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Symptoms of anxiety and worry about climate impacts among Finnish forest owners

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ABSTRACT

Private forest owners face conflicting pressures regarding management of their forests, including producing timber for the forest industry, preserving biodiversity, and enhancing carbon sequestration to mitigate climate change. At the same time, climate change poses a threat to the viability of forests. It is poorly known how these pressures affect the mental well-being of forest owners. We used a Finnish forest owner survey ($N = 1224$) to examine whether distress due to public demands regarding forest management is associated with symptoms of anxiety. We also examined which factors are associated with worry about the climate change impacts on own forests. Distress due to public demands on forest management was not associated with symptoms of anxiety. Only stress due to the invasion of Russia into Ukraine was associated with symptoms of anxiety. Having multiple objectives as a forest owner, being female gender, and having higher education were associated with worry about the climate change impacts on own forests. In conclusion, distress due to public demands regarding forest management may not be associated with forest owners' anxiety symptoms. Worry about the climate change impacts on own forests may be partly explained by higher awareness regarding the various possibilities that forests can offer.

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Anxiety; climate change; forest owner; stress; worry

Introduction

Climate change impacts forests: increasing prevalence of storms, changing precipitation, new pest species, and wildfires are among threats that impact growth and functioning of ecosystem services (Lindner et al. 2014; Keenan 2015; Brodribb et al. 2020). Forests are also an important carbon storage in the Northern latitudes and thus their management is essential in the fight against increasing atmospheric CO_2 levels and climate change (Gustavsson et al. 2017). About half of forestland is owned and managed by private households in both Europe (EUROPE 2020) and the US (Perry et al. 2022). In Finland, more than half of the productive forest land is owned by private households (Forest.fi 2019). Thus, the effects of climate change on forests and demands related to forest management can cause mental pressures among individual forest owners.

Forest management practices that promote adaptation to climate change, such as the selection of appropriate tree species and varieties, and strengthening of diversification of tree species mixtures (Olofsson and Jakobsson 2024), have been developed for over a decade, but tangible actions have been modest (Sousa-Silva et al. 2018). Moreover, intentions to continue using traditional forest management practices, like low diversification of tree species and even age distribution, are common (Juutinen et al. 2020). While up to 91% of European forest owners think that climate change is happening, and over 70% expect climate change to affect their forests (Sousa-Silva et al. 2018), it has been suggested that the risks in changing the forest management practices are perceived as higher than those caused by climate change (Brunette et al. 2020). Other limiting factors for changes in forest management practices may be highly valued family heritage and traditions among forest owners (Matilainen et al. 2019). Indeed, place attachment has also been linked to forest owners' behavioural intentions (Leahy and Lyons 2021).

In addition to the individual and family expectations, forest owners face conflicting external demands of

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producing timber for the forest industry, enhancing biodiversity, providing recreation environments as well as acting against climate change (Jakobsson et al. 2021). It can be said that local forest management is situated in a web of multifaceted interests, claims, concerns and information, where climate change adaptation and mitigation are a few of several aspects that forest owners must consider (Uggla and Lidskog 2016). A body of literature covers forest owners' concerns about multi-objective forest management and external pressures to achieve various goals (Bergstén et al. 2018; Muttilainen and Vilko 2022). In the face of conflicting demands as well as worry about the impact of climate change on their own forest, there is a chance that some forest owners will feel stress or anxiety, and in the long run, this could lead to lowered well-being or even anxiety disorder. Moreover, environmental threats from climate change itself can affect experiences of well-being and may cause stress and anxiety (Lawrance et al. 2022). Forest owners, in particular, have reasons to be worried, since their property and livelihood may be affected by climate change-related harms, such as droughts and storms. However, factors that associate with worry about the impact of climate change on a forest the individual owns, or symptoms of anxiety related to climate issues among forest owners, have not, to our knowledge, been scientifically investigated.

