Beyond climate-change risk: subjective attribution, multidimensional impact appraisal, and adaptation advocacy among Swedish forestry professionals

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Abstract: Adaptation may depend on whether decision-makers recognise climate change, but also on whether they attribute experienced changes to climate change and how they appraise consequences across valued domains. We analysed survey data from 140 Swedish forestry professionals to examine whether stronger subjective attribution of experienced forest changes to climate change is associated with more risk-dominated valuation of expected impacts, measured using the net value of expected climate-change impacts (NVEI), and whether these appraisals are associated with adaptation advocacy.

Stronger subjective attribution was associated with more risk-dominated NVEI: each one-point increase in attribution corresponded to 50% higher odds of belonging to the risk-dominated rather than opportunity-dominated group ($\beta = 0.40$, 95% CrI = 0.15–0.66; $P(\beta > 0) = 0.999$). This association remained essentially unchanged after accounting for region. Risk- and opportunity-dominated respondents differed in the direction of sudden and gradual expected impacts. Adaptation advocacy was observed among 55% of respondents (95% CrI = 0.47–0.63). Domain-specific analyses showed that associations between partial NVEI and advocacy varied across forest-value domains and expected-impact direction. Advocates showed greater breadth and intensity of differentiation across domains.

Overall, stronger subjective attribution was associated with greater odds of risk-dominated expected-impact valuation, whereas adaptation advocacy was associated less with aggregate risk–opportunity orientation than with the breadth, intensity, and domain-specific configuration of expected-impact appraisals. These findings support a theoretical proposition that subjective attribution may link environmental experience with expectations about future climate-change consequences, highlighting the importance of distinguishing attribution from recognition and aggregate from domain-specific appraisals.

Keywords: Subjective attribution; Net value of expected impacts; Climate-change appraisal; Adaptation advocacy; Forestry professionals; Environmental experience; Risk perception; Climate change adaptation

1. Introduction

Climate change is altering forest ecosystems globally through changing temperature and precipitation regimes, shifting species distributions, and increasing disturbances such as wildfires, storms, pest outbreaks, and disease (IPCC, 2022; IPBES, 2019). Yet observed and expected climate-change impacts do not translate uniformly into adaptation responses. Despite increasing recognition of climate risks and ambitious policy commitments, adaptation implementation remains uneven across sectors and regions (Moser & Ekstrom, 2010; Moser, 2016; van Valkengoed & Steg, 2019). Research among European forest owners and managers likewise indicates that climate-change awareness does not necessarily translate into adaptive responses, with knowledge and information identified as important constraints (Sousa-Silva et al., 2018). Experiences of climate-related events may also shape subsequent responses: among small woodland owners in the United States, characteristics of experienced events were associated with both how climate change was experienced and with response behaviours (Denny & Fischer, 2023). Understanding why some decision-makers support and advocate adaptation while others do not is therefore central to explaining variation in climate-change adaptation.

A key starting point is how decision-makers interpret environmental change. People do not respond to environmental exposure alone; they interpret observed changes through cognitive appraisal processes that shape perceptions of causes, consequences, and possible responses (Grothmann & Patt, 2005). General recognition that climate change affects forests does not necessarily imply that observed changes in a particular forest are attributed to climate change. The latter involves an additional interpretive judgement concerning the causes of experienced environmental change. In this study, subjective attribution refers to the extent to which individuals interpret experienced changes in forest conditions as consequences of climate change. Attribution may be particularly important for adaptation because it connects observed environmental change to expectations about climate-change related consequences and may influence subsequent evaluations and behavioural responses (Blennow et al., 2012, 2020; Blennow & Persson, 2021; Thaker & Cook, 2021; Wong-Parodi & Berlin Rubin, 2022; Cologna et al., 2025). Previous research among private forest owners has shown that both the strength of belief in local climate-change impacts and the strength of attribution of observed changes to climate change are associated with adaptation responses (Blennow et al., 2012).

Recognising climate change, however, is not equivalent to evaluating its consequences as either harmful or beneficial. Adaptation decisions also depend on how expected consequences are valued. The net value of expected climate-change impacts (NVEI) captures the balance between positively and negatively valued expected consequences of climate change and provides a measure of the overall direction of expected-impact valuation (Persson et al., 2020). Negative NVEI values indicate that negatively valued expected impacts outweigh positive ones, whereas positive values indicate the reverse, distinguishing risk-dominated from opportunity-dominated expected-impact valuation. However, an aggregate NVEI value does not reveal how this balance is formed and may therefore conceal substantial heterogeneity across valued domains. Partial NVEI values capture the direction and magnitude of expected impacts within individual domains, such as sawlog production, hunting opportunities, and rural development. Thus, respondents with similar aggregate NVEI values may differ substantially in the domains in which they expect positive or negative consequences. Examining these domain-specific valuations is therefore important for understanding how expected impacts relate to adaptation responses. This distinction is particularly relevant because adaptation advocacy may be associated with both negatively and positively valued expected climate-change consequences. Previous research among European forestry professionals has shown that adaptation advocacy was generally associated with the absolute value of NVEI, consistent with an approximately V-shaped relationship in which advocacy was higher at more negative and more positive NVEI values than around the neutral point (Blennow et al. 2020).

