	1000 m^2/ha	72%	30%	-1

3.3 Results

Figure .3 gives an overview of the (annualised) probability of thinning and clearfelling by country and biogeographic region. In this graph, three clusters can be distinguished.

1. Regions with high probabilities of clearcuts and relatively low thinning probabilities (orange rectangle), connected to the dominant clearcut system in Scandinavia and the intensive (conifer) plantations along parts of the Atlantic coast (Ireland, France, and Spain).

2. Regions with a low management intensity, i.e., low probability of both clearcut and thinning (green rectangle). This is connected to topographical restrictions, given that the cluster represents the entire Alpine region, as well as steep slopes in the Norway Atlantic region. Additionally, climate may play a role as Mediterranean regions are also found in this cluster.

3. Regions with high thinning probabilities and low clearcut probabilities (blue rectangle). These are found mostly within the Atlantic and Continental zones in Western and Central Europe. This may be a result of generally positive growing conditions and limited physical restrictions to harvesting. Forests in this zone can be managed using a variety of silvicultural systems and with different purposes, very much depending on the country. It contains multi-purpose forests in densely populated areas as well as production forests with long rotations.

Important country differences are also visible in Figure 3.4. There is a negative relationship between the probability of thinning versus intensity. In other words, infrequent thinnings tend to be more intense. This relationship is visible within the regions with a low management intensity (i.e., Alpine and Mediterranean) but also within the Atlantic/Continental and Western/Central Europe areas. For example, forests in Poland, Czechia, and Denmark tend to be thinned frequently but with low intensity, while in the remainder of Western/Central Europe thinnings are infrequent and of intermediate intensity. This is in line with the findings by Suvanto et al. (submitted).

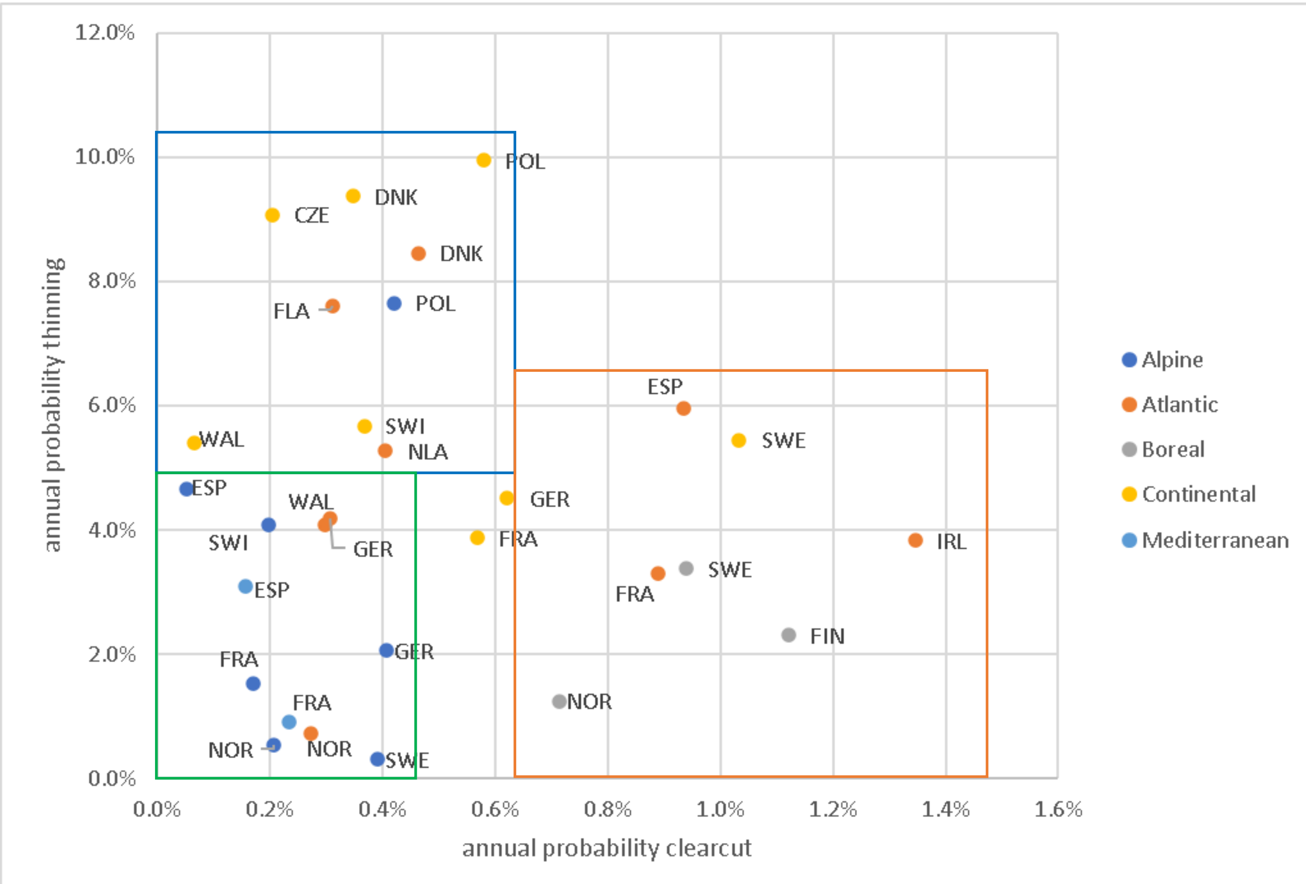


Figure 3.3 Probability of a thinning or clearcut being carried out (annualised for comparability) for combinations of biogeographic region and country (CZE=Czechia, DNK=Denmark, ESP=Spain, FIN=Finland, FLA=Flanders (Belgium), FRA=France, GER=Germany, IRL=Ireland, NLA=Netherlands, NOR=Norway, POL=Poland, SWE=Sweden, SWI=Switzerland, WAL= Wallonia (Belgium)). Rules in the orange rectangle show a high clearcut and a low thinning probability, rules in the green region have a low clearcut and low thinning probability and rules in the blue rectangle a low clearcut and a high thinning probability.

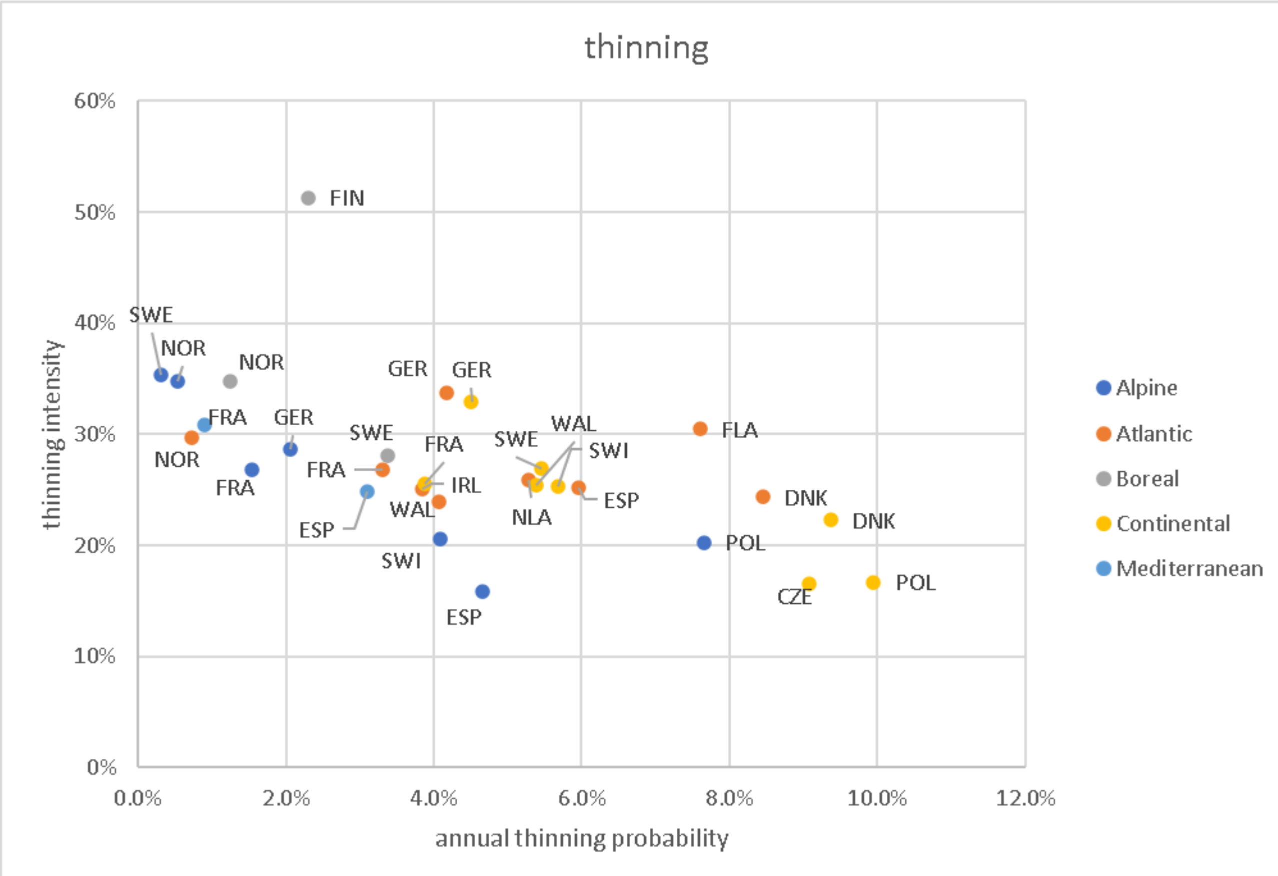


Figure 3.4 Relationship between annual probability of a thinning being carried out and its intensity for combinations of biogeographic region and country (CZE=Czech Republic, DNK=Denmark, ESP=Spain, FIN=Finland, FLA=Flanders (Belgium), FRA=France, GER=Germany, IRL=Ireland, NLA=Netherlands, NOR=Norway, POL=Poland, SWE=Sweden, SWI=Switzerland, WAL= Wallonia (Belgium)).

Our final set of harvesting rules contains 816 rules for a total of 13 countries. These rules are available upon request from the authors. If sufficient data is available for a specific group (defined by country, biogeographic region and species), patterns look consistent and logical. Typically, the probability of a thinning increases with increasing basal area, while the intensity tends to decrease (Figure). In addition, thinnings from below are more likely to occur as basal area increases. Absolute levels of probabilities and intensities vary per country and biogeographic region along the lines as sketched before. The number of clearcuts observed in the data is relatively low (4% of the number of plots), making the patterns less easy to interpret. A typical pattern shows low probabilities if qmd is low, with a rather clear increase beyond a certain threshold (Figure 1). This threshold can be interpreted as the target diameter for that species in that country and biogeographic region. Target diameters as specified in the rules are around 40 cm for light-demanding conifers and 50-60 cm for shade-tolerant conifers (Figure), but generally lower in Ireland, Denmark and in the boreal zone. For long-lived broadleaves the target diameters are in the range of 40-65 cm, but in the Mediterranean region 20-25 cm. Target diameters in short-lived broadleaves range from 20 to 50 cm, without clear patterns in relation to species or regions.

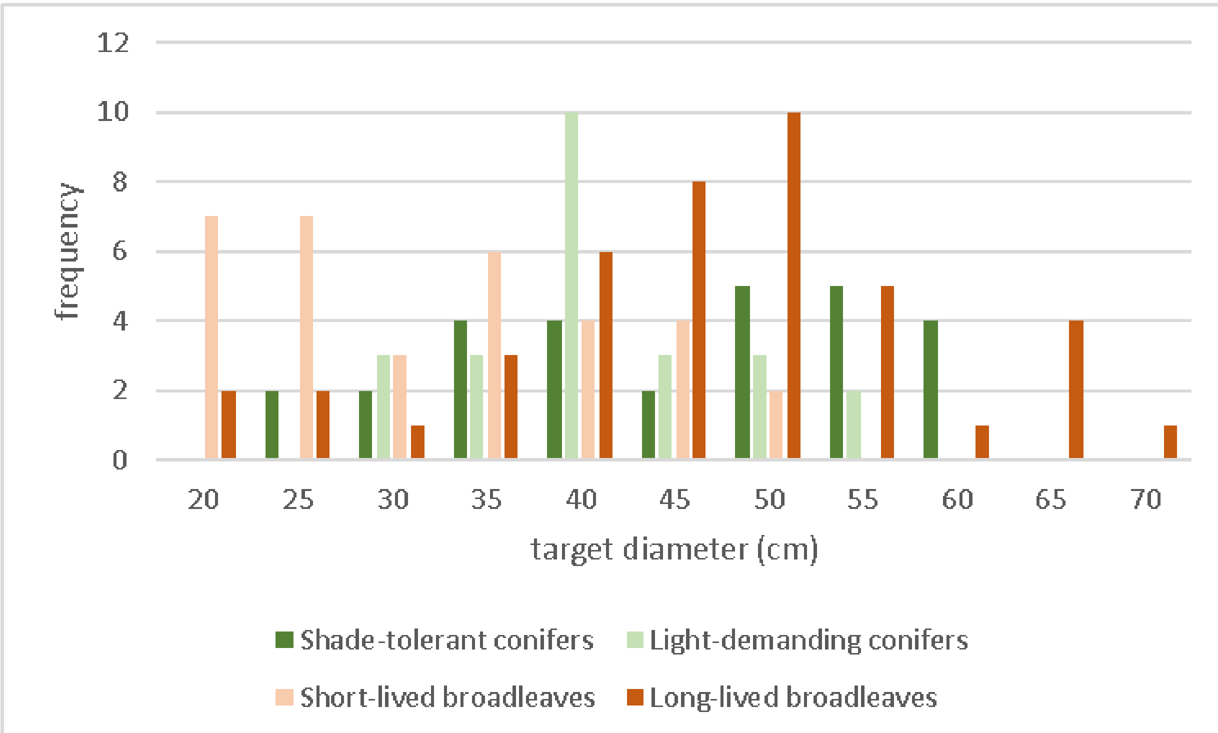


Figure 3.5 Frequency of target diameters as defined in the rules, split by species type. The group shade-tolerant conifers contain firs (Abies spp.), Douglas fir and spruces, the group light-demanding conifers contains pines and larch. Short-lived broadleaves contain birch, poplar and other broadleaves, while long-lived broadleaves contain beech, oaks, chestnut and Eucalypt.

3.4 Discussion

Harvest events as detected in the repeated NFI data are currently attributed crudely to either clearfelling or thinning, based on the basal area removed. Future analysis may focus on ways to determine the type of silvicultural activity more precisely, like shelterwood cutting or single-tree selection harvest, as for example done in the US by Belair and Ducey (2018). The development of such a method in Europe will be challenged by the variability of the NFI designs but could perhaps be assisted by remote-sensing maps such as developed in WP2. Despite our somewhat crude approach, our set of simple rules allows a realistic simulation of the observed patterns and harvest levels at the level of countries and biogeographic regions, as also demonstrated in D3.1 (Pugh et al. 2024). Moreover, the current set of rules allows easy manipulation of the harvesting activities by simply increasing or decreasing probabilities, intensities or thresholds, and even allows the application of rules from a different region or country. One drawback of our approach is that the interval for the rules is equal to the census interval. Therefore, the interval does not express the actual management cycle as used by forest managers in the country. Multiple harvest events between two censuses will be detected as a single event. This may be problematic in cases where the harvest cycles are short compared to the census intervals, although the overall level of extraction should be minimally affected.

Our approach allows to mimic observed harvest patterns over Europe, taking into account the variability as caused by species, climate conditions and national differences. Although our approach is able to show clear differences among countries and biogeographic regions as a whole, it does not provide any information about the variability within the region itself. Such variation may occur among others due to different preferences and behaviour of individual owners, but no consistent data layers are available to investigate such effects in more detail.

4 Narratives on suitable CBS management and factors influencing implementation

4.1 Data collection: workshops with forest practitioners in the Demo Cases

Four workshops were organized between April and May 2024 in 4 case study countries (Demo Cases): The Netherlands, Romania, Finland, and Italy. The workshop in Italy was held in the island of Sardinia, as the agroforestry systems present this island are a good representation of those found in the mediterranean region, more specifically South of Portugal and South of Spain, Greece, or Croatia.

As described in T1.2.2 Exchanging knowledge and co-designing CBS options of the Grant Agreement, the objective of the workshops was to allow knowledge dissemination about scientific literature on the contribution of forest management practices to carbon sequestration, climate change adaptation, and biodiversity protection and habitat creation. The workshops also allowed contextualisation of barriers and enablers encountered by forest owners and practitioners to manage forests in different countries and to complement interview findings (reported in D1.2). By promoting the interaction between participants, the workshops also contributed to peer-to-peer learning and knowledge exchange and revealed areas of consensus and disagreement between workshop participants. Workshop participants were selected by stakeholder analysis by the Demo case leaders and WP1 partners. The workshops in the Demo cases consisted of two main activities, namely a discussion with participants indoors and a discussion with the participants outdoors in related forest field sites. The indoor sessions generally focussed on discussions around the definition and exploration of the CBS concept, while the outdoor session was focussed on the fieldtrip to discuss the suitability of CBS forest management on the ground. The discussions outdoors and indoors covered similar topics but occurred in different formats. Details on the workshops are described in the Table below:

Table 4.1 Workshops details

Country	Date and collaborations	Number of participants, type of participants	Venue and field sites	Forest characteristics	Land ownership
The Netherlands	04/042024. Embedded in an event organised by the *Koninklijke Nederlandse Bosbouw Vereniging* (Royal Dutch Forestry Association).	N=15. Forest practitioners, researchers, forest managers, forest owners.	Indoors: restaurant *Hooghei* near St Michielsgestel. Outdoors: the nearby municipality forest.	Mixed stand forests composed of a (previous) dominant layer of Scots pine with abundant advanced regeneration of birch, chestnut, beech, and other tree species as a result from past management actions to increase the tree species diversity.	Municipality (public ownership by local government)
Romania	17/05/2024. Co-organized with Horizon Europe funded project "*Sustainable Development Goals - Enhanced monitoring through the family of Copernicus Services*".	N= 15. Landowners (local community, private individuals, commons, private companies), forest managers (State Forest services, local community forest service), control agencies (Forest Guard), certification systems (FSC Romania).	Indoors: Experimental Research Station of the Transilvania University of Brasov, outside Brasov city. Outdoors: 2 marteloscope sites[4]	Mixed deciduous forest composed of oak and hornbeam, and pure European beech stands. The forest area is protected as it is considered important for biodiversity conservation. Area is included in a natural reserve and designated as Natura 2000.	The forest sites are owned by the municipality (public ownership by local government)
Sardinia - Italy	23/05/2024. In collaboration with the Municipality of *Alà dei Sardi*.	N=23. Small-scale forest owners, representatives from AGRIS-Research Institute and Fo.Re.STAS Regional Forestry Agency and cork producers, academics and PhD and MSc students from local universities.	Indoors: village hall in Alà dei Sardi Outdoors:'Sos Onorcolos-Sas Codineddas' forest.	Cork oaks stand (*Quercus suber L.*). These are managed as agroforestry systems and provide multiple ecosystem services, namely hunting, mushroom foraging, and biodiversity. Mediterranean and continental climates.	Privately owned (private forest), the owners were members of a forest owners' cooperative.
Finland	24/05/2024. In collaboration with Metsäkeskus.	N=23. Forestry students from local universities, forest owners and forest extension practitioners.	Indoors: Lusto Finnish Forest Museum, Outdoors: Punkaharju research park.	Not discussed in the workshop.	Research Park

[4] http://iplus.efi.int/marteloscopes-data.html

The format of the indoors workshop was adjusted to each country by Demo country leaders and co-host. These are described below (order of country follow date of the event):

The Netherlands

The workshop indoors was organised in two phases. In the first phase, participants were split into three groups. Each group was assigned one of the three pillars of CBS: climate change mitigation, adaptation of forests to climate risks and biodiversity conservation respectively. Each group was asked to develop the ideal management for the CBS pillar assigned to them for the forest sector in the Netherlands, assuming no constraints/barrier to their implementation. Afterwards, the groups were asked to identify the current barriers and enablers to implement this ideal management. In the second phase of the indoor session, the three groups from the first phase were regrouped into two groups, in such a way that each group had participants from each of the previous three groups during the first session. Afterwards, the groups were asked to combine the three pillars and develop the ideal forest management to actualise them in the Netherlands context. They were free to combine or separate functions as needed, and free to emphasise specific pillars if they thought it was important. The questions discussed in the workshop indoors were: 1) Where would they focus on which pillar? 2) Where would they combine them? 3) Which pillar gets priority? And 4) Would they favour land sharing or land sparing options? In the outdoor session, participants visited the nearby forest, owned by the municipality, and had the opportunity to ask the forest manager about the practicalities of implementing a network of deadwood, as well as the benefits provided, the barriers for implementation and the supporting factors.

Romania

The event started with the indoor session and a 20min presentation about the concept and objective of the ForestPaths project. The presentation contextualised the ForestPaths project, stressing the need to improve forest management and policies and explain the CBS concept and its three pillars: Mitigation – Biodiversity – Adaptation. Finally, participants were introduced to some of the most common forest management rules in Romania and their outcomes. The outcomes were presented to make practitioners to think beyond the technical facets of management and assess the effects on the three pillars (mitigation, adaptation, and biodiversity) and therefore to assess their fitness to CBS but also to defend any new proposed CBS measures (i.e., a proposed measure which does not have a positive effect on at least one of the pillars - is not part of CBS). Following the presentations, detailed information was provided to the workshop attendants on the implementation of ethical consideration guiding how data emanating from the workshop will be handled and processed.