The current study aims to address this gap by examining whether distress due to public demands regarding forest management or distress due to demands to maintain forests as carbon storage is associated with symptoms of anxiety among Finnish forest owners. In addition, we aimed to identify which factors are associated with worry about the climate change impacts on their own forests.

Table 1. Descriptive statistics of the study population in the two different analytical samples with complete data.

Variable	Anxiety models *n* (%)	Worry about climate change impacts on own forests models *n* (%)
Sex	854 (100)	840 (100)
Male	654 (77)	651 (77)
Female	200 (23)	189 (23)
Education		
Elementary school	150 (18)	131 (16)
High school/ vocational	259 (30)	262 (31)
University of applied	248 (29)	254 (30)
University	197 (23)	193 (23)
Occupational position		
Retired	411 (48)	397 (47)
Employee	260 (30)	266 (32)
Agricultural or forest entrepreneur	98 (12)	96 (11)
Other (entrepreneur in another field, student, unemployed)	85 (10)	81 (10)
Ownership status		
Owner / with partner	696 (82)	682 (81)
Joint	158 (18)	158 (19)
Remote owner		
No (living ≤ 120 km)	657 (77)	653 (78)
Yes	197 (23)	187 (22)
New owner		
No (owner ≥ 5 years)	745 (87)	736 (88)
Yes	109 (13)	104 (12)
Objectives of forest ownership		
Uncertain	–	128 (15)
Activities	–	135 (16)
Multiple objectives	–	234 (28)
Economic safety and income	–	184 (22)
Recreation	–	159 (19)
Stress due to the Ukraine war		
Not at all, not much	449 (53)	–
To some extent to very much	405 (47)	–
Worry about climate change impacts on own forest		
Not at all	121 (14)	124 (15)
Not much	323 (38)	310 (37)
To some extent (and very much in anxiety analyses)	410 (48)	375 (44)
Very much (in worry analyses)		31 (4)
Level of anxiety		
Minimal	715 (84)	–
Mild	106 (12)	–
Moderate	24 (3)	–
Severe	9 (1)	–

Material and methods

Study population

We used data from a forest owners' survey that was conducted in May–June 2022 among Finnish forest owners by Pellervo Economic Research. The eligible study population consisted of non-industrial private forest owners (families, real property partnerships and undistributed estates of deceased persons), and the contact information was obtained from the Finnish Forest Centre. The mailed survey, also available online, collected information on, e.g. forest owners' property, worry over climate change, forest management activities, and background factors regarding the property and the respondent. The data included 1224 responses (20.4% response rate). For the statistical analyses, we excluded participants with missing data on the main explanatory variables, outcomes or covariates. As the data were limited in size and we wanted to keep as many responses as possible in the analyses, we formatted two different analytical samples, based on the outcomes examined, with complete data on all included variables. These datasets are described in detail in Table 1. The Ethics Committee for Human Sciences at the University of Turku, Humanities and Social Science Division, has approved the study in April 2022.

Outcomes

We had two outcomes: (1) symptoms of anxiety and (2) worry about the climate change impacts on own forests.

We used the Finnish-translated GAD-7 questionnaire to measure the symptoms of anxiety among forest owners. The questionnaire included the following questions and items: "Over the last two weeks, how often have you been bothered by the following problems?" (1) Feeling nervous, anxious, or on edge, (2) not being able to stop or control worrying, (3) worrying too much about different things, (4) trouble relaxing, (5) being so restless that it is hard to sit still, (6) becoming easily annoyed or irritable, and (7) feeling afraid, as if something awful might happen. The four response options (and their points) were: not at all (0), several days (1), more than half the days (2), and nearly every day (3). The sum of the points of all seven problems was calculated to form a score (scale 0–21) for symptoms of anxiety (Spitzer et al. 2006). First, a linear regression model was applied to both the untransformed and the logarithmically transformed continuous score. However, linear regression models did not work due to the right-skewed distribution of the residuals. Therefore, the continuous score was further classified into four categories for ordinal logistic regression analyses as follows: minimal (0–4), mild (5–9), moderate (10–14) and severe (15–21) symptoms of anxiety (Spitzer et al. 2006; Plummer et al. 2016). The reliability of the variable in this dataset was considered good ($\alpha = 0.87$). The prevalence of anxiety (moderate and severe 4%, Table 1) in this study population (mean age 63 years) was close to that in the older age groups of the Finnish population in general; i.e. among 55–64-year-old women 4.3%, and among 55–64-year-old men 2.8% (Partonen and Suvisaari 2023).