In forestry, climate change can affect forests through relatively gradual changes in growing conditions and forest growth as well as through more sudden disturbances such as storm damage, wildfires, droughts, and pest outbreaks (Reyer et al., 2017; Seidl et al., 2017; Laudon et al. 2024). Sudden and salient events may receive greater cognitive attention and influence how climate-related impacts are perceived and weighted (Slovic, 1987; Weber, 2006). The composition of valued expected impacts may therefore provide additional context for understanding variation in NVEI orientation and adaptation advocacy.

Forestry is particularly relevant for studying climate-change adaptation because management decisions involve long planning horizons and are made in relation to forest conditions that may change over time (Millar et al., 2007). Previous studies among European forestry professionals have documented geographical variation in NVEI and adaptation behaviour (Persson et al., 2020; Blennow et al., 2020). Regional variation in climate-change adaptation has also been documented among Swedish private forest owners (Blennow, 2012), suggesting that differences in environmental context may contribute to variation in climate-change appraisal. In the present study, geographical region is considered primarily as contextual information and a robustness consideration rather than as a separate explanatory focus.

Differences in environmental experience may influence how observed forest changes are interpreted and attributed to climate change. If experienced changes are interpreted as manifestations of climate change, they may make adverse consequences more salient and increase the perceived importance of climate-related threats to existing forest functions (*cf.* Slovic, 1987; Weber, 2006). On this basis, stronger attribution may be expected to be associated with a more risk-dominated valuation of expected impacts. This expectation is directional rather than definitional: attribution of observed change to climate change could also increase expectations of beneficial consequences. Less is known about whether the attribution of experienced environmental change to climate change is associated with how people evaluate the expected consequences of climate change, particularly whether stronger attribution is associated with a more risk-dominated valuation.

In 2023, we surveyed Swedish forestry professionals to examine whether stronger subjective attribution of experienced forest changes to climate change is associated with more risk-dominated expected-impact valuations, and how expected impacts across forest-value domains relate to adaptation advocacy. This study contributes in two ways. First, building on Blennow et al. (2012), we examine whether stronger subjective attribution is associated with the direction of expected-impact valuation. Second, we examine whether adaptation advocacy is associated with the domain-specific configuration of expected climate-change impacts rather than simply with aggregate risk–opportunity orientation.

1.1 Hypothesis

We test the hypothesis:

H1: Stronger subjective attribution of experienced forest changes to climate change is associated with more risk-dominated valuation of expected climate-change impacts (*cf.* Blennow et al., 2012; Persson et al., 2020).

2. **Materials and Methods**

2.1 Data

Data were collected via an online survey of mainly non-public-sector forest professionals in Sweden employed by major forestry organisations. Approximately 917 professionals working with forest planning, implementation, and advisory services were invited by email. Of these, 140 provided complete responses (approximately 15%). Data were collected via an online survey administered using the Netigate platform (Netigate, 2024). The survey was open from 27 November 2023 to 16 January 2024, with four reminders sent during December. Participation was voluntary.

The questionnaire included 142 items covering climate change, forest management, advisory services, forest damage, and socio-demographic characteristics. This study analyses 140 complete responses focusing on climate-change perceptions, expected climate-change impacts, and adaptation advocacy. The analysed variables and their coding are summarised in SUPPLEMENTARY INFORMATION (Table S1), while the complete questionnaire is provided in SUPPLEMENTARY INFORMATION (Appendix A).

Respondents reported their geographical region of activity as Götaland, Svealand, or Norrland (SUPPLEMENTARY INFORMATION, Figure S1). The regional composition of the sample was uneven across these three regions. Two respondents reported activity in two regions and were therefore not assigned to a single region. These respondents were retained in the full analyses but excluded from analyses requiring assignment to a single region. The three regions represent broad climatic and ecological gradients across Sweden and were used as contextual predictors in regional analyses.