The outdoors session was held in two marteloscope plots: a mixed deciduous specie stand and a pure European beech stand. The participants were split in two groups. Each group included as many types of participants as possible. All participants were given a clipboard with a printed table prefilled with the forest management rules presented during the indoor session and with free lines for adding new proposals for CBS in Romania. A short introduction to marteloscopes (using the dedicated app – I+ Trainer) and their usefulness for practitioners was also provided to participants. During the outdoor session, workshop attendants were asked to identify CBS forest management options they will employ in managing the forest and discussed them without thinking of any enablers or barriers. The discussion considered the most common disturbances (foreseen in the future) occurring in the forest. Next, each of the options presented during the first session and any newly identified CBS measure (during the field visit) were assessed for effects on mitigation, adaptation and biodiversity conservation. The assessment was scored qualitatively as "+" = positive effect, "-" = negative effect, and "0" =no effect. After the individual assessment of each of these options, the groups returned to the research station for the final session of the workshop. During this session, enablers and barriers for the existing and newly identified CBS options were described. Each option identified was discussed separately, and opinions were recorded by the meeting moderator. After the meeting, the data from field tables (with the information completed by participants) was pooled together to assess the effects of each option on each of the three pillars (mitigation, adaptation, and biodiversity). The usefulness for CBS was weighed based on the share of positive (or at least not-negative) effects for each pillar (i.e., best option would be positive for all; second best options which are beneficial for one/two pillars but no negative effect on the other(s).

Italy- Sardinia

The indoor session focused on the understanding of forest management options under changing climate and collaboratively identify forest management options that can benefit mitigation and biodiversity, also highlighting barriers and enablers (in terms of governance, knowledge sharing, legislation, and policy support) to their implementation. The first presentation illustrated the concept and objective of the ForestPaths project and also highlighted the need to improve forest management under new contexts and explaining the CBS concept. A subsequent presentation discussed the main results obtained during the stakeholder interviews collected in Sardinia under DLV 1.2. Finally, participants were split into three groups who, facilitated by a moderator, discussed three main themes:

1) What are the main impacts of climate change on forest experienced in the region?
2) How should forest management be changed to respond to perceived climate change risks?
3) What forest management practices should be implemented to increase biodiversity?

The three groups reconvey in plenary to summarize and discuss the main findings, and, in the second phase of the indoor session, the participants discussed and analysed the main obstacles and enablers to the implementation of the identified options, considering biophysical, social, economic, and political aspects, using the interactive tool Mentimeter. The outdoor session entailed a visit to the FSC certified cork oak sustainable forest which is a 460ha forest estate managed by the municipality of *Alà dei Sardi* (a unicum in Europe). During the discussion, participants covered various aspects of cork and forest management, highlighting both the techniques used and the challenges faced.

Finland

The aim of the workshop was to gather information on the factors influencing forest management decisions by forest owners and other stakeholders, as well as inform forest owners on new methods and expected changes affecting forestry due to climate change and EU policies. The workshop happened indoors and outdoors. First, research on the effects of climate change on forests, how forestry measures can adapt to climate change, and ongoing policy changes were presented in the auditorium of Lusto museum (indoors session). The presentations were followed by group discussion in which participants identified enablers and barriers for climate and biodiversity-smart (CBS) forest management, highlighting the consensus on the necessity for sustainable practices and professional forest management advisory services, and by questionnaire survey to explore forest owners' perspectives on CBS forest management and to evaluate their changing perspectives and practicalities of CBS concept after being at the field site. Thus, the questionnaire survey was administered in two phases. In the first phase, questionnaire was disseminated in the indoor session to get their unbiased views of the CBS forest management concept. In the second phase, the questionnaire was disseminated during the outdoor session after they were introduced to the field sites and the implemented practical management options in the specific site. The indoor session also featured a video panel discussion among forest owners, show casing insights from the recent group discussions, hosted by Metsäkeskus expert Henna Höglund. The outdoor session included a tour in the Punkaharju research park, where participants learned about forest damages and alternative forest management methods at four field sites (extended rotation, root-rot infection, mixed forest plantation, carbon, and biodiversity – also bark beetle infected site was visited).

4.2 Data collection and analysis

Written notes were taken (manually) in each country's language (Dutch, Romanian, Italian, Finish) workshops by designated notetakers (notebooks) and by facilitators (flipchart sheets). In Sardinia (Italy), discussions happening indoors were also recorded. In addition, 2 ForestPaths partners acted as observers in each Demo case, taking written notes in English. Each Demo leader compiled a workshop report in English which was complemented with the observer notes. The report content was used to manually organize the qualitative data collected in 4 main themes:

- Perceived climate change risks, impacts and adaptation

- Options for improved CBS forest management
- Barriers for CBS forest management
- Enablers of CBS forest management
- Factors that could promote CBS implementation

The method used to organise the data collected during the discussions in themes and sub-themes was thematic analysis. This is a type of qualitative analysis that involves identifying core themes via the careful reading, and rereading, of the material collected (Fereday and Muir-Cochrane, 2006). It extracts meaning from qualitative data and includes identifying, sharpening, recording, and/or evaluation of recurring themes (Javadi and Zarea, 2016).

4.3 Results from the workshops[5]

4.3.1 The Netherlands

4.3.1.1 Perceived climate change risks

The effects of climate change were recognised by participants. Perceived climate change risks identified were windthrow, fires, and pests and diseases (especially in Scots pine). Participants considered that weather events such as droughts and rainfall events are more extreme and more common. They also noticed a drastic reduction in the snow days from 20-25 days per year, to 2-3 days of snow per year, as well as an increase of the dry period without rain to about 4 months covering the spring – summer period, with little or no rain and with very hot temperatures in the summer. Participants stated that summer climate is changing from a maritime climate (predominant westerly winds bringing colder and humid air from the North Sea) to aa more continental climate (bringing hot and dry air from Central Europe) and recognised that nature is already under pressure due to climate change and declining biodiversity.

4.3.1.2 Options for improved CBS management

In relation to the implementation of CBS forest management, participants considered that the best practices for adaptation were agroforestry, plant a mix of tree species resistant to drought and heat, connect forest patches, increase genetic diversity, favour tree species that produce easily decomposable litter, which would increase soil carbon and consequently improve soil health, the regulation of game density, which would ensure that game population levels are consistent with the carrying capacity of the soil. For

[5] Results per demo case presented according to date of event.

mitigation, participants considered practices such as planting fast-growing species such as Douglas fir, a tree which was considered good to sequester carbon and as a source of high-quality wood products, or to avoid harvesting during wet conditions to limit the release of soil carbon emissions, and afforestation. They speculated that pure production forests could be a potential practice to promote carbon storage but recognised that production forests can have lower adaptive capacity and therefore increase climate change risks. For biodiversity, the main practices considered were to leave deadwood and old trees in the forest, increase tree diversity, improved water and soil management, passive management, or no management, increase forest connectivity and promote multistorey forests with a certain degree of anarchy.

4.3.1.3 Barriers for CBS implementation

Barriers to implement CBS options include current subsidies to woody biofuels which were perceived to contribute to carbon dioxide emissions by promoting more use of low-grade wood quality. Nitrogen deposition was also pointed out as a barrier as it causes forest degradation and consequently decreases the mitigation potential. Nitrogen deposition is also detrimental of biodiversity. Participants recognised that climate change-related events such as droughts, heatwaves and waterlogging are constraining the implementation of practices that would favour mitigation and adaptation, such as establishing new forest areas and planting new species. Bureaucracy around the uptake of subsidies was also mentioned as a barrier for implementing alternative forms of management. Another barrier mentioned was the lack of a stable long-term holistic vision for the forest sector and the different, non-holistic, sectoral policies influencing parts of the sector to achieve short-term targets (e.g., mitigation). Participants considered that policy is focused on mitigation and on achieving mitigation targets rather than on other dimensions (e.g., adaptation). The lack of knowledge about the forest sector by policymakers was also mentioned, this being exacerbated by their high turnover in post. Participants pointed out the current tendency to manage forests as business-as-usual, neglecting the need to adapt to climate change, which will exacerbate climate change risks.

4.3.1.4 Enablers of CBS implementation

In the Netherlands, multifunctional forest management has been discussed and implemented for at least 30 years, and this has enabled the integration of the multiple dimensions of forests in management decisions. In terms of biodiversity, they mentioned the wide societal support (emotional, passion) for measures to protect and recover it.

4.3.1.5 Factors that could promote CBS implementation

Participants emphasised the need for climate change adaptation, including the need to promote a healthy and robust forest, as well as a healthy soil, as the basis for the provision of a wide range of ecosystem services. Participants considered the need for increased subsidies for afforestation and understory planting but recognised that policies and subsidies should focus on the outcomes, rather than on promoting certain measures that may not lead to the outcomes required.

4.3.2 Romania

4.3.2.1 Perceived climate change risks

Participants perceptions of climate change risk and impacts for forests include the increasing risk of droughts, especially impacting on newly established regeneration (by planting but sometimes also naturally as for example beech), increasing risks of pests and diseases such as dieback and /or insect outbreaks, and increasing risks of windthrow, especially impacting older forests. Participants considered that these disturbances are more frequent and more intense lately in Romania.

4.3.2.2 Options for improved CBS management

After discussions on existing forest management rules and practices, the following list of CBS options resulted:

1) Maintain/restore natural composition of stands is imposed by national norms.
2) For planting best site adapted native species are used.
3) Silvicultural treatments with natural regeneration under shelter are prevalent (group or uniform shelterwood, selection cuttings); clearcutting is restricted (in terms of size and species).
4) Harvesting (even for clearcutting) maintains stumps, roots and harvesting waste (branches, treetops); avoid soil erosion and damage to residual stand and undergrowth.
5) Principle of sustained yield (balanced proportion of age classes) imposed by national norms at management unit level.
6) Long rotations imposed by national norms (in general ≥100-120 year); virgin (old-growth) forests protected.
7) Conservation of deadwood in certain quantities (no “clean” forest), according to the stand development stage and forest condition.
8) Conservation of rare ecosystems in the forest: riparian vegetation, swamps, bogs woodlands, screes, small meadows inside forested landscapes, scrublands, sparse woodlands, old-growth forests.

9) During the last quarter of rotation, only sanitation cuttings allowed (= long periods of tranquillity).
10) Strict control of land use change by law and high costs of land-use change (= maintenance of forestland area and its connectivity).

Besides these, few more were identified during discussions:

11) Changing stand composition by:
    a. keeping species but changing species proportion.
    b. keeping species but mixing provenances.
    c. bringing new native species (assisted migration).
    d. bringing new exotic species.

12) Applying thinnings, at the right time and with the proper intensity.

4.3.2.3 Enablers of CBS implementation

Most CBS practices presented are already mandatory and therefore compulsory by the forest management plans and these include practices number 1, 2, 3, 4, 5, 6, 9 and 10. Practice no. 7 (conservation of deadwood) is required by the certification schemes and by legislation in the Natura 2000 sites plus in many cases extraction is not economically viable. In the case of practice no. 8, conservation of some types is also ensured by regulations (old-growth, bog woodlands, some sparse woodlands) while others are maintained by nature (land not appropriate for afforestation). Maintaining stand composition but mixing the provenances (11b) is possible but not explicitly proposed as CBS tool (i.e., as a rule). Applying tending operations with proper intensity and timely is also prescribed by forestry rules.

4.3.2.4 Barriers for CBS implementation

As most of the measures identified as CBS are not optional but mandatory by law, it seems that not too many barriers exist for their implementation. However, the lack of financial support (incentives or compensations) might hinder in the future their application on private lands or will make owners ask for changes in the legislation. For some other options proposed by participants, the main barriers identified were related to the strict legislation imposed on forest management and lack of flexibility to experiment alternative management options on the ground. For example, the forestry guidelines for plantations enforce the use of best adapted species (including bringing new species if site conditions have changed) but at the same time prescribe (and therefore restrict) the species to be used. Therefore, changing stand composition by bringing new native species (no. 11c) or new exotic species (no. 11d) are not allowed by legislation. More flexibility would enable such measures. Maintaining stand composition but change species proportion (11a) is also difficult and flexibility is required. In the case of practice 12, operational costs, bureaucracy and scarcity of skilled workers were identified as barriers for implementation (mainly at early stages when interventions have no economic benefit – resulting timber not valuable).

4.3.2.5 Factors that could promote CBS implementation

Participants considered that legislation should change and become less strict for them to able to implement some alternative forest management practices. For most CBS options (mandatory now) they considered that financial support (incentives, or compensations) would be essential (i.e., a true enabler) to keep implementing them in the future. They suggested the funding to come from the EU but also offered some solutions from local funding (the so-called environmental fund) which exists, but it is not being distributed for improving forest management among private owners and practitioners, in Romania.

4.3.3 Sardinia - Italy

4.3.3.1 Perceived climate change risks

Participants perceptions of climate change risks and impacts for forests in Sardinia include higher incidence of pests and diseases such as the *Phylloxera quercus* in cork oak, pests and diseases in sweet chestnut (ink disease), causing chestnuts to dry, anticipation of flowering by 1 month in sweet chestnut, changes in the behaviours of certain pests (insects), changes in tree growth affecting the cork quality in cork oak, increased fire risk, biodiversity loss and change in rainfall patterns. Participants recognised the need for climate-smart management practices, especially those contributing to adapt to increasing climate change-related risks such as fire.

4.3.3.2 Options for improved CBS management

Participants considered that the increasing abandonment of the territory is leading to an increased fire risk which threatens biodiversity. They identified various feasible CBS forest management approaches, namely as active forest management, respect for the vegetative cycles rather than following strict legislation, implementation of fire breaks, increasing the tree mix, and promoting integrated land use (including animal grazing).

4.3.3.3 Barriers for the implementation of CBS

Barriers to implement forest management practices included rural outmigration and loss of traditional knowledge and skills, scattered funding for forest management, land fragmentation, dated legislation and high cost of forest management. Currently traditional knowledge is hardly recognised by the official authorities.

4.3.3.4 Enablers of CBS implementation

The municipality's approach already emphasizes biodiversity, mixed stands, and contributions to the local bioeconomy. The municipality-managed forest (460 ha) has obtained FSC (Forest Stewardship Council) certification for sustainable forest management. This certification was achieved through the implementation of a forest management plan that ensures sustainable and responsible use of forest resources. The plan includes biodiversity conservation, pasture management, and other ecosystem activities. Additionally, a public-private cooperative named *Landhe*, is being established as the first example in Sardinia of collectively managing the forest. Forest owners revealed their deep spiritual connection with the cork oak trees and the landscape, emphasizing their strong historical bond with the forest. The local people respect the trees and understand when and how to extract the cork without causing harm. They consider that they "*don't just grow trees, they also communicate with them*." This communication involves understanding the signs and signals the forest provides, reflecting a deep relationship between the human and non-human components. They consider that their ability to read the forest is crucial for adapting to changing environmental conditions and that there is a risk of losing this knowledge due to current demographic trends and rural exodus. This underscores the importance of passing down traditional techniques through generations to maintain essential skills for this activity. Participants also highlighted the existence of traditional knowledge about fighting forest fires, which has been passed down through generations, underscoring its importance in forest management and conservation. They expressed frustration that local traditional knowledge is not always respected or integrated into official fire management strategies. They suggested that traditional knowledge should be formally certified and recognized.

4.3.3.5 Factors that could promote CBS implementation

Participants considered that payments for ecosystem services, establishment of forest cooperatives, joint forest management and associated plans covering contiguous small-scale forest area, educational activities for forest practitioners and training for forest workers should be in place to support the implementation of CBS forest management. They consider that financial support from the EU should support these activities, but this is not reaching rural Sardinia where improvements are required. One important contextual factor that should be strengthened and recognised, in the participants opinion, is traditional knowledge. Participants suggested that educational activities, knowledge sharing, forestry cooperatives, and improved dialogue between institutions and citizens should be in place to address the social and economic barriers. Additionally, to lessen these barriers, they called for improved legislation, increased research funding, economic incentives for forest management and more training for forest workers.

4.3.4 Finland

4.3.4.1 Perceived climate change risks and opportunities

Participants stated that climate change impacts such as increase in pest infestation, especially by bark beetles (*Ips typographus*) and spruce budworm (*Zeiraphera diniana*), which has become more common in many areas. They also pointed out to the increase of storm damage due to stronger winds and storms, causing more damage to forests, and from droughts which became more frequent and long lasting. They noticed that this is weakening the vitality of trees and increasing the risk of pest damage. Another impact of climate change is the shorter winters, including a shorter snow season and a shorter frost duration, which they believe is affecting forest ecosystems in several ways. Other reported impacts by participants include wind damage, spruce dieback, reduced soil frost layer, decreased grouse populations, and difficulties in transporting timber from logging sites.

Participants also identified some climate change opportunities, namely an improvement in tree growth in some areas, possibly due to the longer growing season and increased carbon dioxide levels (fertilisation). They also observe changes in the distribution of tree species, with some species moving further north, and believe this can bring opportunities regarding the adoption of new tree species and forest management practices. Participants considered the opportunity of generating income without having to harvest the wood (through carbon markets), as well as opportunities for the creation of more diverse forests for adaptation purposes, which could be more attractive for tourists and recreation.

4.3.4.2 Options for improved CBS management

Forest practitioners' suggestions for changing forest management to **adapt** to climate change and **protect biodiversity** include:

- **To increase mixed-species forestry:** increase biodiversity and improve the resilience (adaptation) of forest ecosystems.
- **Change harvesting methods:** Reducing clearcutting and favouring smaller-scale harvests. Strip harvesting and natural regeneration.
- **Tree species selection:** Choosing the right tree species for the site and reducing spruce cultivation were common suggestions, including to experiment with new tree species and breeding native trees.
- **Timing and intensity of forest management measures:** More cautious thinning, timely forest management, and ensuring forest health.

- **Increase deadwood:** Increasing the amount of deadwood to provide habitats for many species.
- **Use continuous cover forestry:** Applying continuous cover forestry for forest regeneration instead of clearcutting.
- **Favour nature-based forest management methods:** The use of nature-based methods, such as natural regeneration and silvicultural treatments.
- **Other practices for climate change adaptation:** Reducing the moose population, preventing forest damage, increasing research, tree breeding, fertilization, developing soil cultivation methods, and using artificial intelligence in forestry.
- **Other practices for biodiversity protection:** Establishing buffer zones, smaller cutting areas, diverse tree species selection, leaving game thickets, adding deadwood using artificial logs, utilizing protected trees and protective forests, conserving valuable forest nature sites and buffer zones, timing and adjusting the intensity of forest management.

4.3.4.3 Barriers

Participants identified the main barriers for the implementation of climate change adaptation and biodiversity protection in the forest sector. These include current forest owners' (and other forestry actors) **attitudes**, which are not always supportive CBS forest management. Additionally, old habits and customs (**traditions**) and resistance to new methods were believed to hinder adaptation and biodiversity protection, as well as the **average age of forest owners** considered a blockage to the introduction new practices for the future generations. Participants also mentioned the **lack of awareness** of climate change impacts **and the lack of knowledge** on suitable forest management practices that could support climate change adaptation and/or promote biodiversity. They believed that forest owners do not always know how and what they should change in their forest management to adapt to climate change and believed that CBS forest management practices were more expensive (**costs**) than traditional methods. Participants also pointed out that forest disturbances (**climate change impacts**), such as pests and diseases, can hinder adaptation efforts, that the long rotation period (**long-term land use**) of forests makes it difficult to make rapid changes and that the unpredictability of nature and the **uncertainty of climate change** can make it difficult to develop adaptation strategies. The industry demand and wood requirements were also believed to constrain adaptation. Specific barriers for biodiversity promotion include high **deer numbers** (and other species), which can damage trees and habitat and consequently biodiversity, and **uncertainty about the market** situation for wood in the future, which may prevent forest owners from investing in biodiversity conservation.

4.3.4.4 Enablers of current implementation of CBS

Not discussed/Not included in the notes.

4.3.4.5 Factors that could promote CBS implementation

Participants identified the supporting factors that should be in place to enable the implementation of CBS forest management. Participants considered that easily accessible, reliable, and clear information and knowledge and education about CBS forest management should increase, and suggested **training** and the provision of practical **guidance and advice** for forest owners, forestry professionals, and forest industry actors. They suggested that **cooperation and partnerships** between forest owners, forestry actors, authorities, and researchers, and between trusted partners (e.g., MHYs), forestry companies, and authorities, should be in place to provide the information, advice, and support required. More specifically, participants considered that **professional forest management advisory services** should be established to support the implementation of CBS. Participants considered that **financial incentives** should be available to support carbon sequestration and biodiversity promotion, financial compensation for forest protection and nature-based forest management, and financial benefits from adopting new tree species and forest management methods. Participants consider that there is a need for more research to better understand the complex interactions between climate change, forestry practices, and forest ecosystems. Other factors mentioned by participants include to reduce the deer population, research and development of new tree species and new forest management methods, forest protection and voluntary conservation, and for the wood processing industry to start valuing and using alternative tree species. Finally, they consider essential to create a vision for the future regarding the promotion of intergenerational thinking, including attitude's change and communication based on information.

4.4 Summary of contextual factors influencing practitioners' decision making about CBS implementation in the case study countries

Apart from exchange of knowledge about CBS, the workshops intended to discuss 5 main themes, namely:

- Perceived climate change risks, impacts and adaptation
- Options for improved CBS forest management
- Barriers for CBS forest management
- Enablers of CBS forest management
- Factors that could promote CBS implementation

From the discussion of these main themes the main findings are highlighted below.