Worry about the climate change impacts on own forests was asked with a question: "How worried are you about the effects of climate change on your forests?" Four response options were available and used for the analyses: not at all, not much, to some extent and very much. These four categories were used in the ordinal logistic regression analyses, where worry was the outcome. However, when this variable was used as an explanatory variable in the anxiety analyses, models with the 4-category variable were unstable. Thus, the responses "to some extent" and "very much" were combined, and the resulting 3-category variable was used.

Main explanatory variables

In the analyses regarding symptoms of anxiety, we used one main explanatory variable. Distress due to public demands on forest management was assessed by asking agreement with six claims in the following way: "I feel distressed about the views brought up in public discussions that indicate that": (1) forest owners are viewed as neglecting forest management, (2) forests should be maintained as carbon storages to mitigate climate change, (3) continuous cover forestry would not be a reasonable option, (4) forest management is seen as a threat to forest biodiversity, (5) forest owners should produce more timber for industry, and (6) clear-cutting should not be done in forests. These claims have been previously used in a forest owner survey (Korhonen et al. 2024). Five-point Likert-scale response options ranged from "fully disagree" to "fully agree" with a sixth alternative to respond: "I cannot say". We formed an index variable of the six claims by providing points to the responses ranging from 1 for "fully disagree" to 5 for "fully agree", "neutral" and "I cannot say" responses providing 3 points, and summarising these points. For the analyses, we used a continuous scale for *distress due to public demands on forest management*.

In addition to the index variable, we assessed associations between each of the individual claims and anxiety symptoms separately. For the analyses, we categorised the responses to the claims as: distress (fully agree or agree), neutral (neutral and I cannot say) and no distress (disagree or fully disagree).

In the analyses regarding worry about climate change impacts on own forests, we used four main explanatory variables that relate to ownership characteristics. As shared forest ownership can incorporate a variety of owner types with different ownership feelings (Lähdesmäki et al. 2023), we examined *farm ownership status* as one explanatory variable. In the survey, ownership status of the forest estate was requested with four response options: (1) owned by a person him/herself, (2) owned with a spouse, (3) owned by a partnership with x number of members and (4) owned by the undistributed estate of a deceased person with x number of members. We dichotomised the variable as: own or owned with spouse = 1 and jointly owned (partnership or undistributed estate) = 2.

The mean age of forest owners in Finland is 62 years (Karppinen et al. 2020), and many of them have owned forest land for a long time. Since the forest ownership motives have been observed to nowadays include also other than the traditional monetary value orientation, such as biodiversity conservation (Häyrinen et al. 2015), younger and more recent (often younger) forest owners may have different motives to own and manage their land than those who have longer ownership history (Juutinen et al. 2020; Liu et al. 2023). Thus, we examined whether being a "new owner" is associated with worry about climate change impacts on own forests. In the survey, the year when the forest estate

ownership started was requested. The *new owner* was defined as having owned the estate for less than five years.

Many forest estate owners today are not living on the estate themselves, and thus, the place of residence was requested in the survey with response options: (1) permanently on the estate, (2) elsewhere in the same municipality as the estate, with x km from the estate, and (3) in another municipality with x km from the estate. We formed a binary variable *remote owner* using a cut-off point of 120 km.