2.2 Variables and derived indices

Variables are referenced using numbering Q1–Q8, see SUPPLEMENTARY INFORMATION (Table S1). Local climate-change belief and subjective attribution were measured using 7-point Likert scales. Local climate-change belief (Q1) was assessed by agreement with “Climate change will affect the forest”, whereas subjective attribution (Q2) was assessed by agreement with “I have experienced changes in forest stands resulting from climate change”. These measures were treated as distinct constructs: Q1 captures general recognition that climate change will affect the forest, whereas Q2 captures the respondent’s attribution of experienced forest changes to climate change.

Adaptation advocacy (Q3) was operationalised as a binary indicator ($y = 1$) based on responses to adaptation items, where respondents selecting “Yes, always” for at least one item were classified as advocates, following Blennow et al. (2020). This operationalisation identifies respondents expressing the strongest response category for at least one adaptation measure and follows the definition used in the previous European forestry-professional study. For measure-specific analyses, each adaptation item was likewise represented as a binary indicator, with a value of 1 corresponding to “Yes, always”

The net value of expected climate-change impacts (NVEI; Q4–Q7) was calculated across 12 forest-related objects using four question batteries. Responses were symmetrically coded as +4/−4 (“Yes, always”), +3/−3 (“Often”), and 0 for all remaining categories. Scores were then summed across items, producing values from −96 to +96. Negative values indicate that negative expected impacts outweigh positive expected impacts, whereas positive values indicate the reverse (Persson et al., 2020). NVEI therefore represents the aggregate direction of expected-impact valuation across the considered forest-related domains.

Value strength (VS) was calculated from the same expected-impact evaluations (Q4–Q7) by summing the absolute values of each impact rating, thereby capturing the overall magnitude of expected impacts regardless of whether they were positive or negative. VS was used to distinguish between respondents with NVEI = 0 because they reported no valued expected impacts (VS = 0) and respondents with NVEI = 0 because positive and negative valuations offset one another (VS > 0).

Partial NVEI indices were calculated by separating positive and negative expected impacts and aggregating across forest-value categories (Q4–Q7; Blennow and Anander, 2026). These indices retain information on the domain-specific composition of expected-impact valuation that may be obscured by the aggregate NVEI. They were used in exploratory analyses to characterise the domain-specific components of expected-impact valuation.

For interpretation, observations with NVEI < 0 were classified as risk-dominated and observations with NVEI > 0 as opportunity-dominated. Observations with NVEI = 0 were retained separately where relevant, with VS used to distinguish between respondents with no valued impacts and respondents with offsetting positive and negative valuations. NVEI = 0 observations were excluded only from the directional risk-versus-opportunity outcome used to test H1.

2.3 Statistical modelling and inference framework

Previous research among European forest professionals, including Swedish respondents, has established a relationship between NVEI and advocacy of climate change adaptation (Blennow et al. 2020). Building on this established relationship, we distinguish respondents according to whether their NVEI was risk-dominated or opportunity-dominated.

H1 was tested using Bayesian logistic regression. The dependent variable was NVEI orientation, coded as risk-dominated (NVEI < 0) versus opportunity-dominated (NVEI > 0); NVEI = 0 observations were excluded from this directional outcome because they did not indicate either risk or opportunity dominance. Subjective attribution was included as a continuous predictor. The coefficient therefore represents the change in the log-odds of risk-dominated versus opportunity-dominated valuation associated with a one-point increase in subjective attribution.

A sensitivity model additionally adjusted for geographical region to assess whether the association between subjective attribution and NVEI orientation was robust to regional differences.

Regional differences in subjective attribution and NVEI orientation were examined using posterior pairwise contrasts. An exploratory probability-scale decomposition was additionally used to assess whether regional differences in NVEI orientation were statistically consistent with regional differences in subjective attribution. The decomposition separated an attribution-associated component from a residual regional component. Because the data were cross-sectional and subjective attribution and NVEI were measured contemporaneously, these components were interpreted as statistical decompositions rather than evidence of causal mediation. Full details are provided in the SUPPLEMENTARY INFORMATION (Methods S2).

Bayesian bootstrap comparisons were used for descriptive analyses of partial NVEI structures underlying expected-impact valuation. These analyses were used to characterise differences in valuation structures rather than as formal hypothesis tests. Full computational details are provided in the SUPPLEMENTARY INFORMATION (Methods S2).