4.4.1 Perceived increased risks from climate change

Workshop participants in the 4 case study countries perceived an increased climate change risk for forests (e.g., wildfire risk, drought risk) and clearly listed the observed impacts of climate change in forests. These impacts, however, differ depending on the country. In **The Netherlands**, workshop participants, the observed impacts were windthrow, fires, and pests and diseases (especially in Scots pine). In **Romania**, workshop participants highlighted the increased risk of droughts and the impacts of pests and diseases such as dieback and insect outbreaks, and windthrow in older forests. In **Sardinia (Italy)**, the impacts highlighted by workshop participants were the incidence of pests and diseases such as the *Phylloxera quercus* in cork oak, and the ink disease in sweet chestnut, which are important tree species for rural livelihoods in the island. They also had a strong perception of an increased forest fire risk. In **Finland**, impacts such as pest infestation, strong winds, storms, and long-lasting droughts, were the main experienced impacts mentioned by workshop participants.

4.4.2 Climate change opportunities

Workshop participants in **Finland** were the only ones to also identify some opportunities from climate change, namely an improvement in tree growth in some areas, possibly due to the longer growing season and increased carbon dioxide levels (fertilisation). They also considered the opportunity of generating income without having to harvest the wood but through participation in carbon markets, as well as opportunities for the creation of more diverse forests for adaptation purposes, which could be more attractive for tourists and recreation.

4.4.3 Suitable CBS forest management according for workshop participants

Table 4.2 below shows the CBS forest management practices considered suitable in each country according to the workshop participants. Some practices as for example increased mixed species, leaving deadwood in the forest, reduce deer/moose population, were mentioned in more than one country. In Romania, most forest management practices identified as CBS and discussed in the workshop are imposed by legislation. Some of the CBS forest management practices identified as suitable in the countries were also included in the survey that was disseminated across Europe, these are leaving deadwood in the forest, continuous cover forest, buffer strips, long rotations, retention trees.

Table 4.2 CBS forest management practices identified in the case study countries[6]

Country	Perceived suitable CBS forest management	No. of workshops where the CBS practice was mentioned
The Netherlands	Agroforestry	
	Plant a **mix of tree species** resistant to drought	3
	Connect forest patches (**connectivity**)	2
	Increase genetic diversity	
	Favour tree species that produce litter	
	Control **game** intensity	2
	Planting fast-growing species such as Douglas fir	
	Avoid harvesting during wet conditions	
	Leave **deadwood** and old trees in the forest	3
	Water and soil management	
	Passive management or no management	
	Multistorey forests with some anarchy	
Finland	To increase **mixed-species** forestry	3
	Reducing clearcutting and favouring smaller-scale harvests	2
	Strip harvesting and **natural regeneration**	2
	Choosing the **right tree species for the site**	2
	More cautious thinning, timely forest management	
	Increase **deadwood**	3
	Use **continuous cover forestry** (in peatland)	
	Establishing **buffer zones**, smaller cutting areas, diverse tree species selection	2
	Reducing the moose population (**game**)	2
Italy	Active forest management	
	Respect for the vegetative cycles rather than following strict legislation	2
	Implementation of fire breaks (**buffer zones**)	2
	Increasing the **tree mix**	3
	Promoting integrated land use	
Romania	Maintain/restore natural composition of stands	
	Best site adapted native species are used for planting	2
	Silvicultural treatments with **natural regeneration** under shelter	2
	Clearcutting is restricted (in terms of size and species).	2
	Harvesting (even for clearcutting) maintains stumps, roots and harvesting waste (branches, treetops) - Retention trees	
	Avoid soil erosion and damage to residual stand and undergrowth	
	Principle of sustained yield	
	Long rotations	
	Conservation of **deadwood** in certain quantities (no “clean” forest)	3

[6] Countries appear according to the date of the event.

	Conservation of rare ecosystems in the forest	
	During the last quarter of rotation, only sanitation cuttings allowed (= long periods of tranquillity)	
	Maintenance of forestland area and its **connectivity**	2
	Changing stand composition	
	Applying thinnings, at the right time and with the proper intensity	

4.4.4 Barriers for CBS implementation

Even though the consensus about the need to adapt to climate change was evident, workshop participants pointed out for barriers to implement climate change adaptation measures. In **The Netherlands**, perceived climate change risks, by workshop participants, seemed to be related to the strong emphasis on the need of adaptation by practitioners, but they perceived current policies to have a negative effect on climate change adaptation. In **Romania**, workshop participants mentioned that inflexible legislation constrains climate change adaptation which, together with the lack of proper financial incentives/compensations, may hinder the future implementation of current CBS measures which are in place. In Sardinia (Italy), perceived climate change risks may explain why adaptation to climate change was considered the most important dimension of CBS forest management by practitioners at the workshop. Interestingly, workshop participants in **The Netherlands** also emphasised the importance of the adaptation dimension in the CBS forest management concept, recognising that a healthy and robust forest and healthy soil are the basis for the provision of a wide range of ecosystem services (including mitigation and biodiversity). In **Finland**, synergies between adaptation and biodiversity protection were also highly recognised. In Italy, workshop participants were concerned that the increased fire risk due to climate change is being exacerbated by the increasing land abandonment and lack of active management due to rural outmigration that impedes climate change adaptation.

4.4.5 Policy barriers

Current policies were unanimously considered as the main factor constraining the implementation of CBS forest management by participants in workshops in the 4 Demo Cases. In **The Netherlands**, workshop participants considered there is a mismatch for long-term holistic vision of the forest as well as an existing short-term and sectoral (non-integrative) policy vision. In **Romania**, concerns over strict legislation (which is limiting flexibility in decision making and is imposing costly management without compensation to forest owners) seem to make difficult the continuation of CBS forest management and consider the adoption of new CBS options. In **Sardinia (Italy)**, legislation was perceived to have a negative effect on adaptation, including the lack of public funding to promote active forest management, essential to ensure CBS implementation.

4.4.6 Influence of socio-economic, environmental and policy factors on CBS implementation

Table 4.3 Current barriers (-) and enablers (+), and future enablers (+) for the implementation of CBS forest management as perceived in the 4 Demo Cases (workshops)[7]

Forest management activities	Barriers (-)	Enablers (+)	Factors that should be there to promote implementation (future enablers) (+)
The Netherlands	-Perverse incentives (policy) -Bureaucracy around the uptake of subsidies (policy) -Non-holistic policies (policy) -Policy is focused on mitigation (policy) -Lack of knowledge about the forest sector by policymakers (policy)	-Societal support -Policy support (policy)	-Increased subsidies (financial incentives) -Subsidies coupled to measure outcomes
Romania	-Strict legislation (policy) - Lack of proper incentives or compensations	-Mandatory by law (policy) - Some options are enforced by FSC system in certified forests	-Change of legislation - Financial incentives/compensations
Italy (Sardinia)	-Rural outmigration -Loss of traditional knowledge (traditional knowledge) -Lack of recognition of traditional knowledge (traditional knowledge) -Land fragmentation -Cost of forest management (economic) -Dated legislation (policy) -Scattered funding (policy)	-Spiritual connection with forests (spiritual values) -Existence of traditional knowledge (traditional knowledge)	-Payments for ecosystem services -Establishment of forest cooperatives -Joint forest management of contiguous small-scale forest -Educational activities for forest practitioners -Training for forest practitioners -Financial incentives -Recognition of traditional knowledge.
Finland	-Negative attitudes towards CBS (attitudes) -Old habits and customs and resistance to new methods (attitudes) -Average age of forest owners (age) -Lack of knowledge/awareness of climate change impacts (lack of knowledge) -Lack of knowledge on suitable forest management practices (lack of knowledge) -Cost of CBS forest management (economic) -Deer numbers (ecological)	Not discussed	-Clear information, knowledge, and education about CBS -Training, guidance, and advice for forest practitioners -Cooperation and partnerships between practitioners -Professional forest management advisory services -Financial incentives -Reduce the deer -Research about new tree species and new forest management methods

[7] Countries are presented according to date of workshop.

Existing barriers (negative effect -) identified by forest practitioners to the implementation in the Demo Cases, as well as current enablers for CBS implementation (positive effect +) and factors that could support CBS implementation (positive effect +) are presented in the Table 4.3 below. In Finland, for example, workshop participants considered that cooperatives and forest owners' associations should be implemented to support CBS forest management, even though this is one of the countries with long tradition of forest owners' associations and cooperatives (see Kittredge, 2005).

4.5 Limitations of data collection in the Demo Cases

Differences in the format of the workshops and on how the questions were asked in each workshop decrease the reliability of data collected. In addition, not all the same types of qualitative data were collected. In some cases, there were no note takers, or the facilitator also took notes in flipcharts, or there were discussion groups left without a facilitator or a note taker. This inconsistency can introduce a degree of unreliability of data, subjectivity and other (non-reported methods for data collection). It would be important that in future activities workshop structure are more harmonized and ensure environmental social scientists are involved in designing, facilitating, reporting, and analysing qualitative data collected.

5 Synthesis and concluding remarks

5.1 Forest practitioner typologies

The analysis of a large-scale survey in 13 European countries resulted in the development of a forest practitioner typology that classifies owners based on their values towards different forest management objectives. The typology resulted in five distinct groups dubbed environmentally conscious passives, environmental implementers, traditionalist, maximisers, and societal satisfiers. What distinguishes these groups is the perceived importance towards a) different forest management objectives, b) the opinions of different referent groups, and c) resources required to implement forest management objectives.

In short, the forest practitioner typologies are distinct in the following ways. Environmentally conscious passives place importance on Regulating Ecosystem Services (RES) objectives. Environmental implementers place importance on RES objectives, the opinion of forestry networks, and the usefulness of market mechanisms. Traditionalist place importance on RES objectives and the opinions of society. Maximizers place importance on income objectives and the usefulness of market mechanisms. Lastly, societal satisfiers place importance on amenity objectives, the opinions of forestry networks, and the opinions of society.

The forest practitioner typologies, which represent groupings based on personal values, show a limited relationship to the actual management activities implemented on the ground. For example, all the forest practitioner typology groups are observed to engage in clearcutting, continuous cover forestry, and inactive management. Nevertheless, environmental implementers, traditionalist, and societal satisfiers were observed to engage in certain management activities to a greater degree than. This suggests that the effect of values on the implementation of different forest management activities is limited by additional factors beyond values.

When characterizing respondents from the different forest practitioner typology groups according to geographical regions, forest holding size, and tenure (i.e., if the respondent is a private forest owner versus a forest manager), the findings show the typology groups are composed of numerous heterogenous practitioner types, from different regions, holding different sizes of forest. Some characteristics are overrepresented in all the groups except maximizers, who appear to be a group without any observable overrepresentation, meaning they are an extremely heterogenous group of practitioners.

5.2 The importance of understanding contextual factors influencing forest management decisions

ForestPaths aims at co-designing forest-based policy pathways for climate change mitigation that simultaneously deliver biodiversity recovery, climate change adaptation as well as other ecosystem services such as raw materials for the economy. Forest resource characteristics, contextual factors, social goals, and economic values influence forest resource retention, allocation, management, and protection (Cubbage et al., 2007). Several factors have been identified by the literature review (Deliverables 1.1, 1.2) and by the survey, which constrain or enable the implementation of climate and biodiversity smart (CBS) management by forest owners and forest practitioners. Workshops in the demo cases captured unique contextual factors that also influence forest practitioners' decision-making on the implementation of CBS forest management.

Governments often require using policy instruments when the nature of goods and services (e.g., carbon sequestration, climate change adaptation, biodiversity protection) does not allow for efficient resource distribution in the market (market failure). There is a wide range of policy instruments that can be used by governments to ensure the implementation of sustainable land management, including climate and biodiversity smart (CBS) forest management. This may include to undertake a carrot (financial incentives such as subsidies) and/or stick (regulations) approach. The rationale for providing subsidies and other financial incentives to land managers for the implementation of sustainable land management is that the society, through their taxes, should pay for the ecosystem services it benefits from. However, not all types of land managers (e.g., forest owners, forest practitioners) respond in the same way to financial incentives. As the survey demonstrated, different types of forest practitioners are influenced by different factors. For example, maximisers are more influenced by financial incentives and markets, while traditionalists are more influenced by societal opinions.

Other values and beliefs play a role on how land managers behave, and some of these values are highly influenced by contextual factors. Therefore, in the development and evaluation of land-based schemes aiming at climate change mitigation, adaptation and biodiversity protection policy goals, it is crucial to understand what works in different contexts to ensure high uptake from land managers so the required policy outcomes (mitigation, adaptation, biodiversity protection) are achieved. The workshops in the demo cases helped to better understand the contextual barriers and enablers influencing land managers' decisions for sustainable forest management. According to literature, contextual factors strongly affect behaviour, levels of uptake, and success of different policy levers (e.g., Simmons et al., 2021).

Workshop findings show the different socio-ecological systems in which forest practitioners in Europe operate. For example, the role of traditional knowledge in adaptation to fire risk was highlighted as very important in Sardinia (Italy), while in Finland tradition was seen as a barrier for climate change adaptation. In both Finland and The Netherlands, the problem of deer number and the needs to reduce these were discussed (and this is common to other countries in Europe as for example United Kingdom) but there was no suggestion on how this could be dealt with. Finally, in both Romania and

Sardinia (Italy), participants mentioned the conflicting views between rural and urban dwellers about how forests should be managed. These conflicts can hinder the implementation of CBS forest management.

Models such as EVAST[8], which simulates the potential effects of government policies, more specifically UK Defra's Environmental Land Management (ELM) schemes, on ecosystem service stocks, flows and values, or CRAFTY[9], a large-scale agent-based modelling (ABM) framework for the simulation of land use change, use information on contextual barriers and enablers for the uptake of land management practices to develop the assumptions from generalisations that lead to model parameters.

Given that the objective of ForestPaths is to co-design policy pathways that can support the wider implementation of climate and biodiversity forest management in European countries, contextual factors must be taken into consideration when designing policies and schemes to promote the implementation in CBS forest management. Findings from the workshops can provide the following advice:

- Increasing tree species mixture, forest connectivity and deadwood amounts in forests, are consensually accepted by forest practitioners as effective forest management activities for promoting biodiversity, contributing to climate change mitigation and for increasing the adaptation capacity of forests.
- In European countries where there is high rural outmigration and high land fragmentation (e.g., Sardinia, North and Centre of Portugal, Galicia in Spain), forest owners' cooperatives and associations should be supported to undertake the management on behalf of absent owners, as well as other models of forest management such as joint management.
- In countries where local traditional knowledge about climate change adaptation and biodiversity protection exists (e.g., Sardinia, South of Portugal, Finland, Southwest Germany, Hungary), channels for capturing, disseminating, and including this knowledge in guidelines for good forest management practice should be provided, as well as channels for passing this knowledge to future generations.
- In countries with strict legislation for forest protection (e.g., Romania, Bulgaria, Greece), forest owners should be financially compensated, and legislation enforced, or instead legislation (sticks) could be replaced by incentives or awards for good practice (carrots).
- In countries where lack of knowledge prevails about the societal benefits of climate and biodiversity smart management, knowledge awareness programmes should be implemented.
- In countries where deer numbers are constraining natural regeneration of forests (e.g., The Netherlands, Finland, Scotland) limits to number of deer per hectare

[8] https://catalogue.ceh.ac.uk/documents/6838d805-92c1-44a5-b3d8-d7b8c02156e6
[9] https://landchange.imk-ifu.kit.edu/CRAFTY

should be introduced according to sustainable carrying capacity, or predators (e.g., wolves) should be reintroduced.
- In countries with conflicting urban and rural views about how forest should be managed (e.g., Italy - Sardinia, Romania), with urban dwellers calling for strict protection and conservation of forests while forest practitioners calling for more active management and higher intervention in forests, participatory processes should be adopted during policy development to resolve conflicts, to bring stakeholders to a consensus and to come up with solutions that everyone can support.
- In countries with high risk of forest fires (e.g., Sardinia, Portugal, Spain), native tree species such as cork oak should be protected and agroforestry systems (mixed forest and livestock or crops) should be incentivised through land-based schemes aiming at contributing to climate change mitigation, forest resilience and biodiversity protection, instead of forest monocultures.

The survey findings highlighted that country differences explain most of the differences in earlier implementation of climate and biodiversity smart forest management (CBS) by forest practitioners. Other explanatory variables from the survey included in the models were not able to capture these differences that were seen at the country level. Country differences may be related, for example, to geographical conditions, traditions, management guidelines, or differences in forest product markets. The findings from the survey and its lack of ability to explain why country differences are relevant justifies the need for further research on contextual factors influencing the implementation of CBS forest management through interviews and workshops with local practitioners across Europe. This is corroborated by the findings of the workshops held in the 4 case study countries (Demo Cases), namely The Netherlands, Romania, Italy – Sardinia, and Finland.

5.3 Narratives, decision rules, and parameters for modelling

Repeated NFI data showed considerable variation in harvest intensity across Europe. This variation could be explained for a large part by countries, biogeographic regions, and tree species. From the NFI data we therefore derived harvest rules and parameters for use in the EFISCEN-Space model as developed in WP3, split by country, biogeographic region and tree species. This set of rules and parameters allows the simulation of current harvesting patterns across Europe and gives the opportunity for easy implementation of the exploratory scenarios as defined in WP5. A similar exercise will be carried out in parallel for the LPJ-GUESS model. The grouping by country, biogeographic region and tree species works well, but these forests are owned and managed by a very heterogenous set of people, probably leading to variation inside these groups as well. Due to a lack of consistent (EU-wide) ownership maps, we could not allocate ownership types at NFI plot level, and thus we could not investigate differences in harvest behaviour in relation to ownership. However, the results of the survey do not provide a robust relationship between forest ownership, forest practitioner typology and actual management activities implemented on the ground. Instead, it seems that important differences exist among countries how forest owners and managers are and could be influenced in their management behaviour, as also evidenced by the outcomes of the workshops and the literature review. These insights will be translated into narratives, decision rules and parameters for the CRAFTY model. Within the development of the policy scenarios, CRAFTY is then expected to inform LPJ-GUESS and EFISCEN-Space on the (average) expected change in harvesting behaviour at the level the harvesting rules are implemented, i.e. countries, biogeographic region and tree species.

6 Acknowledgements

The authors would like to thank the workshop participants and workshop hosts in the four Demo Cases, as well as the survey respondents across Europe. In addition, the authors would like to thank the individuals involved in the translation of the survey into multiple languages.

7 Qualitative data availability statement

The reports from the workshops in The Netherlands, Romania, Italy (Sardinia), Finland, are accessible upon request to the lead author.

8 References

Agnoletti, M. (2022). Atlante dei boschi italiani. Gius. Laterza & Figli Spa.

Ajzen, I (2020). The theory of planned behavior: Frequently asked questions. Human Behavior and Emerging Technology: 2:314–324. *Human Behavior and Emerging Technologies 2*(4): 314–324. https://doi.org/10.1002/hbe2.195

Baker R., Brick M., Bates N., Battaglia M., Couper M., Dever J., Gile K., Tourangeau R. (2013) Summary Report of the AAPOR Task Force on Non-probability Sampling. Journal of Survey Statistics and Methodology 1(2): 90-143.

Bagozzi, R., Yi, Y. (2012) Specification, evaluation, and interpretation of structural equation models. Journal of the academy of marketing sciences 40:8-34. https://doi.org/10.1007/s11747-011-0278-x.

Bosnjak M, Ajzen I, Schmidt P (2020) The Theory of Planned Behavior: Selected Recent Advances and Applications. Europe's Journal of Psychology 16: 352–356. https://doi.org/10.5964/ejop.v16i3.3107

Cubbage, F., Harou, P., Sills, E. (2007). Policy instruments to enhance multi-functional forest management. Forest Policy and Economics. 9. 833-851. https://doi.org/10.1016/j.forpol.2006.03.010

Danley, B (2019) Forest owner objectives typologies: Instruments for each owner type or instruments for most owner types? Forest Policy and Economics 105: 72–8. https://doi.org/10.1016/j.forpol.2019.05.018

Dettori, S., Filigheddu, M.R., Muroni, A., Puxeddu, M., & Deplano, G. (2008). Quantità e qualità delle produzioni sughericole regionali. In S. Dettori & M.R. Filigheddu (Eds.), Alla Ricerca della Qualità nella Filiera Sughero - Vino. Atti del Congresso, Oristano, 12 maggio 2006 (pp. 15-32). Università di Sassari, Dipartimento di Economia e Sistemi Arborei.

Deuffic, P., Sotirov M., and Arts B. (2018). “Your policy, my rationale”. How individual and structural drivers influence European forest owners’ decisions. Land Use Policy 79: 1024–1038. https://doi.org/10.1016/j.landusepol.2016.09.021

Ekström, H., Danley, B., Clough, Y., Droste, N. (2024) Barking up the wrong tree? - A guide to forest owner typology methods. Forest Policy and Economics Volume 163:103208. https://doi.org/10.1016/j.forpol.2024.103208

Feliciano, D., Schelhaas, M.J., Starcevic, A., Staritsky, I., Uzquiano, S., Boonen, S., Lindner, M., Franzini, F., Lovric, M., Tiongco, J., Ofoegbu, C., Peltoniemi, M., Stancioiu, T., (2024) Forest management approaches across Europe. ForestPaths Deliverable 1.1

Fishbein, M. and I. Ajzen (2010). Predicting and Changing Behavior: The Reasoned Action Approach. New York, Psychology Press.