As mentioned, the motives to own forest differ between private forest owners (Häyrinen et al. 2015). Thus, the fourth main explanatory variable for worry about climate impacts on own forests was the *objectives of forest ownership*. Importance of 25 claims representing six topics in forest ownership were requested in the survey, including "My forest is a part of my residential or recreational environment", "My forest offers me regular income for consuming", "My forest represents nature protection to me" and "My forest offers me safety in times of emergency". using principal component analysis with varimax rotation, ownership objectives were summarised into three dimensions, namely "economic security and sales income", "immaterial values" and "opportunities for work and recreation". Summarisation was based on the loadings of over 0.35 of the original variables on principal components (Supplemental Table 1).

Forest owners were further classified into five clusters of ownership objectives. For this, we applied K-means clustering, a machine learning algorithm that partitions observations into *k* distinct clusters. In this case, clustering was based on three factors identified in the prior factor analysis: "economic security and sales income", "immaterial values" and "opportunities for work and recreation." These factors were derived from data on the 25 claims and served as the basis for grouping observations. We tested several values for *k* and selected $k = 5$ based on the interpretability and internal coherence of the resulting clusters. This solution effectively captured the key variation in the data while minimising redundancy and preserving conceptual clarity across clusters. The clusters were called "Uncertain", "Activities", "Multiple objectives", "Economic safety and income" and "Recreation". The cluster Uncertain (share 15.6%) does not set any specific objectives for forest ownership. The cluster Activities (17.1%) is interested in the work and recreation opportunities, especially productive leisure like berry picking, that forest ownership offers. The cluster Multiple objectives (27.4%) represents those who see many objectives as simultaneously important. The Economic Safety and Income cluster (20.9%) sets its objectives as having regular income from timber sales and securing economic stability. Recreation cluster (19.0%) emphasised the intangible aspects of forest ownership, such as nature conservation and scenic value, as well as outdoor recreation opportunities, especially such as relaxation and walking in nature.

Other covariates

Other covariates were also obtained from the survey. We included in our analyses age (based on self-reported birth year) and gender (male/female). As indicators of socioeconomic status, we included level of education and occupational status. Education included five response options: elementary school, high school, vocational education or similar, college or university of applied sciences, and university. Education was further categorised into four classes: (1) elementary school, (2) high school, vocational education or similar, (3) college or university of applied sciences and (4) university. Occupational status was based on a question about primary livelihood obtained as: employee, agricultural entrepreneur, forest entrepreneur, entrepreneur in another field, retired and other (unemployed and student). We categorised this as: retired, employee, agricultural or forest entrepreneur, and other (entrepreneur in another field, unemployed, student). The survey also included a question about annual household income (before tax) with nine response options <15, 15 000–20 000, 20 001–40 000, 40 001–70 000, 70 001–100 000, 100 001–120 000, 120 001–150 000, ≥ 150 000€, and "I don't want to, or I cannot estimate". However, response to this question was missing from the respondents who jointly owned the farm (owned by a partnership or undistributed estate), and thus, this variable was only used in a sensitivity analysis where we replaced the ownership status with household income.

Finally, the invasion of Russia into Ukraine started shortly before the time of the data collection, and the event caused concern in many people living in Finland, as Finland shares over 1000 km of land border with Russia. To try to control for elevated anxiety and stress that might be stemming from the invasion, the question: "Has the invasion of Russia to Ukraine increased your stress level?" was presented to the respondents. Four response options (not at all, not much, to some extent and very much) were dichotomised as: No = "not at all" and "not much", and Yes = "to some extent" and "very much". This variable was used in the anxiety models only.