An exploratory domain-specific analysis examined whether negative and positive components of the partial NVEI were differentially associated with adaptation advocacy. For each of the 12 forest-value domains, the signed partial NVEI was decomposed into a negative component, representing the magnitude of negative expected impacts, and a positive component, representing the magnitude of positive expected impacts. Bayesian logistic regression was then used to model binary adaptation advocacy with all 24 sign-specific components entered simultaneously. Thus, each coefficient estimates the association between greater magnitude of expected impacts of a given direction in a particular value domain and advocacy, conditional on the corresponding components of the other domains. Because 24 predictors were estimated from 140 observations, this analysis was treated as exploratory and hypothesis-generating rather than confirmatory. Coefficients were therefore interpreted as domain-specific patterns requiring replication rather than as independent hypothesis tests**.** Full model specifications and sensitivity analyses are provided in the SUPPLEMENTARY INFORMATION (Methods S2).

2.4 Posterior inference and robustness

Bayesian inference was summarised using posterior means, 95% credible intervals (CrI), and posterior probabilities of directional effects. Descriptive adaptation advocacy rates were estimated using Bayesian binomial inference with a Beta(1,1) prior and are reported as posterior means with 95% credible intervals. Rates were calculated for the full sample and separately for Götaland, Svealand, and Norrland; respondents reporting activity across multiple regions were excluded from the regional estimates, see SUPPLEMENTARY INFORMATION (Table S2). For comparisons between NVEI regimes, measure-specific adaptation advocacy was examined among respondents classified as advocates ($y = 1$), contrasting risk-dominated (NVEI < 0) and opportunity-dominated (NVEI > 0) conditions. Posterior probabilities were interpreted using adapted IPCC-style likelihood categories following Mastrandrea et al. (2010), see SUPPLEMENTARY INFORMATION (Table S3). Posterior pairwise regional contrasts were calculated directly from posterior draws. Respondents reporting activity across multiple regions were retained in analyses that did not require a single-region classification and excluded from analyses requiring assignment to a single region.

Full model specifications, prior distributions, posterior contrast calculations, regional decomposition procedures, and bootstrap implementation are provided in the Supplementary Information (Methods S2).

2.5 Software

Analyses were conducted in R (v4.4.1; R Core Team, 2024). Bayesian regression models were implemented using the *brms* package (Bürkner, 2017; 2018), with posterior analysis conducted using *posterior* (Bürkner et al., 2026). Data processing and tabulation were performed using standard R packages. Fixed random seeds were used to ensure reproducibility.

3. Results

Adaptation advocacy was observed among approximately 55% of respondents nationally (95% CrI = 47–63%), with broadly similar descriptive rates across the three regions, see SUPPLEMENTARY INFORMATION (Table S2).

3.1 H1: *Stronger subjective attribution of experienced forest changes to climate change is associated with more risk-dominated valuation of expected climate-change impacts*

Subjective attribution was generally weaker and more heterogeneous than local climate-change belief (Figure 1a,b).