Fereday, J., Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: a hybrid approach of inductive and deductive coding and theme development International Journal of Qualitative Methods, 5(1), 80-92.

Franzini, F., Feliciano, D., Menini, A., Stancioiu, T., Wiersma, H., Häyrinen, L., Schelhaas, MJ., Lovrić, M., & Ofoegbu, C. (2024). Key factors influencing forest practitioners' decisions. ForestPaths project Deliverable D1.2.

Ingemarson, F., Lindhagen A., and Eriksson, L. (2006). A typology of small-scale private forest owners in Sweden. Scandinavian Journal of Forest Research 21(3): 249-259. https://doi.org/10.1080/02827580600662256

Hair, J., Babin, B., Anderson, R., & Black, W. (2018). Multivariate Data Analysis (8th Eds.). Cengage Learning EMEA.

Husa, M., Kosenius, A-K. (2021). Non-industrial private forest owners' willingness to manage for climate change and biodiversity. Scandinavian Journal of Forest Research, 36(7-8), 614-625. https://doi.org/10.1080/02827581.2021.1981433

Javadi, M., Zarea, K. (2016). Understanding thematic analysis and its pitfall. Journal of Client Care, 1: 33-39.

Jöreskog, K.G., Goldberger, A.S. (1975). Estimation of a model with multiple indicators and multiple causes of a single latent variable. Journal of the American Statistical Association, 70(351a): 631-639. https://doi.org/10.2307/2285946

Jöreskog, K.G. (1971). Simultaneous factor analysis in several populations. Psychometrika, 36(4): 409-426. https://doi.org/10.1007/BF02291366

Karppinen, H. (1998). Values and objectives of non-industrial private forest owners in Finland. Silva Fennica 32(1): 43–59. https://doi.org/10.14214/sf.699

Karppinen, H., S. Berghäll (2015). Forest owners' stand improvement decisions: Applying the Theory of Planned Behavior. Forest Policy and Economics 50: 275-284. https://doi.org/10.1016/j.forpol.2014.09.009

Kittredge, D. B. (2005). The cooperation of private forest owners on scales larger than one individual property: international examples and potential application in the United States. Forest Policy and Economics, Elsevier, 7(4): 671-688. https://doi.org/10.1016/j.forpol.2003.12.004

Kuuluvainen, J., Karppinen, H., Ovaskainen, V. (1996). Landowner objectives and nonindustrial private timber supply. Forest Science. 42(3): 300–309. https://doi.org/10.1093/forestscience/42.3.300

Kuuluvainen, J., Karppinen, H., Hänninen H., Uusivuori J. (2014). Effects of gender and length of land tenure on timber supply in Finland. Journal of Forest Economics 20(4): 363-379. https://doi.org/10.1016/j.jfe.2014.10.002

Molnar, C. (2023). Interpretable Machine Learning (Second Edition): A Guide for Making Black Box Models Explainable. https://christophm.github.io/interpretable-ml-book/index.html

Levers, C., Verkerk, P. J., Müller, D., Verburg, P. H., Butsic, V., Leitão, P. J., ... Kuemmerle, T. (2014). Drivers of forest harvesting intensity patterns in Europe. Forest ecology and management, 315: 160-172. https://doi.org/10.1016/j.foreco.2013.12.030

Metzger, M.J., Bunce, R.G.H., Jongman, R.H.G., Mücher, C.A., Watkins, J.W. (2005). A climatic stratification of the environment of Europe. Global Ecology and Biogeography, 14(6): 549–563. https://doi.org/10.1111/j.1466-822X.2005.00190.x

Pollastrini M, Chiavetta U, Cutini A, Casula A, Maltoni S, Dettori S, Corona P. (2018). Indicators for the assessment and certification of cork oak management sustainability in Italy. iForest 11: 668-674. https://doi.org/10.3832/ifor2587-011

Pommerening, A., Murphy, S.T. (2004). A review of the history, definitions and methods of continuous cover forestry with special attention to afforestation and restocking. Forestry, 77(1):27-44. https://doi.org/10.1093/forestry/77.1.27

Pugh TA, Schelhaas MJ, Arneth A, Dutca I, Eckes-Shephard A, Filipek S, König L, Jacobs S, Jönsson AM, Patacca M, Lerink B, Lindeskog M, Munoz Avilez R, Nabuurs GJ, Olin S, Peltoniemi M, Piltz K, Senf C, Starcevic A, Staritsky I, Viana-Soto A, Wittenbrink M, 2024. Enhanced and evaluated forest ecosystem models. ForestPaths Deliverable 3.1.

Simmons, B.A., Wilson, K.A., Dean, A.J. (2021). Psychosocial drivers of land management behaviour: How threats, norms, and context influence deforestation intentions. Ambio 50, 1364–1377 (2021). https://doi.org/10.1007/s13280-020-01491-w

Sotirov, M., Sallnäs, O., Eriksson, L.O. (2019). Forest owner behavioral models, policy changes, and forest management. An agent-based framework for studying the provision of forest ecosystem goods and services at the landscape level. Forest Policy and Economics: 10379–89. http://dx.doi.org/10.1016/j.forpol.2017.10.015

Suvanto S, Esquivel-Muelbert A, Schelhaas MJ, Astigarraga J, Astrup R, Cienciala E, Fridman J, Hentonnen HM, Kunstler G, Kändler G, König LA, Ruiz-Benito P, Senf C, Stadelmann G, Starcevic A, Talarczyk A, Zavala MA, Pugh TAM, submitted. Understanding Europe's forest harvesting regimes. Preprint available at https://eartharxiv.org/repository/view/5858/

Verdinelli M., Loi A., Luciano P., (2011). Le formiche nocive negli ecosistemi a Quercus suber della Sardegna. Atti XXIII Congr. Naz. Ital. Ent. Genova, 13-16 giugno 2011: 144.

Westin, K., Bolte, A., Haeler, E., Haltia, E., Jandl, R., Juutinen, A., Kuhlmey, K., Lidestav, G., Mäkipää, R., Rosenkranz, L., Triplat, M., Skudnik, M., Vilhar, U., Schueler, S., (2023). Forest values and application of different management activities among small-scale forest owners in five EU countries. Forest Policy and Economics. 146, 102881. https://doi.org/10.1016/j.forpol.2022.102881

Wiersum, K., Elands, B., Hoogstra, M., (2005). Small-scale forest ownership across Europe: Characteristics and future potential. Small Scale Forestry 4: 1–19. https://doi.org/10.1007/s11842-005-0001-1

9 Annex

9.1 Annex A: Questionnaire

[SURVEY INTRODUCTION]

Thank you for your interest in our survey.

Climate change is transforming European forests. This transformation has implications on future forest management decisions. The aim of this survey is to assess how forest management trajectories may evolve in response to climate change. The survey is distributed across thirteen European countries and collects views from forest owners, forest managers and the general public towards acceptable forest management practices.

The survey is led by the European Forest Institute (EFI) and Natural Resources Institute Finland (LUKE) under a collaboration between three European research projects: FORESTPATHS, FORWARDS, and HOLISOILS. Additional information is available on the project homepages:

FORESTPATHS: https://forestpaths.eu/
FORWARDS: https://forwards-project.eu/
HOLISOILS: https://holisoils.eu/

By completing the survey, you will support the development of European forest management recommendations. Your answers will only be used for research purposes. Answers cannot be linked to individual respondents. Your personal data is treated confidentially and is only available to project researchers.

FORESTPATHS receives funding from the European Union's Horizon Europe Research and Innovation Programme under grant agreement No. 101056755, as well as from the United Kingdom Research and Innovation Council (UKRI). FORWARDS receives funding from the European Union's European Research Executive Agency under grant agreement No. 101084481. HOLISOILS receives funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 10100289.

NEXT

[AREA 2 - RESPONDENT IDENTIFICATION (OWER/MANAGER/GENERAL PUBLIC)]

The following question determines if you represent the views of a *forest practitioner* or the *general public*.

1. Please identify yourself.	
☐	I own a forest.
☐	I am responsible for managing a forest, but I do not own the forest.
☐	Both of the above.
☐	None of the above.

NEXT

[AREA 3A – PREAMBLE: FOREST OWNERS]

You are representing the views of a private forest owner.

The survey contains four sections and takes approximately 15-20 minutes to complete. We recommend that you complete the survey on a desktop or tablet. You may begin the survey on a mobile device and switch to a desktop or tablet at any time.

- Section 1 asks about the characteristics of your forest.
- Section 2 asks about ongoing management activities in your forest.
- Section 3 asks about your views on forest management.
- Section 4 asks about your views on financial compensation for forest management.

NEXT

[AREA 3B – PREAMBLE: FOREST MANAGERS]

You are representing the views of a forest manager managing a forest owned by another party. Please note the survey refers to the activities carried out in the forest you manage as “your forest” and “your management objectives”, even though you do not own the forest.

The survey contains three sections and takes approximately 10-15 minutes to complete. We recommend that you complete the survey on a desktop or tablet. You may begin the survey on a mobile device and switch to a desktop or tablet at any time.

- Section 1 asks about the characteristics of the forest holdings you manage.
- Section 2 asks about ongoing management activities in the forest you are managing.
- Section 3 asks about your views on forest management.

NEXT

[AREA 4A – FOREST HOLDINGS: FOREST OWNER]

Section 1. The following section asks about the characteristics of your forest.

2. In which country is your forest located?

- ☐ Croatia
- ☐ Czechia
- ☐ Finland
- ☐ France
- ☐ Italy
- ☐ Germany
- ☐ The Netherlands
- ☐ Latvia
- ☐ Romania
- ☐ Spain
- ☐ Sweden
- ☐ Switzerland,
- ☐ The United Kingdom
- ☐ Other. Please describe: [---]

3. How did you become a forest owner?

☐	Transfer of ownership within family (e.g., family inheritance; purchase from family member)
☐	Purchase from entity outside the family
☐	Marriage
☐	Restitution
☐	Other. Please describe: [---]

4. Approximately how many years have you been a forest owner?

_________ years.

5. What is the approximate total area of forest you own?
___________hectares.

6. Are there areas of your forest that are left unmanaged? *In this context, unmanaged areas refer to areas where no silvicultural activities take place whatsoever, regardless of whether this choice is intentional.*	
☐	The entire forest is managed.
☐	The entire forest is unmanaged.
☐	Only some areas of the forest are unmanaged. Please estimate the total number of hectares that are unmanaged: [---]

NEXT

[AREA 4B – FOREST HOLDINGS: FOREST MANAGER]

Section 1. The following section asks about the characteristics of the forest you are responsible for managing.

2. In which country are the forest you manage located?

- ☐ Croatia
- ☐ Czechia
- ☐ Finland
- ☐ France
- ☐ Italy
- ☐ Germany
- ☐ The Netherlands
- ☐ Latvia
- ☐ Romania
- ☐ Spain
- ☐ Sweden
- ☐ Switzerland,
- ☐ The United Kingdom
- ☐ Other. Please describe: [---]

3. **Who owns the forest(s) you are managing?** (tick all that apply)	
☐	Public ownership by the state at national level.
☐	Public ownership by the state at sub-national level.
☐	Public ownership by local government (e.g., municipality or equivalent).
☐	Private ownership by individual or family.
☐	Private ownership by private business entity.
☐	Private ownership by private institution (e.g., church, foundation, etc.).
☐	Contested ownership (e.g., due to restitution or family inheritance dispute).

☐	A family member
☐	I do not know who owns the forest.
☐	Other (please specify):

4. Approximately how many years have you been a forest manager?
___________years.

5. What is the approximate total area of the forest(s) you manage?
___________hectares.

6. Among the forests you manage, are there areas that are left unmanaged? *In this context, unmanaged areas refer to areas where no silvicultural activities take place whatsoever, regardless of whether this choice is intentional.*
☐ The entire forest is managed.
☐ The entire forest is unmanaged.
☐ Only some areas of the forest are unmanaged. Please estimate the total number of hectares that are unmanaged: [Open-ended. Number responses only]

NEXT

[AREA 5 – PREVALENT FOREST TYPE: OWNERS + MANAGERS]

Section 2. This section asks about ongoing management activities in your forest.

The following page asks you to identify the **prevalent forest type** within your forest property. In this context, the **forest type** is composed of forest stands that share similar tree species composition and forest structure. The **prevalent forest type** refers to the **forest type** of the largest area within your forest property. Please answer the following questions with your **prevalent forest type** in mind.

7. What is the dominant tree species found in the prevalent forest type?
[Dropdown list of 5-6 species, queries according to the forest country]

8. What is the secondary tree species found in the prevalent forest type, if any?
[Dropdown list of 5-6 species, queries according to the forest country]

9. Approximately how much area of the prevalent forest type does the dominant tree species cover?	
☐	More than 80% of the prevalent forest area.
☐	Less than 80% of the prevalent forest area.
☐	I do not know.

10. Are the stands in the prevalent forest type primarily even-aged or uneven-aged?	
☐	Even-aged (i.e., more than 80% of trees within a stand are of similar age and size).
☐	Uneven-aged (i.e., more than 20% of trees in a stand are of dissimilar age and size).
☐	I do not know

11. **What is the estimated area of the prevalent forest type within your total forest property?** *Note: the area of the prevalent forest type cannot exceed your total forest property.*
________hectares.

In the previous question, you described your prevalent forest type. Next, select the typical forest management activities implemented in the prevalent forest type. Typical activities refer to the most frequently implemented option among the list of choices.

12. What is the typical cutting regime used within the prevalent forest type?
A) Clear felling
B) Clear felling with retention of seed trees
C) Group selection
D) Shelterwood
E) Single tree selection
F) No cutting regimes
G) I don't know

13. What is the typical thinning regime used within the prevalent forest type?
A) Thinning from above (selects larger trees for harvest, leaving smaller trees on site)
B) Thinning from below (selects smaller trees for harvest, leaving larger trees on site)
C) Thinning of all size classes
D) No thinning regime
E) I don't know

14. What is the typical regeneration method used within the prevalent forest type?
A) Natural regeneration
B) Plantings
C) Seedlings
D) Coppice
E) I don't know

15. Is the prevalent forest type typically regenerated using native or exotic tree species?
A) Native species
B) Exotic species
C) A mix of both
D) I don't know

16. What is the most typical type of planting material used to regenerate the prevalent forest type?
A) Regular, non-certified planting material (e.g., no preference for genetic material)
B) Regular, certified planting material (e.g., recognized national provenances)
C) Improved planting material (e.g., from national tree breeding program)
D) Certified endemic material
E) Non-endemic material
F) I don't know

17. Species composition
A) Maintaining current forest species composition
B) Shifting towards broadleaves dominated forest
C) Shifting towards conifers dominated forest
D) Shifting to mixed species forest
E) I don’t know

18. What is the typical post-disturbance management approach used within the prevalent forest type?
A) Salvage logging with planting
B) Salvage logging with natural regeneration
C) Leaving all wood with natural regeneration on the area affected by disturbances
D) No post-disturbance management
E) I don’t know

19. What is the typical agroforestry system used within the prevalent forest type?
A) No agroforestry system
B) Livestock grazing
C) Alley cropping
D) Combination livestock grazing and alley cropping
E) Other agroforestry systems
F) I don’t know

20. What is the typical deadwood management system used within the prevalent forest type?
A) Retaining of deadwood
B) Proliferation of deadwood

C)	Removal of deadwood
D)	I don’t know

21.	**What is the typical stand tending system used within the prevalent forest type?**
A)	Removal of undergrowth (e.g., clearing shrubbery)
B)	Precommercial thinning
C)	Neither of the above systems
D)	I don’t know

NEXT

[AREA 7. FOREST MANAGEMENT PERCEPTIONS: ALL]

Section 3. This section asks about your views on forest management.

22. How important do you find the following forest management objectives?

	Extremely important	*Very important*	*Moderately important*	*Somewhat important*	*Slightly important*	*Not at all important*
Generating income from timber.	☐	☐	☐	☐	☐	☐
Generating income from a wild forest product (e.g., cork, nuts, berries, medicinal plants, mushrooms, game meat, etc.).	☐	☐	☐	☐	☐	☐
Generating income from a recreational service, such as ecotourism lodging, nature tours, hunting concessions, etc.	☐	☐	☐	☐	☐	☐
Producing wild forest products (e.g., cork, nuts, berries, mushrooms, game meat) for non-commercial uses, such as collection for household use.	☐	☐	☐	☐	☐	☐
Producing timber for non-commercial uses, such as collecting firewood for household use.	☐	☐	☐	☐	☐	☐
Creating opportunities for recreation, such as walking, picnicking, birdwatching, hunting, etc.	☐	☐	☐	☐	☐	☐
Creating accessible forest areas (e.g., forest paths, recreational trails).	☐	☐	☐	☐	☐	☐
Ensuring safe forest areas (e.g., forest paths, recreational trails).	☐	☐	☐	☐	☐	☐
Biodiversity preservation.	☐	☐	☐	☐	☐	☐
Improving forest soil quality.	☐	☐	☐	☐	☐	☐
Improving local watershed quality.	☐	☐	☐	☐	☐	☐
Mitigating climate change by, for example, increasing forest carbon sinks.	☐	☐	☐	☐	☐	☐
Reducing biotic forest disturbances caused by sources such as pest, fungi, or disease.	☐	☐	☐	☐	☐	☐
Reducing abiotic forest disturbances caused by sources such as forest fires, drought, or windthrow.	☐	☐	☐	☐	☐	☐

Safeguarding cultural heritage sites, such as areas important to the family or community.	☐	☐	☐	☐	☐	☐
Creating opportunities for upholding traditional knowledge among family, friends, or community members (e.g., how to ski, fish, hunt, forage, manage the forest).	☐	☐	☐	☐	☐	☐
Creating beautiful forest areas (e.g., forest paths, recreational trails).	☐	☐	☐	☐	☐	☐

23. To what extent do you believe that implementing your forest management objectives will lead to the following outcomes.

	Strongly agree	*Agree*	*Slightly agree*	*Slightly disagree*	*Disagree*	*Strongly disagree*
Income from timber sales.	☐	☐	☐	☐	☐	☐
Income from the sale of a wild forest product (e.g., cork, nuts, berries, medicinal plants, mushrooms, etc.).	☐	☐	☐	☐	☐	☐
Income from a recreational service, such as ecotourism lodging, nature tours, or hunting concessions.	☐	☐	☐	☐	☐	☐
Production of wild forest product (e.g., cork, nuts, berries, mushrooms) for non-commercial use.	☐	☐	☐	☐	☐	☐
Production of timber for non-commercial use.	☐	☐	☐	☐	☐	☐
Opportunities for recreation, such as hiking, collecting wild forest products, birdwatching, or hunting.	☐	☐	☐	☐	☐	☐
Accessible forest areas (e.g., forest paths, recreational trails).	☐	☐	☐	☐	☐	☐
Safe forest areas (e.g., forest paths, recreational trails).	☐	☐	☐	☐	☐	☐
Beautiful forest areas (e.g., forest paths, recreational trails).	☐	☐	☐	☐	☐	☐
Biodiversity preservation.	☐	☐	☐	☐	☐	☐
Improved forest soil quality.	☐	☐	☐	☐	☐	☐
Improved local watershed quality.	☐	☐	☐	☐	☐	☐
Climate change mitigation.	☐	☐	☐	☐	☐	☐
A reduction in biotic forest disturbances caused by pest, fungi, disease, etc.	☐	☐	☐	☐	☐	☐
A reduction in abiotic forest disturbances caused by fires, drought, windthrow, etc.	☐	☐	☐	☐	☐	☐
Safeguarding cultural heritage sites important to the family or community.	☐	☐	☐	☐	☐	☐
Opportunities for sharing traditional knowledge among family, friends, or community members (e.g., how to ski, fish, hunt, forage, manage the forest).	☐	☐	☐	☐	☐	☐

24. Please evaluate the following statements. “*Overall, I believe that implementing my forest management objectives is…*”

Good	☐	☐	☐	☐	☐	☐	☐	Bad
Important	☐	☐	☐	☐	☐	☐	☐	Unimportant

Convenient	☐	☐	☐	☐	☐	☐	☐	Inconvenient
Harmful	☐	☐	☐	☐	☐	☐	☐	Beneficial

25. If you had to give an opinion, to what extend do you think that the following individuals would approve or disapprove of the implementation of your forest management objectives?

	Strongly approve	*Approve*	*Somewhat approve*	*Don't care*	*Somewhat disapprove*	*Disapprove*	*Strongly disapprove*
My family members	☐	☐	☐	☐	☐	☐	☐
My friends	☐	☐	☐	☐	☐	☐	☐
My neighbours	☐	☐	☐	☐	☐	☐	☐
The general public	☐	☐	☐	☐	☐	☐	☐
Other forest owners in my region	☐	☐	☐	☐	☐	☐	☐
Local forest owner's association	☐	☐	☐	☐	☐	☐	☐
Local forest authority	☐	☐	☐	☐	☐	☐	☐
National forest authority	☐	☐	☐	☐	☐	☐	☐

26. How important are the opinions of the following individuals regarding your decision to implement your forest management objectives?

	Extremely important	*Very important*	*Moderately important*	*Somewhat important*	*Slightly important*	*Not at all important*
Family members	☐	☐	☐	☐	☐	☐
My friends	☐	☐	☐	☐	☐	☐
My neighbours	☐	☐	☐	☐	☐	☐
The general public	☐	☐	☐	☐	☐	☐
Other forest owners in my region	☐	☐	☐	☐	☐	☐
Local forest owner's association	☐	☐	☐	☐	☐	☐
Local forest authority	☐	☐	☐	☐	☐	☐
National forest authority	☐	☐	☐	☐	☐	☐

27. Ultimately, how strongly would you agree or disagree with the following statements about society's impact on your choice of forest management objectives?