Statistical analyses

The ordered logit model with maximum likelihood estimation method (McCullagh 1980) was used to assess associations between the explanatory variables and

the 4-category symptoms of anxiety and worry about climate change impacts on own forests. The model assumes proportional odds, that is, the coefficients that describe the relationship between, e.g. the lowest versus all higher categories of the outcome variable are the same as those that describe the relationship between the two lowest categories and all higher categories. Thus, because the relationship between all pairs of groups is assumed to be the same, there is only one set of result coefficients. We tested the proportional odds assumption using the score test, and the partial proportional odds model was used to identify covariates one by one for those for which the assumption was not met (new owner, stress due to war in Ukraine and worry about climate change impacts on own forests). The effect estimates were robust to these tests.

We formed three different models to examine how different explanatory and confounding variables affected the main association with anxiety symptoms and how they were associated with the outcome. Model 1 was adjusted for age and gender; Model 2 was additionally adjusted for education, occupational status, forest estate ownership status, new owner and remote owner variables and Model 3 was further adjusted for stress due to the invasion of Russia into Ukraine and worry about the climate change impacts on own forests.

Associations between ownership characteristics, namely: forest estate ownership status, new owner, remote owner, and ownership objectives, and worry about climate change impacts on their own forests were analysed in the same model. We used two different model specifications: Model 1 was adjusted for age and gender (including the 4 explanatory factors), and Model 2 was additionally adjusted for education and occupational status.

We also ran several sensitivity analyses. As older forest owners may have a better level of resilience and different management motives (Juutinen et al. 2020; Liu et al. 2023) than the younger ones, we re-ran the analyses excluding those who were over 75 years of age. For the main anxiety model, we also exchanged the ownership status variable with household income, and dichotomised responses for worry about the climate change impacts on own forests as "not at all and not much" (reference) and "to some extend and very much". We also classified age into five (≤45, 46–55, 56–65, 66–75 and 76+ years with proportions: 8%, 13%, 27%, 33% and 18%, respectively) and distress due to public demands on forest management into four (score point categories: 0–7, 8–12, 13–16 and 17–24 with proportions: 12%, 42%, 34% and 12%, respectively) categories to examine the linearity. Categorised analyses supported linear associations.

The results for ordinal regression models are presented as odds ratios (OR) with 95% confidence intervals (CI). The data analyses for this paper were generated using SAS/STAT® software, Version 15.2 for Linux. Copyright © 2020 SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA.

Results

In both analytical datasets, the majority of the study population were males (77%), and the mean age was 64 years (range 23–95 years). Most of the responders owned the forest estate by themselves or with their spouse (82% and 81% in the anxiety and worry samples, respectively). The proportion of remote owners was 23% and 22% and that of new owners was 13% and 12%. Nearly half of the responders in the anxiety sample reported some or very much stress due to Russia's invasion of Ukraine (47%). In both datasets, a similar proportion was not at all worried about the climate change impacts on their own forests (14% and 15%), not much worried (38% and 37%), and to some extent or very worried (48%). Of the responders in the anxiety sample, 4% reported moderate or severe anxiety. Other descriptive statistics of the study population are presented in Table 1.

Symptoms of anxiety

The main explanatory variable, *distress due to public demands on forest management,* was not associated with GAD-7 scores in any of the models (Table 2). Of the other explanatory variables, only stress due to the invasion of Russia into Ukraine was associated with a higher GAD score, even after adjustment for the worry about climate change impacts on own forests (OR 3.92, 95% CI 2.52–6.10). Results for the individual claims and anxiety symptoms were similar (Supplemental Table 2).

Worry about the climate change impacts on own forests

Forest ownership status, being a new owner or remote owner, was not associated with worry about the climate impacts on own forests (Table 3). Of the five clusters for *objectives of forest ownership*, the multiple objectives cluster was more worried (OR 2.46, 95% CI 1.60–3.77 in model 2) when compared to the Uncertain cluster. In these analyses, females (OR 1.64, 95% CI

Table 2. Associations for distress due to public demands on forest management and other covariates with anxiety symptoms among forest owners.