	Strongly agree	*Agree*	*Slightly agree*	*Slightly disagree*	*Disagree*	*Strongly disagree*
I feel pressure to implement my forest management objectives.	☐	☐	☐	☐	☐	☐

People don't want me to implement my forest management objectives.	☐	☐	☐	☐	☐	☐
I feel pressure to change my forest management objectives.	☐	☐	☐	☐	☐	☐
In general, people approve of my forest management objectives.	☐	☐	☐	☐	☐	☐

28. How important would access to the following resources be for implementing your forest management objectives?

	Extremely important	*Very important*	*Moderately important*	*Somewhat important*	*Slightly important*	*Not at all important*
Manual labour	☐	☐	☐	☐	☐	☐
Technology (e.g., GPS equipment, forest machinery)	☐	☐	☐	☐	☐	☐
Infrastructure (e.g., forest roads)	☐	☐	☐	☐	☐	☐
Credit or loans	☐	☐	☐	☐	☐	☐
Advisory services offering trainings, reports, information portals, or other information	☐	☐	☐	☐	☐	☐
Subsidies or grants	☐	☐	☐	☐	☐	☐
Market instruments (e.g., carbon credits, payment for ecosystem services)	☐	☐	☐	☐	☐	☐
Voluntary agreements (e.g., forest certifications)	☐	☐	☐	☐	☐	☐

29. What do you think is the likelihood that you will have sufficient access to the following resources?

	Highly unlikely	*Unlikely*	*Somewhat unlikely*	*Somewhat likely*	*Likely*	*Highly likely*
Manual labour	☐	☐	☐	☐	☐	☐
Technology (e.g., GPS equipment, forest machinery)	☐	☐	☐	☐	☐	☐
Infrastructure (e.g., forest roads)	☐	☐	☐	☐	☐	☐
Credit or loans	☐	☐	☐	☐	☐	☐
Advisory services offering trainings, reports, information portals, or other information	☐	☐	☐	☐	☐	☐
Subsidies or grants	☐	☐	☐	☐	☐	☐
Market instruments (e.g., carbon credits, payment for ecosystem services)	☐	☐	☐	☐	☐	☐
Voluntary agreements (e.g., forest certification)	☐	☐	☐	☐	☐	☐

30. Please indicate how strongly you agree or disagree with the following statements.						
	Strongly agree	*Agree*	*Slightly agree*	*Slightly disagree*	*Disagree*	*Strongly Disagree*
I anticipate I will implement my forest management objectives.	☐	☐	☐	☐	☐	☐
I intend to implement my forest management objectives.	☐	☐	☐	☐	☐	☐
I want to implement my forest management objectives.	☐	☐	☐	☐	☐	☐
It is difficult to implement my forest management objectives.	☐	☐	☐	☐	☐	☐
I can implement my forest management objectives if I want to.	☐	☐	☐	☐	☐	☐
I have the necessary resources to implement my forest management objectives.	☐	☐	☐	☐	☐	☐

31. Lastly, please evaluate your views on the following statements about forest management.						
	Strongly agree	*Agree*	*Slightly agree*	*Slightly disagree*	*Disagree*	*Strongly Disagree*
The basis of my forest management decisions is the law, legislations, and regulations.	☐	☐	☐	☐	☐	☐
The basis of my forest management decisions is upholding traditions.	☐	☐	☐	☐	☐	☐
The basis of my forest management decisions is the market and market conditions.	☐	☐	☐	☐	☐	☐
The basis of my forest management decisions is expertise and knowledge.	☐	☐	☐	☐	☐	☐
The basis of my forest management decisions is the normative pressure I feel.	☐	☐	☐	☐	☐	☐
The basis of my forest management decisions is what I believe is best for my forest.	☐	☐	☐	☐	☐	☐

NEXT

AREA 8. FINANCIAL COMPENSATION: FOREST OWNERS

[THIS PAGE ONLY APPEARS FOR FOREST OWNERS]

Section 4. This final section asks for your views on monetary compensation for various forest management activities. Please read the questions carefully before answering.

32. Have you ever intentionally implemented any of the following forest management activities in any of your forest stands? Please read the questions carefully before answering, as the proposed activities might be atypically implemented.

i. **Retained at least 10 m3/ha of standing or fallen deadwood in a forest stand with low risk of forest fire?** This equals roughly 15-20 stems of over 20 centimetres diameter per hectare.

☐ Yes ☐ No ☐ This activity cannot be implemented in my forest ☐ I don't know

ii. **Implemented continuous cover forestry in 20% or more of your total forest area?** Continuous cover forestry refers to a silvicultural system that largely maintains the forest cover of a forest stand by cutting single trees, groups of trees, or using a shelterwood system, all of which all avoid clearcutting of the entire tree cover.

☐ Yes ☐ No ☐ This activity cannot be implemented in my forest ☐ I don't know

iii. **At final felling, reserved at least 5% of the trees in an even-aged stand as retention trees?** This equals roughly 10 m3/ha (15-20 stems) when logging 200 m3/ha.

☐ Yes ☐ No ☐ This activity cannot be implemented in my forest ☐ I don't know

iv. **Left undisturbed forest buffer strips of 20 meters or more adjacent to any body of water?**

☐ Yes ☐ No ☐ This activity cannot be implemented in my forest ☐ I don't know

v. **Lengthened the rotation period of a forest stand at low risk of forest disturbances by at least 25% of the typical rotation period?** For example, lengthening the rotation period in a stand from 80 to 100 years.

☐ Yes ☐ No ☐ This activity cannot be implemented in my forest ☐ I don't know

vi. **Left all the logging residues in a recently logged forest stand?** For example, not harvesting logging residues for bioenergy.

☐ Yes ☐ No ☐ This activity cannot be implemented in my forest ☐ I don't know

[ITEM ONLY APPEARS FOR SELECTED COUNTRIES: FINLAND, LATVIA, SWEDEN]

vii. Applied continuous cover forestry in a peatland forest stand of 20% or more hectares, by selecting single tree or group trees for felling, rather than clearcutting the entire stand.

☐ Yes ☐ No ☐ This activity cannot be implemented in my forest ☐ I don't know

NEXT

[Q33 ONLY APPEARS IF RESPONDENT SELECTS "NO" IN RESPONSE TO Q30]

33. Imagine that in the future you could be financially compensated for the loss of income associated with changing your current forest management regime to an alternative that supports biodiversity preservation or climate change mitigation.

The financial compensation scheme requires you to implement a ten-year forest management plan. The compensation you receive is based on a percentage of estimated income loss from forgoing your typical forest management regime. In addition, you are compensated for the direct costs of implementing the alternative management activity. You receive a full payment w the forest management plan is accepted. After ten years, the forest is audited. If the management plan was not implemented, you must pay back the money in full.

Given these contractual terms, what percentage of compensation would you request for changing from your current harvesting regime to the alternatives provided below? Note that if you ask for too high a payment, the potential payer may not accept your offer.

	Payment percentage you require for *estimated income loss* and *direct cost*.									
	0%	25%	50%	75%	100%	125%	150%	Over 150%	I would not participate for any amount of compensation	This acti cannot implemente in my forest
1. Retain at least 10 m3/ha of standing or fallen deadwood in a forest stand with low risk of forest fire? This equals roughly 15-20 stems of over 20 centimetres diameter per hectare.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2. Implement continuous cover forestry in 20% or more of your total forest area? Continuous cover forestry refers to a silvicultural system that largely maintains the forest cover of a forest stand by cutting single trees, groups of trees, or using a shelterwood system, all of which all avoid clearcutting of the entire tree cover.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3. At final felling, reserve at least 5% of the trees in an even-aged stand as retention trees? This equals roughly 10 m3/ha (15-20 stems) when logging 200 m3/ha.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4. Leave undisturbed forest buffer strips of 20 meters or more adjacent to any body of water?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5. Lengthen the rotation period of a forest stand at low risk of forest disturbances by at least 25% of the typical rotation period? For example, lengthening the rotation period in a stand from 80 to 100 years.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
6. Left all the logging residues in a recently logged forest stand? For example, not harvesting logging residues for bioenergy.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
7. Implement continuous cover forestry in 20% of a *peatland* forest stand. Continuous cover forestry refers to a silvicultural system that largely maintains the forest cover of a forest stand by cutting single trees, groups of trees, or using a shelterwood system, all of which all avoid clearcutting of the entire tree cover.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

[PAGE 9. FINALIZATION]

You have nearly completed the survey. Please briefly tell us more about yourself before submitting your responses.

Year of birth: ____________________

Where do you live?

Gender

- ☐ Female
- ☐ Male
- ☐ Prefer to self-describe: [---]
- ☐ Choose not to say

Highest educational qualification

- ☐ None

This project receives funding from the European Union's Horizon Europe Research and Innovation Programme (ID No 101056755), as well as from the United Kingdom Research and Innovation Council (UKRI). Views and opinions expressed are those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the EU nor the EC can be held responsible for them

- ☐ Primary education
- ☐ Secondary education
- ☐ Vocational qualification
- ☐ University degree, Bachelor's
- ☐ University degree, Master's
- ☐ University degree, Doctoral
- ☐ Other

What share of your total annual income approximately stems from forestry?

- ☐ No contribution
- ☐ Less than 5 %
- ☐ 6-25 %
- ☐ 26-50 %
- ☐ 51-75 %
- ☐ More than 75 %

What is your combined household annual income before tax?

- ☐ Less than 5 % Less than 10,000€
- ☐ 10,000€ - 19,999€
- ☐ 20,000€ - 29,999€
- ☐ 30,000€ - 39,999€
- ☐ 40,000€ - 49,999€
- ☐ 50,000€ - 59,999€
- ☐ 60,000€ - 69,999€
- ☐ 70,000€ - 79,999€
- ☐ 80,000€ - 89,999€
- ☐ 90,000€ - 99,999€
- ☐ 100,000€ - 149,999€
- ☐ 150,000€ - 200,000€
- ☐ Over 200,000€

☐ Choose not to say

SUBMIT THE SURVEY

Appendix 1.

[The dropdown list of species provided for Question 7 and Question 8]

Countries Polled	***Picea abies***	***Picea sitchensis***	***Pinus sylvestris***	***pines other than Pinus sylvestris***	***Other conifers***	***Betula spp.***	***Eucalyptus spp.***	***Fagus sylvatica***	***Quercus robur&petraea***	***Oaks other than Q. robur***	***other broadleaves***
Croatia	x			x	x			x	x		x
Czech Republic	x		x		x			x	x		x
Germany	x		x		x			x	x		x
Finland	x		x		x	x					x
France	x		x		x			x	x		x
Italy	x			x	x			x		x	x
Latvia	x		x		x			x	x		x
Netherlands	x		x		x			x	x		x
Romania	x		x		x			x	x		x
Spain			x	x	x		x			x	x
Sweden	x		x		x	x					x
Switzerland	x		x		x			x	x		x

United Kingdom		x	x		x			x	x		x

9.2 Annex B. Exploratory Factor Analysis

Table 8.2.1 shows that the EFA met all the criteria for construct validity, dimensionality, and reliability (see: Hair et al., 2019: Chapter 4). The KMO test achieved excellent results (>.900) and the Bartletts test was significant (<.05). Unidimensionality was visible, as each item in the rotated factor matrix displayed only one significant loading per factor (>.40). The Cronbach's Alpha for each factor exceeded the minimum threshold (>.70). There was sufficient correlation between the items in the EFA, as the communalities for each item met the minimum criteria (>.30). Critically, the six factors showed face validity, meaning that the items grouping together in a factor had clear topical linkages.

Table 8.2.1 – Rotated factor solution of 20 items using maximum likelihood and varimax rotation. Highest item loading is visible in bold. Various fitness criteria for the EFA displayed at the bottom of the table.

Belief items (b_i, m_i, c_i)	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Communality Extraction
Watershed quality	**0.662**	0.101	0.140	0.095	0.126	0.229	0.572
Soil quality	**0.657**	0.150	0.153	0.150	0.192	0.189	0.545
Climate change	**0.644**	0.147	0.124	0.106	0.046	0.171	0.494
Abiotic Disturbances	**0.641**	0.106	0.057	0.146	0.104	0.146	0.458
Biotic Disturbances	**0.629**	0.143	0.032	0.099	0.168	0.057	0.478
Local forest authority	0.221	**0.804**	0.259	0.202	0.127	0.082	0.705
National forest authority	0.211	**0.778**	0.229	0.220	0.13	0.097	0.827
FOA	0.218	**0.668**	0.368	0.223	0.119	0.110	0.777
Neighbours	0.121	0.224	**0.800**	0.130	0.125	0.116	0.571
Friends	0.175	0.226	**0.662**	0.152	0.087	0.143	0.751
General public	0.112	0.399	**0.611**	0.221	0.154	0.182	0.650
Subsidies or grants	0.227	0.232	0.103	**0.712**	0.16	0.090	0.657
Market schemes	0.244	0.219	0.193	**0.666**	0.221	0.120	0.652
Credit or loans	0.092	0.200	0.275	**0.596**	0.289	0.187	0.598
WFP income	0.264	0.100	0.149	0.187	**0.652**	0.273	0.461
Timber income	0.135	0.123	0.053	0.166	**0.629**	0.051	0.636
Services income	0.220	0.104	0.212	0.237	**0.585**	0.357	0.630

Accessibility	0.366	0.101	0.198	0.157	0.263	**0.651**	0.701
Safety	0.442	0.141	0.173	0.163	0.208	**0.598**	0.672
Beauty	0.425	0.113	0.185	0.125	0.206	**0.598**	0.610
Bartlett's Test	<.001						
KMO Test	.935						

9.3 Annex C: Hierarchical Clustering Analysis

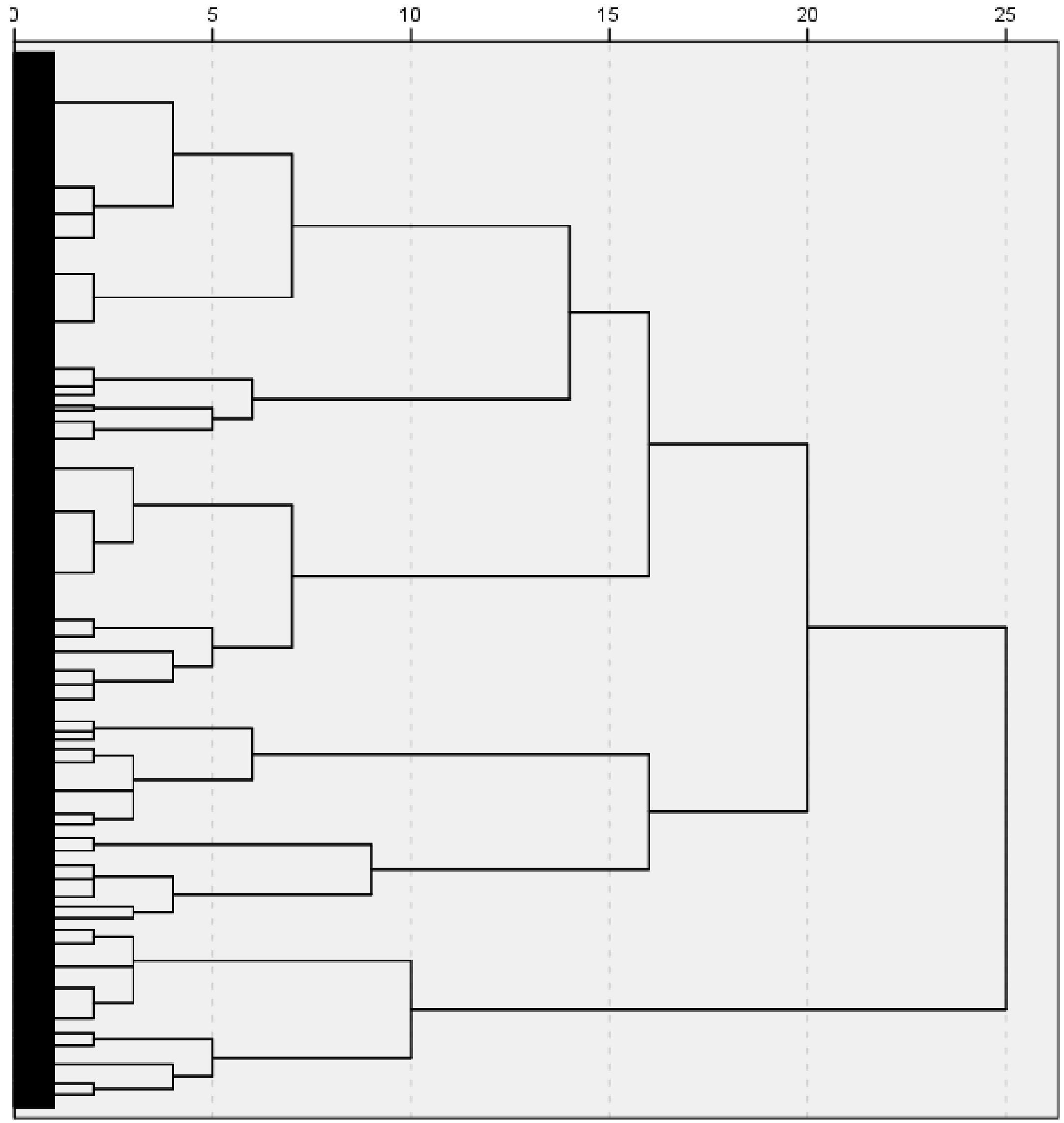


Figure 8.3.1 – Dendrogram produced from Hierarchical Clustering Analysis applying Ward's Linkages.

9.4 Annex D. ANOVA

Table 8.4.1 - Homogeneity of Variances testing between forest practitioner typology groups and the six behavioural factor scores. Note that there is no homogeneity of variance is found among the variables.

Factor Scores		Levene Statistic	df1	df2	Sig.
RES objectives	Based on Mean	16.021	4	2254	<.001
	Based on Median	15.81	4	2254	<.001
	Based on Median and with adjusted df	15.81	4	2051.171	<.001
	Based on trimmed mean	15.944	4	2254	<.001
Forestry Networks	Based on Mean	61.664	4	2254	<.001
	Based on Median	56.629	4	2254	<.001
	Based on Median and with adjusted df	56.629	4	1970.93	<.001
	Based on trimmed mean	60.738	4	2254	<.001
Society	Based on Mean	54.44	4	2254	<.001
	Based on Median	53.689	4	2254	<.001
	Based on Median and with adjusted df	53.689	4	2005.753	<.001
	Based on trimmed mean	54.508	4	2254	<.001
Market Mechanisms	Based on Mean	39.032	4	2254	<.001
	Based on Median	38.337	4	2254	<.001
	Based on Median and with adjusted df	38.337	4	1864.773	<.001
	Based on trimmed mean	38.862	4	2254	<.001
Income Objectives	Based on Mean	57.694	4	2254	<.001
	Based on Median	55.139	4	2254	<.001
	Based on Median and with adjusted df	55.139	4	1850.678	<.001
	Based on trimmed mean	56.967	4	2254	<.001
Amenity Objectives	Based on Mean	35.533	4	2254	<.001
	Based on Median	34.726	4	2254	<.001
	Based on Median and with adjusted df	34.726	4	2086.734	<.001
	Based on trimmed mean	35.367	4	2254	<.001

Table 8.4.2 - Homogeneity of Variances testing between forest practitioner typology groups and the six behavioural factor scores. Note that there is no homogeneity of variance is found among the variables.

Factor Scores		Statistic	df1	df2	Sig.
RES objectives	Welch	160.058	4	833.002	<.001
	Brown-Forsythe	178.326	4	1526.97	<.001
Forestry Networks	Welch	68.651	4	793.049	<.001
	Brown-Forsythe	68.635	4	1360.51	<.001
Society	Welch	182.162	4	794.459	<.001
	Brown-Forsythe	137.627	4	1433.66	<.001
Market Mechanisms	Welch	537.164	4	807.985	<.001
	Brown-Forsythe	416.832	4	1386.33	<.001
Income Objectives	Welch	394.179	4	783.409	<.001
	Brown-Forsythe	272.317	4	1313.99	<.001
Amenity Objectives	Welch	533.138	4	810.814	<.001
	Brown-Forsythe	532.189	4	1508.6	<.001

Table 8.4.3 – Results from six ANOVA test comparing the five forest practitioner typologies against the six behavioural factor scores. Findings are significant across all six ANOVA's.

		Sum of Squares	df	Mean Square	F	Sig.
RES objectives	Between Groups	804	4	201.087	196.931	<.001
	Within Groups	2302	2254	1.021		
	Total	3106	2258			
Forestry Networks	Between Groups	362	4	90.529	83.616	
	Within Groups	2440	2254	1.083		
	Total	2802	2258			
Society	Between Groups	681	4	170.33	164.096	<.001
	Within Groups	2340	2254	1.038		
	Total	3021	2258			
Market Mechanisms	Between Groups	1527	4	381.793	486.953	<.001
	Within Groups	1767	2254	0.784		
	Total	3294	2258			
Income Objectives	Between Groups	1362	4	340.425	338.001	<.001
	Within Groups	2270	2254	1.007		
	Total	3632	2258			
Amenity Objectives	Between Groups	1958	4	489.498	610.815	<.001
	Within Groups	1806	2254	0.801		
	Total	3764	2258			

ForestPaths

Co-designing holistic forest-based policy pathways for climate change mitigation

Table 8.4.4 – Descriptive statistics for Bartlett Factor Scores of the six factors obtained in the EFA per cluster group.

Cluster	EFA Factor Scores	n	Min.	Max	Mean	Std. Dev.	Variance	Skewness	Kurtosis
1	RES objectives	274	-3.08	3.05	0.45	1.19	1.42	-0.30	-0.09
	Income Objectives	274	-3.14	2.95	-0.03	1.23	1.52	-0.49	-0.28
	Amenity Objectives	274	-3.29	2.90	-0.28	1.23	1.52	-0.10	-0.63
	Forestry Network	274	-4.03	2.99	-0.06	1.17	1.36	-0.17	0.08
	The Public	274	-3.64	5.69	-0.14	1.31	1.72	0.35	1.04
	Financing	274	-6.03	-0.54	-2.35	0.94	0.89	-0.80	0.32
2	RES objectives	392	-2.69	2.71	0.59	0.96	0.93	-0.45	0.01
	Income Objectives	392	-4.06	2.11	-0.71	1.28	1.64	-0.52	-0.45
	Amenity Objectives	392	-3.53	3.28	0.09	1.17	1.36	-0.29	-0.19
	Forestry Network	392	-2.02	4.22	0.80	1.01	1.02	-0.15	0.37
	The Public	392	-5.02	1.12	-1.39	1.09	1.20	-0.50	0.08
	Financing	392	-2.90	3.67	0.52	1.00	1.01	0.00	-0.12
3	RES objectives	275	-3.06	2.73	0.50	1.05	1.11	-0.43	0.23
	Income Objectives	275	-3.57	3.02	-0.15	1.29	1.67	-0.31	-0.43
	Amenity Objectives	275	-2.99	3.46	0.07	1.17	1.36	-0.12	-0.29
	Forestry Network	275	-4.63	-0.65	-2.09	0.83	0.69	-0.43	-0.40
	The Public	275	-3.28	3.23	0.27	1.23	1.51	-0.31	-0.43
	Financing	275	-2.28	3.48	0.18	1.06	1.12	0.28	-0.12
4	RES objectives	476	-4.96	1.84	-1.07	1.17	1.37	-0.47	0.44
	Income Objectives	476	-2.77	4.32	0.57	1.00	0.99	-0.32	0.73
	Amenity Objectives	476	-3.77	2.58	-0.92	1.11	1.23	-0.07	-0.38

This project receives funding from the European Union's Horizon Europe Research and Innovation Programme (ID No 101056755), as well as from the United Kingdom Research and Innovation Council (UKRI). Views and opinions expressed are those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the EU nor the EC can be held responsible for them

	Forestry Network	476	-2.88	3.04	0.09	0.98	0.96	-0.14	0.23
	The Public	476	-3.53	2.15	-0.34	1.06	1.13	-0.28	0.05
	Financing	476	-1.75	4.54	0.83	1.00	1.01	0.33	0.31
5	Regulating ES Objectives	842	-2.77	2.14	0.02	0.84	0.71	-0.44	-0.12
	Income Objectives	842	-4.92	1.71	0.07	0.74	0.54	-1.17	3.81
	Amenity Objectives	842	-2.07	2.77	0.55	0.72	0.52	-0.52	0.44
	Forestry Network	842	-1.49	2.55	0.28	0.65	0.42	0.03	-0.24
	The Public	842	-0.99	3.59	0.79	0.68	0.46	0.15	0.41
	Financing	842	-2.53	2.03	0.00	0.68	0.46	-0.31	0.33

Table 8.4.5 – Tamhane post-hoc tests for the six ANOVAs exploring forest owner typology groups against the six behavioural factors.

Dependent Variable (Factor Score)	(I) Cluster Group	(J) Cluster Group	Mean Difference (I-J)	Std. Error	Sig.	95% C.I. Lower	95% C.I. Upper
RES objectives	1	2	-0.14	0.09	0.64	-0.39	0.10
		3	-0.05	0.10	1.00	-0.32	0.22
		4	1.51	0.09	<.001	1.26	1.77
		5	0.43	0.08	<.001	0.21	0.65
	2	1	0.14	0.09	0.64	-0.10	0.39
		3	0.09	0.08	0.94	-0.13	0.32
		4	1.66	0.07	<.001	1.46	1.86
		5	0.57	0.06	<.001	0.42	0.73
	3	1	0.05	0.10	1.00	-0.22	0.32
		2	-0.09	0.08	0.94	-0.32	0.13
		4	1.56	0.08	<.001	1.33	1.80
		5	0.48	0.07	<.001	0.28	0.68
	4	1	-1.52	0.09	<.001	-1.77	-1.26
		2	-1.66	0.07	<.001	-1.86	-1.46
		3	-1.57	0.08	<.001	-1.80	-1.33
		5	-1.09	0.06	<.001	-1.26	-0.92

This project receives funding from the European Union's Horizon Europe Research and Innovation Programme (ID No 101056755), as well as from the United Kingdom Research and Innovation Council (UKRI). Views and opinions expressed are those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the EU nor the EC can be held responsible for them

Forestry Networks	1	2	0.68	0.10	<.001	0.40	0.96
		3	0.12	0.11	0.94	-0.18	0.43
		4	-0.60	0.09	<.001	-0.84	-0.35
		5	-0.09	0.08	0.93	-0.32	0.13
	2	1	-0.68	0.10	<.001	-0.96	-0.40
		3	-0.56	0.10	<.001	-0.84	-0.27
		4	-1.28	0.08	<.001	-1.50	-1.06
		5	-0.78	0.07	<.001	-0.97	-0.58
	3	1	-0.12	0.11	0.94	-0.43	0.18
		2	0.56	0.10	<.001	0.27	0.84
		4	-0.72	0.09	<.001	-0.98	-0.47
		5	-0.22	0.08	0.08	-0.45	0.01
	4	1	0.60	0.09	<.001	0.35	0.84
		2	1.28	0.08	<.001	1.06	1.50
		3	0.72	0.09	<.001	0.47	0.98
		5	0.50	0.05	<.001	0.36	0.65
Public Opinion	1	2	-0.36	0.10	0.00	-0.63	-0.09
		3	-0.35	0.10	0.01	-0.64	-0.06
		4	0.65	0.09	<.001	0.39	0.90
		5	-0.82	0.08	<.001	-1.04	-0.60
	2	1	0.36	0.10	0.00	0.09	0.63
		3	0.01	0.09	1.00	-0.25	0.27
		4	1.01	0.08	<.001	0.79	1.23
		5	-0.46	0.06	<.001	-0.64	-0.28
	3	1	0.35	0.10	0.01	0.06	0.64
		2	-0.01	0.09	1.00	-0.27	0.25
		4	1.00	0.09	<.001	0.75	1.24
		5	-0.47	0.07	<.001	-0.68	-0.26
	4	1	-0.65	0.09	<.001	-0.90	-0.39
		2	-1.01	0.08	<.001	-1.23	-0.79
		3	-1.00	0.09	<.001	-1.24	-0.75
		5	-1.47	0.06	<.001	-1.63	-1.31
Market Mechanisms	1	2	-0.86	0.09	<.001	-1.10	-0.62
		3	2.03	0.09	<.001	1.79	2.28
		4	-0.15	0.08	0.58	-0.38	0.09
		5	-0.34	0.07	<.001	-0.55	-0.13
	2	1	0.86	0.09	<.001	0.62	1.10
		3	2.89	0.07	<.001	2.69	3.10
		4	0.71	0.07	<.001	0.52	0.90

		5	0.52	0.06	<.001	0.36	0.68
	3	1	-2.03	0.09	<.001	-2.28	-1.79
		2	-2.89	0.07	<.001	-3.10	-2.69
		4	-2.18	0.07	<.001	-2.37	-1.99
		5	-2.37	0.05	<.001	-2.53	-2.22
	4	1	0.15	0.08	0.58	-0.09	0.38
		2	-0.71	0.07	<.001	-0.90	-0.52
		3	2.18	0.07	<.001	1.99	2.37
		5	-0.19	0.05	0.00	-0.33	-0.05
Income Objectives	1	2	1.25	0.10	<.001	0.97	1.52
		3	-0.41	0.11	0.00	-0.72	-0.11
		4	0.20	0.09	0.29	-0.06	0.46
		5	-0.93	0.08	<.001	-1.17	-0.70
	2	1	-1.25	0.10	<.001	-1.52	-0.97
		3	-1.66	0.09	<.001	-1.92	-1.40
		4	-1.05	0.07	<.001	-1.25	-0.84
		5	-2.18	0.06	<.001	-2.35	-2.01
	3	1	0.41	0.11	0.00	0.11	0.72
		2	1.66	0.09	<.001	1.40	1.92
		4	0.61	0.09	<.001	0.36	0.86
		5	-0.52	0.08	<.001	-0.74	-0.30
	4	1	-0.20	0.09	0.29	-0.46	0.06
		2	1.05	0.07	<.001	0.84	1.25
		3	-0.61	0.09	<.001	-0.86	-0.36
		5	-1.13	0.05	<.001	-1.28	-0.98
Amenity Objectives	1	2	-2.88	0.08	<.001	-3.09	-2.66
		3	-2.53	0.09	<.001	-2.77	-2.29
		4	-3.18	0.07	<.001	-3.38	-2.97
		5	-2.35	0.06	<.001	-2.52	-2.18
	2	1	2.88	0.08	<.001	2.66	3.09
		3	0.34	0.08	<.001	0.12	0.57
		4	-0.30	0.07	<.001	-0.49	-0.11
		5	0.53	0.06	<.001	0.37	0.68
	3	1	2.53	0.09	<.001	2.29	2.77
		2	-0.34	0.08	<.001	-0.57	-0.12
		4	-0.65	0.08	<.001	-0.87	-0.43
		5	0.18	0.07	0.08	-0.01	0.37
	4	1	3.18	0.07	<.001	2.97	3.38

		2	0.30	0.07	<.001	0.11	0.49
		3	0.65	0.08	<.001	0.43	0.87
		5	0.83	0.05	<.001	0.68	0.97

9.5 Annex F. Structural Equation Model

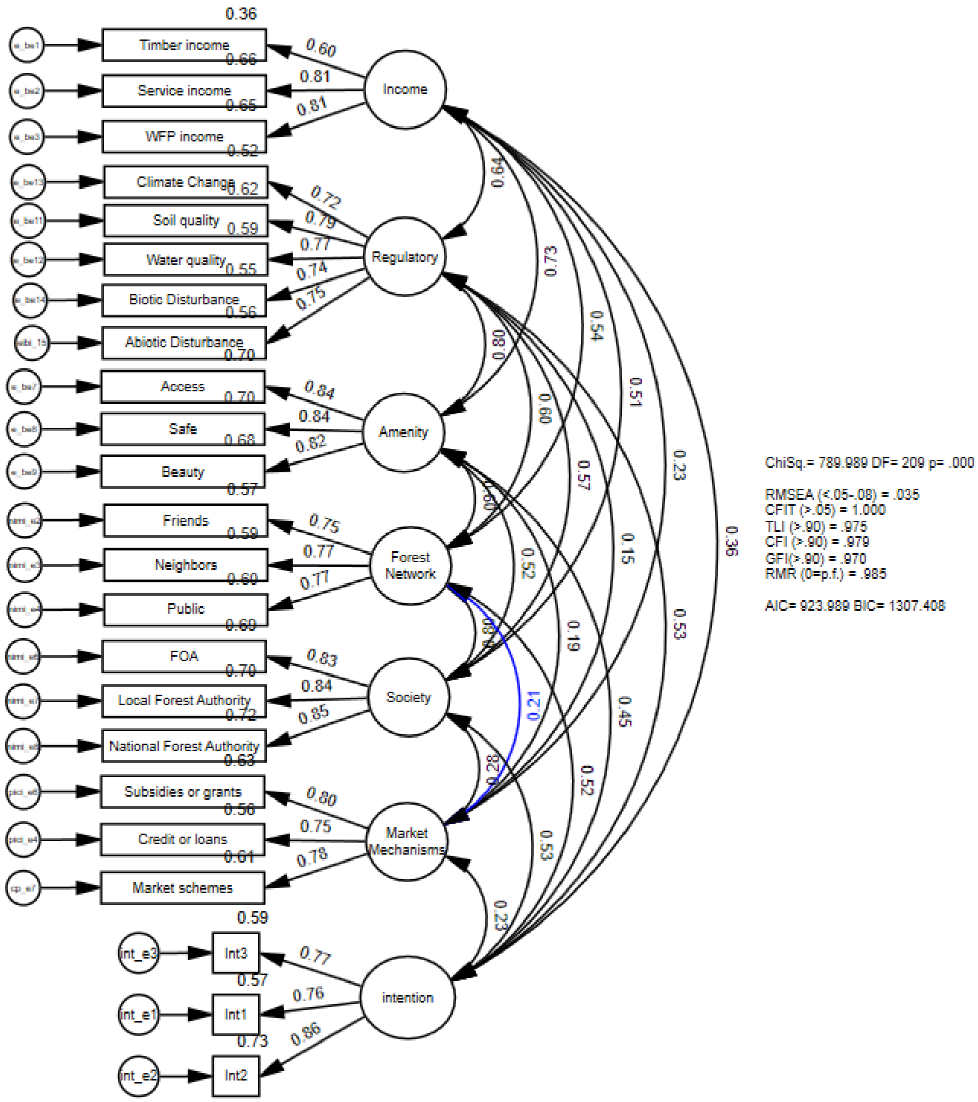


Figure 2.5.1 – The specified measurement model for assessing the behavioural factors measured in the survey (i.e., behavioural beliefs, normative beliefs, control beliefs, and intention). Behavioural beliefs include the latent factor income

objectives, RES objectives, and amenity objectives. Normative beliefs include the latent factor forest networks and society. Control beliefs include the latent factor market mechanisms. The fitness indicators displayed next to the model are within an acceptable range proposed by Hair et al. (2019). The Standardized RMR (not depicted) also showed a good fit (.0246).

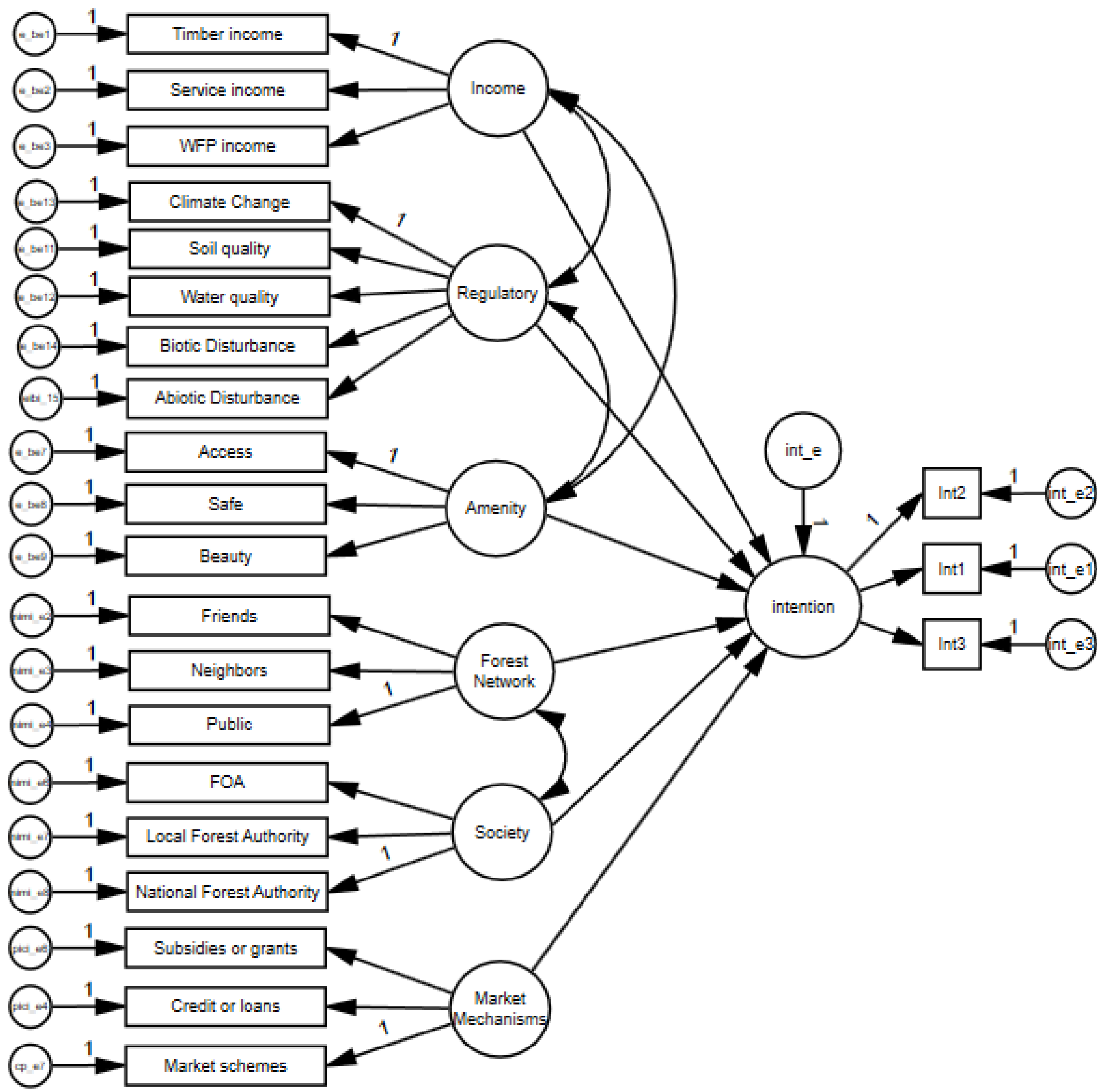
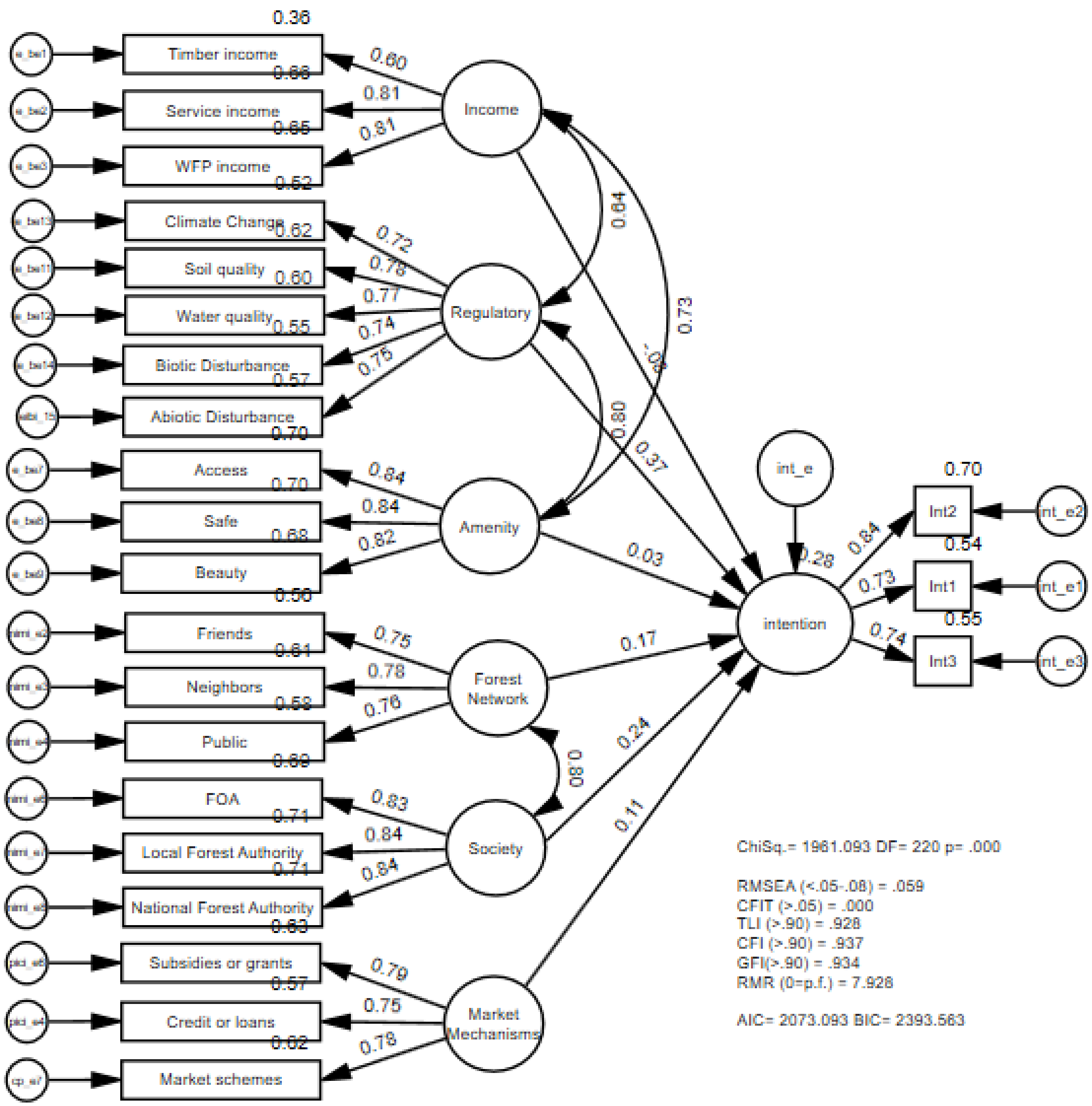


Figure 8.5.2 – Fully specified structural model. The relationships between latent factors were specified according to the TPB (see: Section 2.1.1).