Variable	Model 1			Model 2			Model 3		
	OR	95% low	95% high	OR	95% low	95% high	OR	95% low	95% high
Distress due to public demands	1.01	0.96	1.05	1.01	0.97	1.06	0.99	0.94	1.04
Sex (ref. male)	1.21	0.80	1.83	1.18	0.76	1.84	0.92	0.59	1.46
Age	0.98	0.97	1.00	0.98	0.96	1.00	0.98	0.95	1.00
Education (ref. Elementary school)									
High school/ vocational				0.70	0.38	1.26	0.75	0.41	1.38
University of applied science				0.78	0.43	1.41	0.72	0.39	1.33
University				1.05	0.56	1.96	0.84	0.44	1.62
Occupational position (ref. retired)									
Employee				0.61	0.33	1.12	0.66	0.35	1.23
Agricultural or forest entrepreneur				1.36	0.71	2.61	1.33	0.68	2.62
Other				1.05	0.52	2.12	1.12	0.54	2.32
Ownership status (ref. joint)									
Owner/ with partner				1.18	0.72	1.93	1.12	0.67	1.87
Remote owner (ref. living ≤120 km)									
Yes				1.37	0.78	2.15	1.28	0.80	2.06
New owner (ref. owner >5 years)									
Yes				1.50	0.88	2.56	1.49	0.86	2.59
Stress due to Ukraine war (ref. no)									
Yes							**3.92**	2.52	6.10
Worry about climate change impacts on own forest (ref. Not at all)									
Not much							0.63	0.32	1.22
To some extent or very much							1.17	0.63	2.17

Model 1 adjusted for age and sex.
Model 2 additionally adjusted for education and occupational position, forest estate ownership status, new owner, and remote owner variables.
Model 3 additionally adjusted for stress due to the invasion of Russia into Ukraine and worry about the climate change impacts on their own forests.

1.18–2.29) were more worried about the climate impacts on their own forests than men, as were those with higher than elementary school education (e.g. OR 2.02, 95% CI 1.27–3.20 for those with university education).

Sensitivity analyses

When excluding those aged over 75 years or more, the associations for stress due to the invasion of Russia into Ukraine with anxiety symptoms became slightly stronger (fully adjusted OR 4.54, 95% CI 2.71–7.61 in the distress due to public demands index model). There were no associations between the public demands index or the individual claims and anxiety symptoms (Supplemental Table 3). The association between having multiple objectives as a forest owner and worry about climate change impacts on own forests attenuated slightly when the analysis excluded those over 75 years old (OR 2.24, 95% CI 1.37–3.68) (Supplemental Table 4). When replacing ownership status with household income in the distress due to public demands and anxiety model, the associations remained practically the same, while in the lowest income group, the effect estimate for anxiety symptoms was elevated (OR 2.47, 95% CI 0.98–6.20) (Supplemental Table 5). When replacing the 3-category worry about climate change impacts on own forests variable with the dichotomised variable, the odds ratio for anxiety was 1.66 (95% CI 1.11–2.48) among those reporting worry "to some extend and very much" (Supplemental Table 5).

Discussion

Among Finnish forest owners, we observed that distress due to public demands on forest management was not associated with symptoms of anxiety. However, stress due to the invasion of Russia into Ukraine was associated with higher levels of anxiety symptoms, as was worry about climate change impacts on own forests, but only in the sensitivity analysis. Of the participants, 44% were to some extent, and 4% very, worried about climate change impacts on their own forest. Having multiple objectives as a forest owner, being female gender, and having higher education were associated with worry about the climate change impacts on own forests, while forest ownership status, being a new or remote owner, was not.

The associations between distress due to public demands on forest management and symptoms of anxiety among forest owners have not, to our knowledge, been studied before. Lack of such associations may have several reasons. A working paper from the US reported that family forest owners tended to distribute their concerns rather evenly across different types of concerns. Mean points for concern (rated from 1 to 5) increased from damage from animals (2.65) through,

Table 3. Associations for forest ownership characteristics, objectives of ownership and other covariates with worry about the climate change impacts on their own forests.