ChiSq.= 1961.093 DF= 220 p= .000

RMSEA (<.05-.08) = .059
CFIT (>.05) = .000
TLI (>.90) = .928
CFI (>.90) = .937
GFI(>.90) = .934
RMR (0=p.f.) = 7.928

AIC= 2073.093 BIC= 2393.563

Figure 8.5.3 – SEM estimated using the entire dataset. CFIT values show poor fit. SRMR values exceeded the fitness criteria (.18)

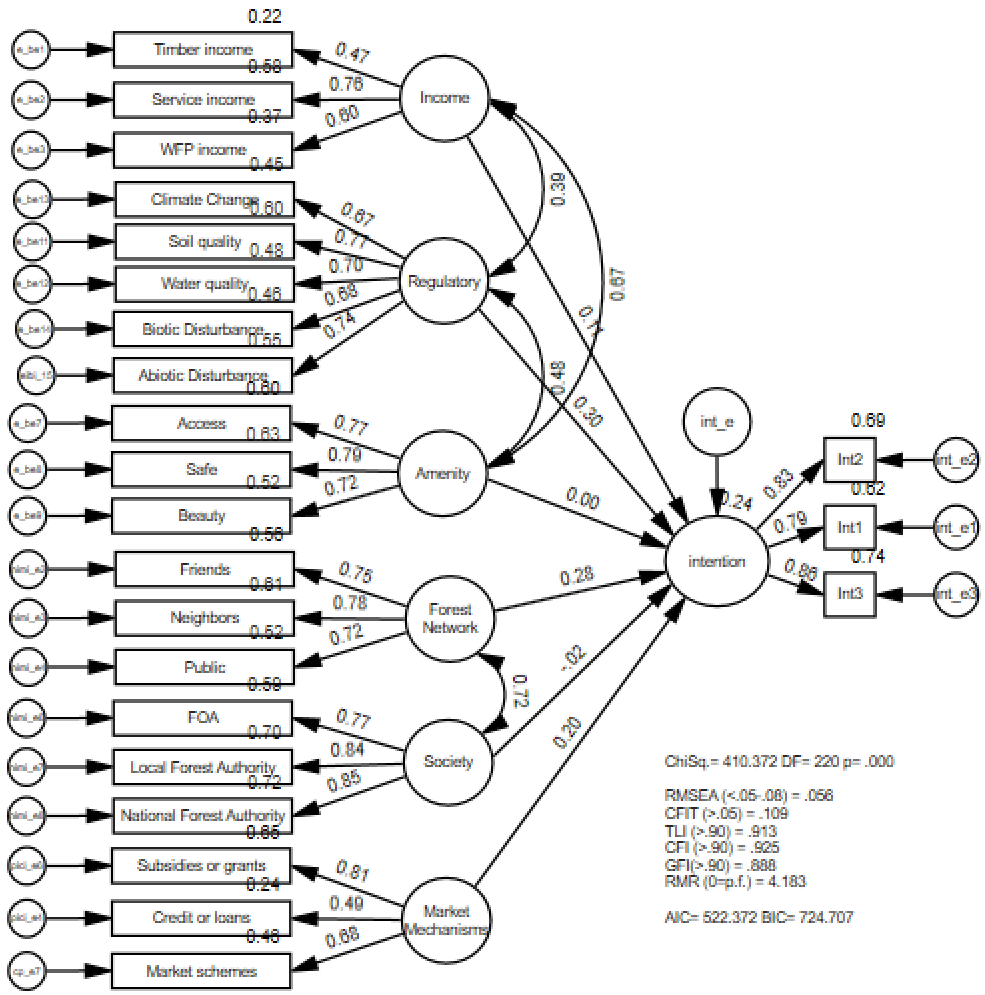


Figure 8.5.4 - SEM estimated using forest practitioner cluster 2 data. SRMR values exceeded the fitness criteria (.117). The GFI fitness values is poor (.88).

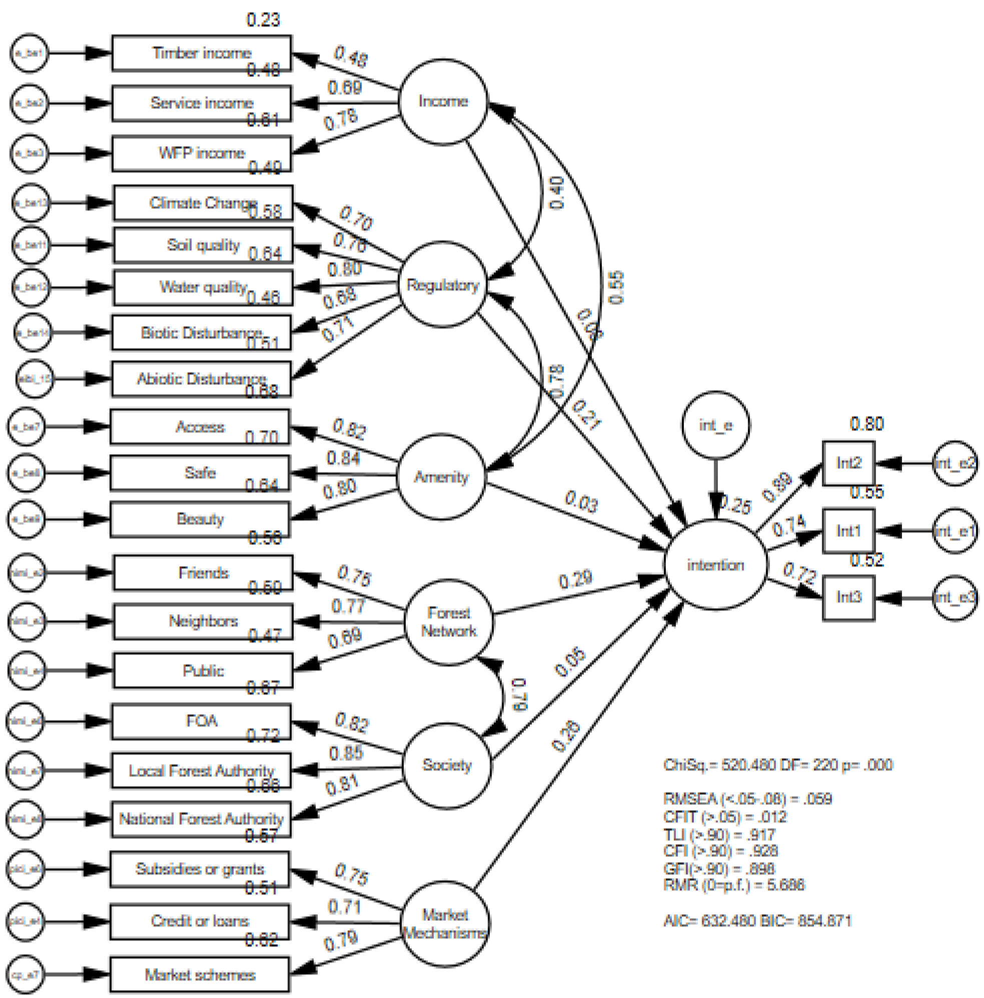


Figure 8.5.5 - SEM estimated using forest practitioner cluster 2 data. SRMR values exceeded the fitness criteria (.136). C-Fit values are poor (.012).

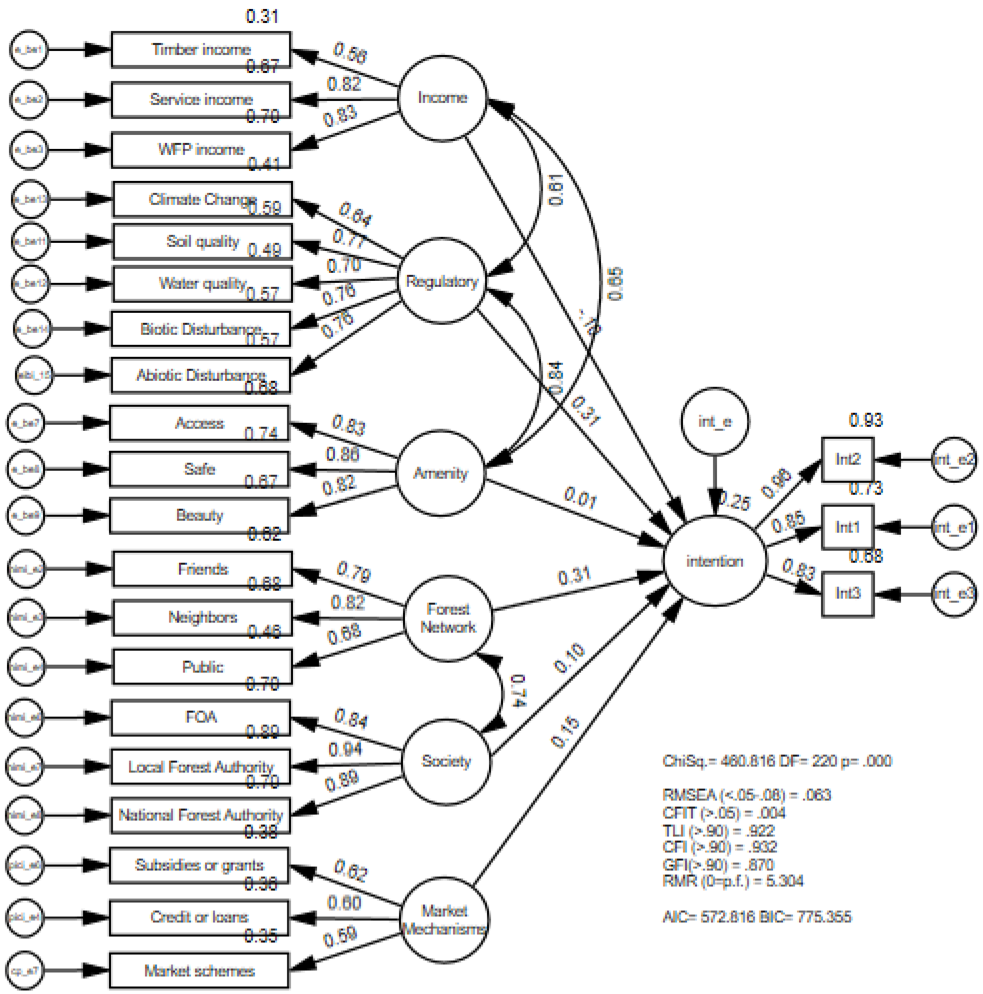


Figure 8.5.6 - SEM estimated using forest practitioner cluster 3 data. SRMR values exceeded the fitness criteria (.134). In addition the CFIT value is poor (.004) and GFI values are poor (.870).

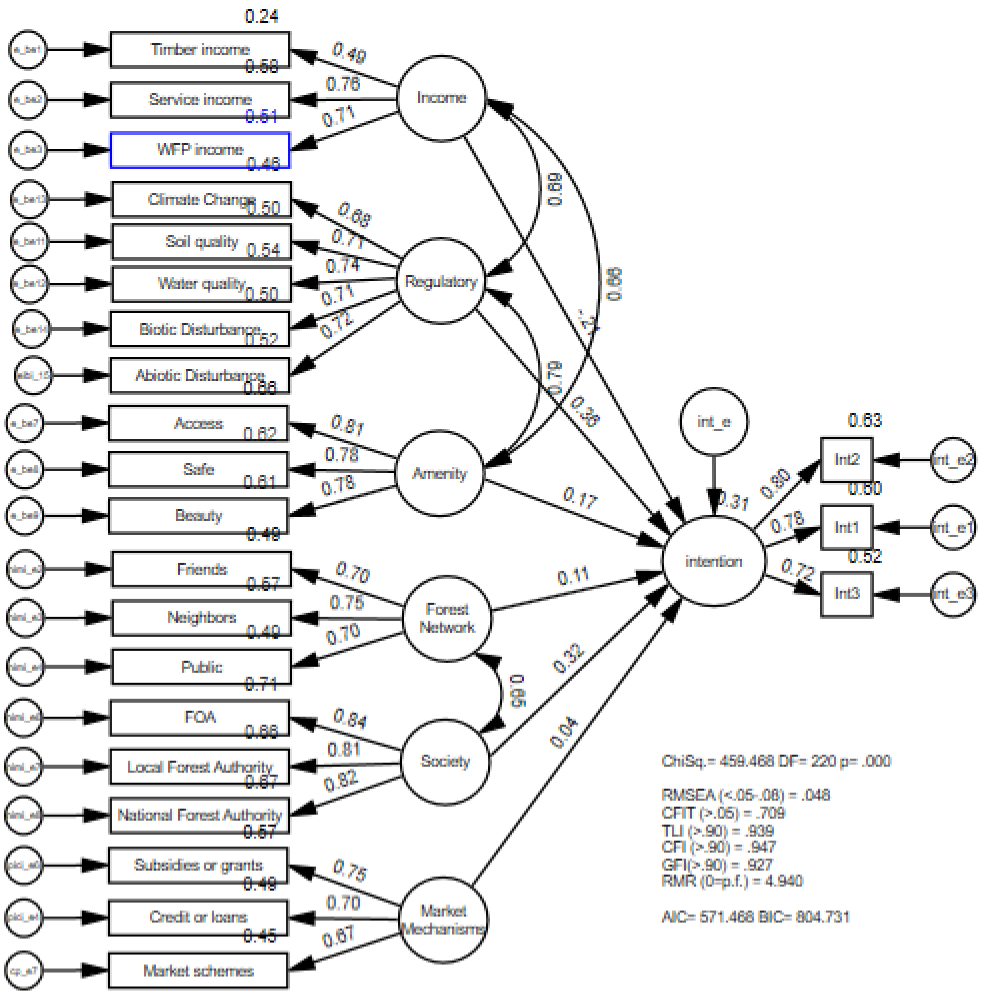


Figure 8.5.7 - SEM estimated using forest practitioner cluster 4 data. SRMR value exceeded the fitness criteria (.143).

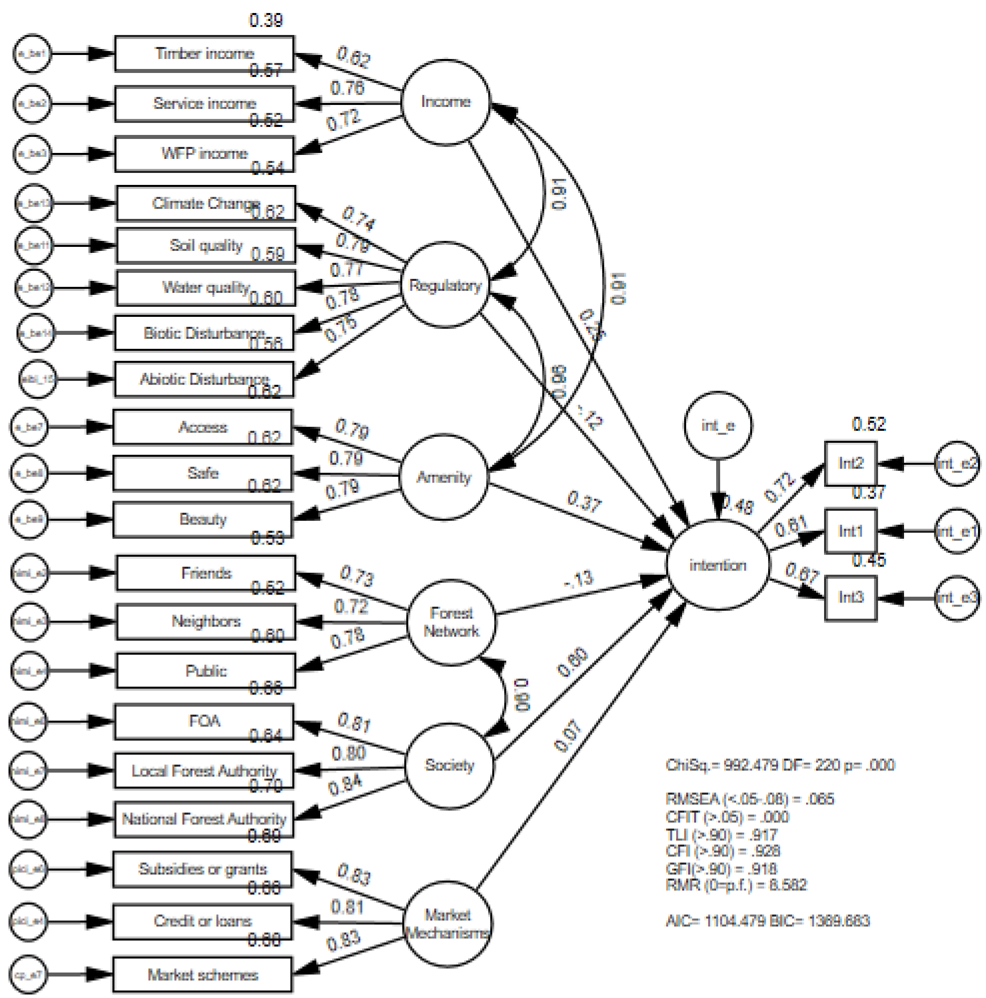


Figure 8.5.8 - SEM estimated using forest practitioner cluster 5 data. SRMR value exceeded the fitness criteria (.223). In addition, the CFIT value is poor (.000).

10.6 Annex G. Model results on typologies and other factors influencing CBS management

Table 10.6.1 – Descriptive statistics of the models used in the logit models.

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
Dependent variables						
Deadwood	Retained at least 10 m3/ha of standing or fallen deadwood in a forest stand with low risk of forest fire? This equals roughly 15-20 stems of over 20 centimetres diameter per hectare.	1066	.536	.499	0	1
Continuous cover forestry*	Implemented continuous cover forestry in 20% or more of your total forest area? Continuous cover forestry refers to a silvicultural system that largely maintains the forest cover of a forest stand by cutting single trees, groups of trees, or using a shelterwood system, all of which all avoid clearcutting of the entire tree cover.	963	.539	.499	0	1
Retention trees	At final felling, reserved at least 5% of the trees in an even-aged stand as retention trees? This equals roughly 10 m3/ha (15-20 stems) when logging 200 m3/ha.	1077	.72	.449	0	1
Buffer strips	Left undisturbed forest buffer strips of 20 meters or more adjacent to any body of water?	949	.718	.45	0	1
Longer rotation	Lengthened the rotation period of a forest stand at low risk of forest disturbances by at least 25% of the typical rotation period? For example, lengthening the rotation period in a stand from 80 to 100 years.	996	.576	.494	0	1
Logging residues	Left all the logging residues in a recently logged forest stand? For example, not harvesting logging residues for bioenergy.	1201	.492	.5	0	1

Continuous cover forestry on peatland**	Applied continuous cover forestry in all spruce dominated peatland forest stands, by selecting single tree or group trees for felling, rather than clearcutting the entire stand.	398	.545	.499	0	1
Independent variables						
Gender: male		1479	.575	.494	0	1
Age: below 39		1486	.276	.447	0	1
Age: 39-55 years		1486	.327	.469	0	1
Age: over 55 years		1486	.397	.489	0	1
Acquisition: purchase		1486	.16	.367	0	1
Forest Area: ≤1 ha		1486	.217	.413	0	1
Forest Area: 2-5 ha		1486	.332	.471	0	1
Forest Area: 6-19 ha		1486	.183	.387	0	1
Forest Area: 20-99 ha		1486	.151	.358	0	1
Forest Area: over 100 ha		1486	.117	.322	0	1
Forestry Income: over 26% of total annual income		1486	.146	.353	0	1
Group 1	Forest practitioner Group 1: Environmentally Conscious Passives	1486	.147	.354	0	1
Group2	Forest practitioner Group 2: Environmental implementers	1486	.182	.386	0	1
Group 3	Forest practitioner Group 3: Traditionalists	1486	.146	.353	0	1
Group 4	Forest practitioner Group 4: Maximizers	1486	.211	.408	0	1
Group 5	Forest practitioner Group 5: Societal Satisfiers	1486	.314	.464	0	1
Unmanaged		1486	.298	.458	0	1
CCF Strong		1486	.236	.424	0	1

CCF WEAK		1486	.14	.347	0	1
CLEARFELL Strong		1486	.091	.287	0	1
CLEARFELL Weak		1486	.12	.325	0	1
Croatia		1486	.166	.372	0	1
Czechia		1486	.083	.277	0	1
Finland		1486	.157	.364	0	1
France		1486	.044	.205	0	1
Germany		1486	.052	.223	0	1
Italy		1486	.028	.164	0	1
Latvia		1486	.147	.354	0	1
Netherlands		1486	.006	.078	0	1
Romania		1486	.138	.345	0	1
Spain		1486	.026	.158	0	1
Sweden		1486	.079	.27	0	1
Switzerland		1486	.052	.223	0	1
United Kingdom		1486	.022	.147	0	1
	*Finland omitted ** Responses only from Finland, Sweden and Latvia.					

Table 10.6.2 – Correlations between the variables in the logit models.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Gender Male	1.000							
(2) Age, 39-55 years	0.045	1.000						
(3) Age, over 55 years	-0.073	-0.566	1.000					
(4) Acquisition: purchase	-0.073	-0.006	0.037	1.000				
(5) Forest Area: ≤1 ha	-0.031	-0.042	0.160	0.061	1.000			
(6) Forest Area: 2-5 ha	-0.032	0.006	-0.004	-0.027	-0.372	1.000		
(7) Forest Area: 6-19 ha	0.028	0.007	-0.035	-0.024	-0.248	-0.333	1.000	
(8) Forest Area: 20-99 ha	-0.000	0.007	-0.061	-0.005	-0.222	-0.298	-0.199	1.000
(9) Forestry Income: over 26%	-0.035	0.045	-0.266	-0.025	-0.200	-0.082	-0.002	0.171
(10) Group 2	0.079	0.027	0.024	0.019	0.059	0.033	-0.017	-0.071
(11) Group 3	0.017	-0.048	0.095	0.007	0.061	0.013	0.009	-0.057
(12) Group 4	-0.010	0.023	-0.048	-0.010	0.012	-0.004	-0.013	0.012
(13) Group 5	-0.056	0.010	-0.123	0.007	-0.073	-0.057	-0.024	0.072
(14) Strong CCF	-0.001	0.006	0.060	0.035	0.024	0.054	-0.018	-0.035
(15) Weak CCF	-0.025	0.037	-0.110	0.009	-0.038	-0.005	0.006	0.019
(16) Strong clearcut	0.010	0.041	-0.136	-0.048	-0.098	-0.038	-0.014	0.103
(17) Weak Clearcut	-0.049	-0.072	0.018	0.008	-0.139	-0.120	0.057	0.168
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(9) Forestry Income: over 26%	1.000							
(10) Group 2	-0.101	1.000						
(11) Group 3	-0.079	-0.195	1.000					
(12) Group 4	-0.070	-0.244	-0.214	1.000				
(13) Group 5	0.284	-	-	-	1.000			

		0.318	0.280	0.350				
(14) Strong CCF	-0.059	-0.034	0.068	0.004	0.015	1.000		
(15) Weak CCF	0.096	0.002	-0.046	0.005	0.028	-0.225	1.000	
(16) Strong clearcut	0.229	-0.063	-0.044	-0.025	0.122	-0.175	-0.128	1.000
(17) Weak Clearcut	0.123	-0.077	-0.047	-0.080	0.117	-0.206	-0.150	-0.117

Table 10.6.3 – Results of logit models on probability of having retained deadwood. Model coefficients and the marginal effects in columns.

	Model 1		Model 2		Model 3		Model 4	
Logit, Yes =1	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect
Constant	0.127		-0.062		0.010		-0.413	
Gender Male	0.143	0.035	0.128	0.031	.120	0.028	0.146	0.033
Age, 39-55 years	0.078	0.019	0.109	0.026	.132	0.031	0.243	0.056
Age, over 55 years	-0.103	-0.025	-0.043	-0.010	-.041	-0.010	0.065	0.015
Acquisition: purchase	-0.013	-0.003	-0.037	-0.009	-.013	-0.003	-0.053	-0.012
Forest Area: ≤1 ha	-0.408*	-0.099	-0.33	-0.079	-.279	-0.066	-0.402	-0.092
Forest Area: 2-5 ha	-0.176	-0.043	-0.114	-0.027	-.072	-0.017	-0.246	-0.056
Forest Area: 6-19 ha	0.113	0.028	0.194	0.047	.203	0.048	0.020	0.005
Forest Area: 20-99 ha	-0.113	-0.027	-0.063	-0.015	-.085	-0.020	-0.199	-0.045
Forestry Income: over 26%	0.480***	0.117	0.343*	0.082	.286	0.068	0.304	0.069
Reference: Group 1								
Group 2			0.064	0.015	0.109	0.026	0.179	0.041
Group 3			-0.196	-0.047	-0.159	-0.038	-0.146	-0.033
Group 4			-0.046	-0.011	-0.005	-0.001	0.029	0.007
Group 5			0.479**	0.115	0.481**	0.114	0.599***	0.137
Reference: Unmanaged								
Strong CCF					-0.102	-0.024	-0.159	-0.036
Weak CCF					-0.184	-0.044	-0.293	-0.067
Strong clearcut					0.385	0.092	0.161	0.037
Weak Clearcut					0.287	0.068	0.218	0.050
Reference: Croatia								
Czechia							0.056	0.013
Finland							0.706***	0.161
France							0.626*	0.143
Germany							0.807**	0.184
Italy							0.201	0.046
Latvia							0.614**	0.140
Netherlands							0.344	0.078
Romania							0.365	0.083
Spain							-0.411	-0.094
Sweden							-0.671**	-0.153
Switzerland							0.861**	0.196
United Kingdom							1.108**	0.253
Mean dependent var	0.537		0.537		0.537		0.537	
Pseudo r-squared	0.016		0.027		0.032		0.063	
Chi-square	23.670		39.005		46.391		91.592	
Akaike crit. (AIC)	1461.30		1453.97		1454.58		1433.38	
SD dependent var	0.499		0.499		0.499		0.499	

Number of obs	1061		1061		1061		1061	
Prob > chi2	0.005		0.000		0.000		0.000	
Bayesian crit. (BIC)	1510.97		1523.50		1543.99		1582.39	

*** p<.01, ** p<.05, * p<.1*

Table 10.6.4 – Results of logit models on probability of implementing continuous cover forestry in 20% of forest area. Model coefficients and the marginal effects in columns.

	Model 1		Model 2		Model 3		Model 4	
Logit, Yes =1	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect
Constant	0.301		0.288				0.389	
Gender Male	0.101	0.025	0.089	0.021			0.067	0.016
Age, 39-55 years	-0.264	-0.064	-0.243	-0.059			-0.168	-0.039
Age, over 55 years	-0.383**	-0.093	-0.356**	-0.086			-0.235	-0.055
Acquisition: purchase	-0.022	-0.005	-0.04	-0.010			-0.096	-0.022
Forest Area: ≤1 ha	-0.116	-0.028	-0.059	-0.014			-0.246	-0.057
Forest Area: 2-5 ha	-0.098	-0.024	-0.055	-0.013			-0.142	-0.033
Forest Area: 6-19 ha	0.157	0.038	0.205	0.049			0.211	0.049
Forest Area: 20-99 ha	-0.094	-0.023	-0.098	-0.024			0.016	0.004
Forestry Income: over 26%	0.438**	0.107	0.304	0.073			0.287	0.067
Reference: Group 1								
Group 2			-0.150	-0.036			-0.187	-0.043
Group 3			-0.265	-0.064			-0.333	-0.077
Group 4			-0.223	-0.054			-0.271	-0.063
Group 5			0.271	0.065			0.281	0.065
Reference: Unmanaged								
Strong CCF								
Weak CCF								
Strong clearcut								
Weak Clearcut								
Reference: Croatia								
Czechia							0.477*	0.110
Finland							-	
France							0.325	0.075
Germany							0.081	0.019
Italy							-0.163	-0.038
Latvia							-0.297	-0.069
Netherlands							-0.050	-0.012
Romania							-0.067	-0.016
Spain							-0.832**	-0.193
Sweden							-0.937***	-0.217
Switzerland							0.595*	0.138

United Kingdom							0.627	0.145
Mean dependent var	0.539		0.539				0.539	
Pseudo r-squared	0.015		0.022				0.051	
Chi-square	19.338		29.751				67.019	
Akaike crit. (AIC)	1327.03		1324.62				1309.351	
SD dependent var	0.499		0.499				0.499	
Number of obs	961		961				961	
Prob > chi2	0.022		0.005				0.000	
Bayesian crit. (BIC)	1375.71		1392.77				1431.050	

*** *p<.01, ** p<.05, * p<.1*

Table 10.6.5 – Results of logit models on probability of leaving at least 5% of the logging volume as retention trees. Model coefficients and the marginal effects in columns.

	Model 1		Model 2		Model 3		Model 4	
Logit, Yes =1	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect
Constant	1.214***		0.871***		0.665**		.817**	
Gender Male	-0.113	-0.023	-0.122	-0.024	-0.130	-0.025	-.153	-0.029
Age, 39-55 years	0.019	0.004	0.031	0.006	0.012	0.002	.068	0.013
Age, over 55 years	0.019	0.004	0.043	0.009	0.053	0.010	.139	0.026
Acquisition: purchase	-0.105	-0.021	-0.117	-0.023	-0.141	-0.027	-.095	-0.018
Forest Area: ≤1 ha	-0.444*	-0.089	-0.412	-0.082	-0.434	-0.085	-.652**	-0.122
Forest Area: 2-5 ha	-0.113	-0.023	-0.070	-0.014	-0.108	-0.021	-.258	-0.048
Forest Area: 6-19 ha	-0.143	-0.029	-0.069	-0.014	-0.088	-0.017	-.113	-0.021
Forest Area: 20-99 ha	-0.280	-0.056	-0.231	-0.046	-0.307	-0.060	-.278	-0.052
Forestry Income: over 26%	0.025	0.005	-0.090	-0.018	-0.166	-0.032	-.246	-0.046
Reference: Group 1								
Group 2			0.372	0.074	0.367	0.072	.386	0.072
Group 3			0.298	0.059	0.219	0.043	.268	0.050
Group 4			0.126	0.025	0.089	0.017	.075	0.014
Group 5			0.556***	0.111	0.481**	0.094	.48**	0.090
Reference: Unmanaged								
Strong CCF					0.813***	0.158	.742***	0.139
Weak CCF					0.445**	0.087	.363	0.068
Strong clearcut					0.585**	0.114	.559*	0.105
Weak Clearcut					0.105	0.020	.117	0.022
Reference: Croatia								
Czechia							-.018	-0.003
Finland							-.19	-0.036
France							-.243	-0.046
Germany							.396	0.074
Italy							-.427	-0.080
Latvia							-.234	-0.044
Netherlands							-1.524*	-0.286
Romania							.699**	0.131
Spain							-1.253***	-0.235
Sweden							-.584**	-0.110
Switzerland							.59	0.111
United Kingdom							.384	0.072
Mean dependent var	0.720		0.720		0.720		0.720	
Pseudo r-squared	0.005		0.012		0.029		0.059	
Chi-square	6.106		14.686		36.639		75.196	
Akaike crit. (AIC)	1288.74		1288.16		1274.21		1259.65	

							4	
SD dependent var	0.449		0.449		0.449		0.449	
Number of obs	1075		1075		1075		1075	
Prob > chi2	0.729		0.327		0.004		0.000	
Bayesian crit. (BIC)	1338.54		1357.89		1363.85		1409.05 6	

*** *p<.01, ** p<.05, * p<.1*

Table 10.6.6 – Results of logit models on probability of leaving undisturbed buffer strips of 20 meters adjacent to water bodies. Model coefficients and the marginal effects in columns.

	Model 1		Model 2		Model 3		Model 4	
Logit, Yes =1	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect
Constant	1.24***		1.299***		1.002***		1.494***	
Gender Male	-0.118	-0.023	-0.112	-0.022	-0.139	-0.027	-0.110	-0.021
Age, 39-55 years	-0.023	-0.005	-0.047	-0.009	-0.033	-0.006	-0.006	-0.001
Age, over 55 years	0.244	0.048	0.200	0.039	0.233	0.045	0.204	0.039
Acquisition: purchase	0.230	0.046	0.218	0.043	0.211	0.041	0.285	0.054
Forest Area: ≤1 ha	-0.709***	-0.140	-0.73***	-0.144	-0.621**	-0.121	-0.811***	-0.154
Forest Area: 2-5 ha	-0.113	-0.022	-0.150	-0.030	-0.079	-0.015	-0.197	-0.037
Forest Area: 6-19 ha	-0.143	-0.028	-0.176	-0.035	-0.138	-0.027	-0.168	-0.032
Forest Area: 20-99 ha	-0.393	-0.078	-0.388	-0.076	-0.413	-0.080	-0.415	-0.079
Forestry Income: over 26%	-0.399**	-0.079	-0.389*	-0.077	-0.509**	-0.099	-0.451**	-0.086
Reference: Group 1								
Group 2			0.344	0.068	0.404	0.079	0.374	0.071
Group 3			0.039	0.008	0.052	0.010	0.002	0.000
Group 4			-0.284	-0.056	-0.258	-0.050	-0.332	-0.063
Group 5			-0.046	-0.009	-0.096	-0.019	-0.086	-0.016
Reference: Unmanaged								
Strong CCF					0.403**	0.079	0.381*	0.073
Weak CCF					0.426*	0.083	0.408*	0.078
Strong clearcut					0.555**	0.108	0.486*	0.092
Weak Clearcut					0.570**	0.111	0.590**	0.112
Reference: Croatia								
Czechia							-0.495	-0.094
Finland							-0.107	-0.020
France							-0.766*	-0.146
Germany							-0.401	-0.076
Italy							-1.100**	-0.209
Latvia							-0.712**	-0.135
Netherlands							-0.635	-0.121
Romania							-0.008	-0.002
Spain							-0.882**	-0.168

Sweden							-0.977***	-0.186
Switzerland							-0.576	-0.110
United Kingdom							-0.415	-0.079
Mean dependent var	0.719		0.719		0.719		0.719	
Pseudo r-squared	0.016		0.022		0.029		0.049	
Chi-square	18.068		24.426		32.967		55.162	
Akaike crit. (AIC)	1122.71		1124.35		1123.81		1125.616	
SD dependent var	0.450		0.450		0.450		0.450	
Number of obs	944		944		944		944	
Prob > chi2	0.034		0.027		0.011		0.002	
Bayesian crit. (BIC)	1171.21		1192.25		1211.11		1271.120	

*** p<.01, ** p<.05, * p<.1

Table 10.6.7 Results of logit models on probability of applying lengthened rotation period by 25% or more. Model coefficients and the marginal effects in columns.

	Model 1		Model 2		Model 3		Model 4	
Logit, Yes =1	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect
Constant	0.640***		0.319		0.265		0.903**	
Gender Male	-0.318**	-0.075	-0.305**	-0.071	-0.306**	-0.072	-0.245*	-0.055
Age, 39-55 years	0.014	0.003	0.029	0.007	0.019	0.004	0.064	0.014
Age, over 55 years	-0.285*	-0.068	-0.260	-0.061	-0.224	-0.052	-0.180	-0.040
Acquisition: purchase	0.012	0.003	-0.011	-0.003	-0.013	-0.003	0.140	0.031
Forest Area: ≤1 ha	-0.216	-0.051	-0.232	-0.054	-0.249	-0.058	-0.605**	-0.135
Forest Area: 2-5 ha	0.052	0.012	0.046	0.011	0.023	0.005	-0.188	-0.042
Forest Area: 6-19 ha	-0.267	-0.063	-0.241	-0.057	-0.245	-0.057	-0.325	-0.072
Forest Area: 20-99 ha	-0.328	-0.078	-0.304	-0.071	-0.299	-0.070	-0.251	-0.056
Forestry Income: over 26%	0.516***	0.123	0.446**	0.105	0.423**	0.099	0.265	0.059
Reference: Group 1								
Group 2			0.649***	0.152	0.632***	0.148	0.573**	0.127
Group 3			0.149	0.035	0.129	0.030	.0109	0.024
Group 4			0.118	0.028	0.093	0.022	-0.040	-0.009
Group 5			0.449**	0.105	0.437**	0.102	0.308	0.069
Reference: Unmanaged								
Strong CCF					0.133	0.031	0.050	0.011
Weak CCF					0.344*	0.080	0.384*	0.085
Strong clearcut					0.162	0.038	0.238	0.053
Weak Clearcut					-0.161	-0.038	-0.061	-0.014
Reference: Croatia								
Czechia							-0.435	-0.097
Finland							- 0.784***	-0.174
France							-0.884**	-0.197
Germany							-0.840**	-0.187
Italy							-0.634	-0.141
Latvia							-0.561**	-0.125
Netherlands							0.094	0.021
Romania							0.245	0.055
Spain							- 1.588***	-0.353
Sweden							- 1.302***	-0.289
Switzerland							-0.537	-0.119
United Kingdom							0.234	0.052
Mean dependent var	0.575		0.575		0.575		0.575	
Pseudo r-squared	0.021		0.030		0.033		0.069	

Chi-square	28.825		40.328		45.395		92.982	
Akaike crit. (AIC)	1346.43		1342.93		1345.86		1322.27 2	
SD dependent var	0.495		0.495		0.495		0.495	
Number of obs	994		994		994		994	
Prob > chi2	0.001		0.000		0.000		0.000	
Bayesian crit. (BIC)	1395.45		1411.55		1434.09		1469.32 4	

**** p<.01, ** p<.05, * p<.1*

Table 10.6.8 Results of logit models on probability of leaving logging residues. Model coefficients and the marginal effects in columns.

	Model 1		Model 2		Model 3		Model 4	
Logit, Yes =1	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect
Constant	0.364*		0.341		0.364		0.325	
Gender Male	-0.087	-0.021	-0.093	-0.023	-0.089	-0.022	-0.074	-0.018
Age, 39-55 years	-0.016	-0.004	-0.010	-0.002	-0.008	-0.002	0.073	0.017
Age, over 55 years	-0.105	-0.026	-0.077	-0.019	-0.082	-0.020	-0.015	-0.004
Acquisition: purchase	0.043	0.011	0.043	0.011	0.059	0.014	0.039	0.009
Forest Area: ≤1 ha	-0.489**	-0.121	-0.459**	-0.113	-0.446*	-0.109	-0.456*	-0.109
Forest Area: 2-5 ha	-0.295	-0.073	-0.277	-0.068	-0.266	-0.065	-0.275	-0.066
Forest Area: 6-19 ha	-0.261	-0.064	-0.235	-0.058	-0.227	-0.056	-0.161	-0.038
Forest Area: 20-99 ha	-0.651***	-0.161	-0.652***	-0.160	-0.655***	-0.161	-0.505**	-0.120
Forestry Income: over 26%	0.285	0.070	0.233	0.057	0.226	0.055	0.142	0.034
Reference: Group 1								
Group 2			-0.025	-0.006	-0.023	-0.006	-0.090	-0.021
Group 3			-0.286	-0.070	-0.281	-0.069	-0.301	-0.072
Group 4			0.029	0.007	0.038	0.009	-0.006	-0.001
Group 5			0.126	0.031	0.123	0.030	0.016	0.004
Reference: Unmanaged								
Strong CCF					-0.076	-0.019	-0.073	-0.017
Weak CCF					-0.195	-0.048	-0.130	-0.031
Strong clearcut					0.151	0.037	0.163	0.039
Weak Clearcut					-0.001	-0.000	0.023	0.005
Reference: Croatia								

Czechia							-0.362	-0.086
Finland							-0.087	-0.021
France							0.719**	0.172
Germany							-0.580*	-0.138
Italy							0.297	0.071
Latvia							-0.215	-0.051
Netherlands							0.015	0.004
Romania							0.223	0.053
Spain							0.230	0.055
Sweden							-0.120	-0.029
Switzerland							0.584*	0.139
United Kingdom							1.447**	0.345
Mean dependent var	0.491		0.491		0.491		0.491	
Pseudo r-squared	0.010		0.013		0.014		0.034	
Chi-square	16.583		21.268		23.630		55.822	
Akaike crit. (AIC)	1662.44		1665.76		1671.40		1663.20	
SD dependent var	0.500		0.500		0.500		0.500	
Number of obs	1197		1197		1197		1197	
Prob > chi2	0.056		0.068		0.130		0.002	
Bayesian crit. (BIC)	1713.32		1736.98		1762.97		1815.83	

*** p<.01, ** p<.05, * p<.1*

Table 10.6.9 Results of logit models on probability of applying continuous cover forestry on spruce dominated peatland forests. Model coefficients and the marginal effects in columns.

	Model 1		Model 2		Model 3		Model 4	
Logit, Yes =1	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect
Constant	0.175		-0.257				0.025	
Gender Male	-0.139	-0.034	-0.112	-0.027			-0.067	-0.016
Age, 39-55 years	0.237	0.058	0.194	0.046			0.140	0.032
Age, over 55 years	-0.016	-0.004	-0.020	-0.005			-0.083	-0.019
Acquisition: purchase	0.346	0.084	0.292	0.070			0.306	0.071
Forest Area: ≤1 ha	-0.458	-0.112	-0.556	-0.133			-0.867	-0.201
Forest Area: 2-5 ha	0.097	0.024	0.097	0.023			-0.167	-0.039
Forest Area: 6-19 ha	0.059	0.014	0.065	0.016			-0.277	-0.064
Forest Area: 20-99 ha	-0.394	-0.096	-0.341	-0.082			-0.665	-0.154
Forestry Income: over 26%	-0.055	-0.013	-0.035	-0.008			0.131	0.030
Reference: Group 1								
Group 2			0.507	0.122			0.478	0.111
Group 3			0.630*	0.151			0.550	0.127
Group 4			0.838**	0.201			0.780**	0.180
Group 5			0.352	0.084			0.421	0.097
Reference: Unmanaged								
Strong CCF								
Weak CCF								
Strong clearcut								
Weak Clearcut								
Reference: Latvia								
Czechia								
Finland							0.315	0.073
France								
Germany								
Italy								
Latvia							-	-
Netherlands								
Romania								
Spain								
Sweden							-0.920**	-0.213
Switzerland								
United Kingdom								
Mean dependent var	0.528		0.528				0.528	
Pseudo r-squared	0.014		0.028				0.054	
Chi-square	7.038		13.637				26.121	
Akaike crit. (AIC)	499.800		501.201				492.718	
SD dependent var	0.500		0.500				0.500	

Number of obs	352		352				352	
Prob > chi2	0.633		0.400				0.037	
Bayesian crit. (BIC)	538.437		555.292				554.536	

**** p<.01, ** p<.05, * p<.1*