Variable	Model 1			Model 2		
Ownership characteristics	OR	95% low	95% high	OR	95% low	95% high
Ownership status (Owner with partner vs. joint)	0.90	0.64	1.25	0.92	0.66	1.29
New owner (<5 years vs. ≥ 5 years)	1.03	0.68	1.56	1.01	0.66	1.53
Remote owner (<120 km vs. ≥ 120 km)	0.90	0.66	1.25	0.82	0.59	1.15
Objectives of forest ownership (vs. Uncertain)						
Activities	1.04	0.66	1.65	1.05	0.66	1.67
Multiple objectives	**2.28**	1.49	3.49	**2.46**	1.60	3.77
Economic safety and income	0.98	0.63	1.54	1.10	0.70	1.75
Recreation	1.21	0.77	1.90	1.26	0.80	1.99
Sex (ref. male)	**1.68**	1.21	2.32	**1.64**	1.18	2.29
Age	1.01	1.00	1.02	1.01	0.99	1.03
Education (ref. Elementary school)						
High school/ vocational				**1.64**	1.08	2.49
University of applied science				**1.69**	1.11	2.58
University				**2.02**	1.27	3.20
Occupational position (ref. retired)						
Employee				0.85	0.56	1.29
Agricultural or forest entrepreneur				0.78	0.48	1.27
Other				0.84	0.50	1.42

Model 1 adjusted for age and sex.
Model 2 additionally adjusted for education and occupational position.

e.g. climate change (2.98) and government regulation (3.93) to high property taxes (4.22) (Shanafelt et al. 2024). It may thus be that looking at one type of stressor at a time does not reveal associations with mental health outcomes among forest owners. A review on farmers, on the other hand, identified links between pesticide exposure, financial difficulties, climate variabilities/ drought, and poor physical health/past injuries and mental health outcomes (Daghagh Yazd et al. 2019). In line with this, in our sensitivity analysis, the effect estimate for anxiety was elevated among those with the lowest income. One possible explanation for the lack of associations in this study may be that the forest owners can manage their emotional distress associated with climate change, e.g. through social/peer support or engaging in activities that promote their well-being. In general, climate change adaptation plans should also consider means to handle distress related to climate change.

Related to climate variabilities, in our study, worry about climate change impacts on own forest was associated with symptoms of anxiety only when using worry as a dichotomised variable in the sensitivity analysis. While this association was statistically significant, the reference category also included those who were a bit worried, which hinders the interpretation of the finding. Also, as the effect estimates were strongly dependent on the type of categorisation of the variable, it indicates the association is overall not robust. The lack of a clear association may be because few forest owners were fully dependent on forests as their livelihood (12% of the responders were agricultural or forest entrepreneurs). Moreover, stress and anxiety can be caused by many other issues or risk factors that were not included in our analyses, such as running a business, family life and changes in the national or EU legislation (Eriksson 2014). EU Forestry Strategy, for example, imposes expectations on all forest owners, whether they are worried about climate change or not. Many of the expectations propose significant changes to the way forests are currently managed and thus could have a significant impact on the economic returns from forests, and consequently, the stress and anxiety of the owners.

The association between stress due to the invasion of Russia into Ukraine and anxiety was consistent, and to our knowledge, such an association among forest owners was identified for the first time. The invasion of Russia into Ukraine, although taking place far away from Finland geographically, may still be considered a safety threat as Finland shares over 1000 km of land border with Russia. At the same time, however, the war impacted the trade between Finland and Russia, where wood has traditionally been a key commodity. This led to rising wood prices in Finland, which can be seen as a positive development for the income of forest owners. Worry about the war was common among Finns in general; Citizens' Pulse inquiry explored citizens' views on war in Ukraine in 2022, with 40% (in May) and 38% (in June) of the respondents reporting being very or somewhat worried (Tilastokeskus [Statistics Finland] 2024). Among the forest owners of this study, 48% felt some extent or very much stress due to the Ukraine war. The finding suggests that global conflicts can shake the feeling of safety and mental health also among forest owners, and they should be provided support when facing such acute stress.

This is, to our knowledge, one of the first studies examining factors related to forest owners' worry about the climate change impacts on their own forests. We observed that those who had multiple objectives in forest ownership, compared to those who were uncertain about their objectives, were more worried about the climate change impacts on their own forests. Indeed, forest owners have different motives to own and manage their forests (Häyrinen et al. 2015; Juutinen et al. 2020; Liu et al. 2023), and this can affect their

actions and perceptions. Those with higher than elementary education were more worried about the impacts that climate change may have on their forests. Higher awareness regarding the various possibilities that forests can offer, and regarding the climate risks that forests may face, may explain these associations. Higher education (Husa and Kosenius 2021) and aiming at multiple gains (Karppinen et al. 2018) may also lead to more environmentally positive motivations and management activities. However, in two recent studies where forest ownership motivations were examined in relation to forest management activities, only income-related objectives correlated with actual activities (Kuhlman et al. 2023; Lidestav and Westin 2023). It has been suggested that worry over climate change can lead to constructive responses (Ojala et al. 2021), such as information-seeking about what they can do about climate change and positive climate actions. However, if there is a lack of resources to cope with the worry, it can lead to less constructive outcomes. Individuals may not identify or implement strategies that would help mitigate their worry, or they may absorb maladaptive behaviours, like substance use or risk-taking behaviours, to avoid or instantly ease negative feelings (Ojala et al. 2021; Crandon et al. 2024). While research on forest owners' behaviours under climate worry per se is lacking, these behavioural patterns are expected to apply also to forest owners, for whom climate change may be a direct threat to livelihood and sense of well-being. Unhealthy behavioural patterns may impair personal, social and work life, potentially affecting forest owners' management practices (Crandon et al. 2024). Providing forest owners with concrete climate change adaptation solutions for forest management might work as a coping method to increase feelings of control and to reduce worry.

Strengths and limitations

In this study, we used a dedicated survey to non-industrial forest owners where we requested information about their mental health, using a validated GAD-7 survey, and worry about climate change impacts on their own forests, along with several possible explanatory variables. We are among the first to examine associations between public demands and anxiety symptoms and between forest ownership characteristics and worry about climate change impacts among forest owners. A limitation of this study is the cross-sectional design, which prohibits us from drawing causal interpretations. Reverse causality is also possible; for example, a higher (general) level of anxiousness may be the cause of reporting stress about the invasion of Ukraine. In addition, all exposure and outcome variables were self-reported, which may cause common method bias. This means that those who report high values on the exposure measures may also report high values on the outcome. However, this practically applies only to the exposures related to public demands. The study population's mean age (64 years) was close to that of the private forest owners in Finland (62 years), while it might not reflect the age distribution of forest owner populations in other countries. Future studies should examine associations related to climate change and public pressures with forest owner's mental health in other countries and using longitudinal designs and objective outcome measures. Considering other stress factors would also be of interest to get a better picture of factors possibly affecting forest owner's mental health and work ability.

Conclusions

Public discussion about the aims of forest management, for example, regarding demands to manage forests to advance climate change mitigation, may not be associated with forest owners' mental health, whereas global acute crises may. Mental health support for forest owners during times of crisis should be available. Multiple objectives in forest management, female gender and higher education were associated with worry about the climate change impacts on own forests, which may be explained by higher awareness regarding the various possibilities and gains that forests can offer as well as climate change-related risks. Such worry could be diluted by providing knowledge about, and support to implement, different climate change adaptation solutions in forest management.

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Data availability statement

The datasets generated and analysed during the current study are not publicly available due to confidentiality reasons regarding sensitive data but are available on a reasonable request.

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