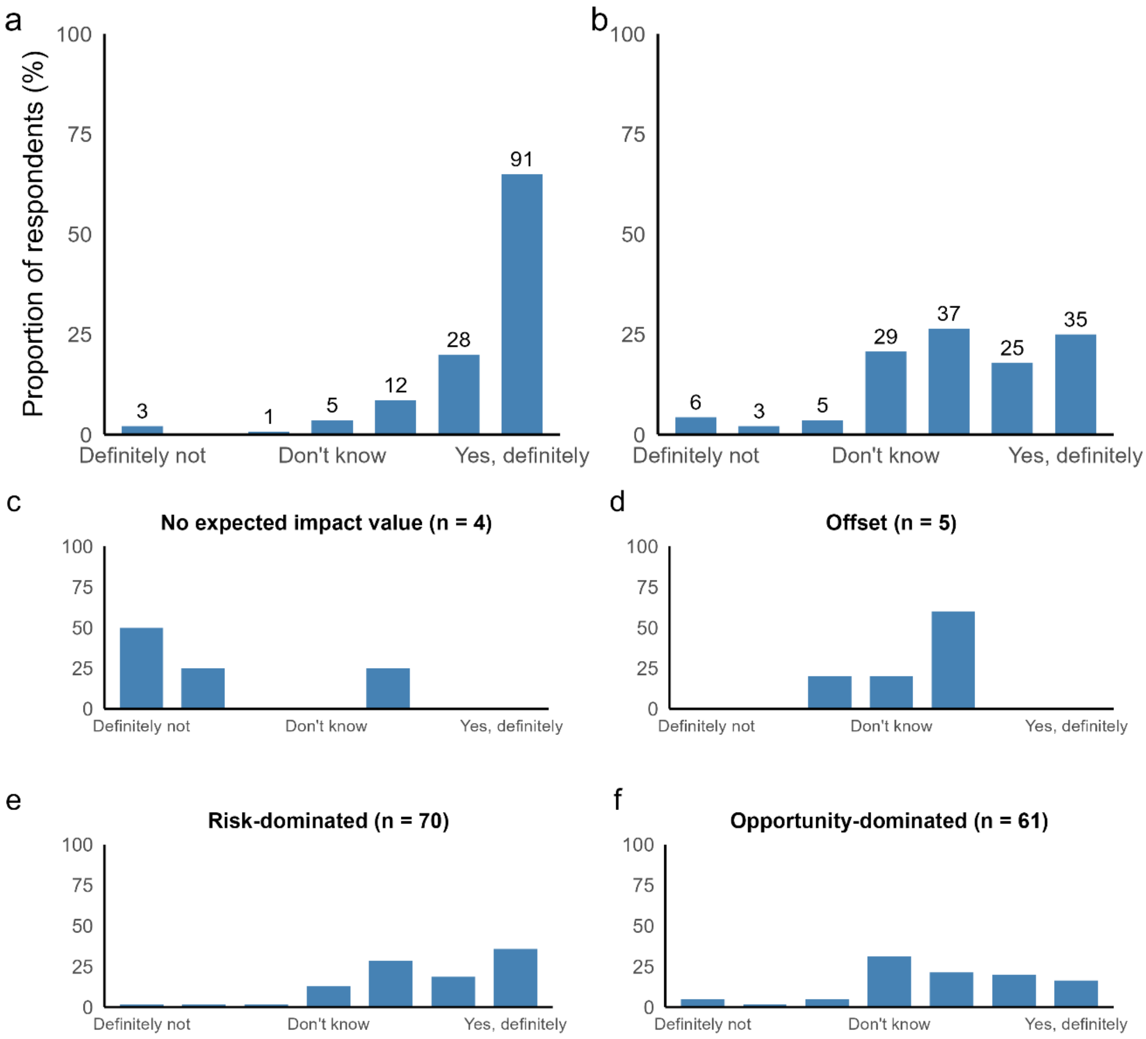

Figure 1. Climate-change beliefs and subjective attribution among forestry professionals. (a) Distribution of responses to “Climate change will affect the forest” (Q1), representing local climate-change belief. (b) Distribution of responses to “I have experienced changes in forest stands resulting from climate change” (Q2). (c–f) Distribution of subjective-attribution responses across four NVEI regimes: (c) no expected impact value (NVEI = 0, VS = 0), (d) offset expected-impact values (NVEI = 0, VS > 0), (e) risk-dominated (NVEI < 0), and (f) opportunity-dominated (NVEI > 0). Panels (a) and (b) show percentages of the full sample; panels (c–f) show percentages within each NVEI regime, with sample sizes indicated in panel titles.

Subjective attribution was positively associated with risk-dominated rather than opportunity-dominated NVEI ($\beta = 0.40$, 95% CrI = 0.15–0.66; posterior probability = 0.999; Table 1). A one-point increase in subjective attribution on the 7-point scale corresponded to 50% higher odds of belonging to the risk-dominated rather than opportunity-dominated NVEI group. The association was virtually unchanged after accounting for region ($\beta = 0.39$, 95% CrI = 0.12–0.67; posterior probability $\beta > 0$ = 0.999), indicating that the relationship was not materially affected by the uneven regional composition of the sample.

Regional differences in subjective attribution were examined separately (SUPPLEMENTARY INFORMATION, Table S4). Attribution was substantially lower among Norrland respondents than among both Götaland and Svealand respondents, whereas the contrast between Svealand and Götaland was smaller and substantially more uncertain.

Regional differences in NVEI orientation were then examined without adjustment for subjective attribution (SUPPLEMENTARY INFORMATION, Table S5). The posterior distributions generally favoured lower odds of risk-dominated NVEI in Norrland relative to the comparison regions, although the corresponding credible intervals included zero. After adjustment for subjective attribution, these paired regional contrasts were attenuated for Norrland–Götaland (β = −0.84 to −0.49) and Norrland–Svealand (β = −0.54 to −0.05), while the adjusted contrasts remained uncertain (SUPPLEMENTARY INFORMATION, Table S6).

This pattern motivated an exploratory probability-scale decomposition of the same two regional contrasts to examine the extent to which the regional probability differences were statistically associated with regional differences in subjective attribution (SUPPLEMENTARY INFORMATION, Table S7). The attribution-associated component was virtually certainly negative for both Norrland–Götaland and Norrland–Svealand, indicating that the regional difference in subjective attribution was statistically consistent with a lower probability of risk-dominated NVEI in Norrland. The residual regional component was likely negative for Norrland–Götaland but highly uncertain for Norrland–Svealand. The attribution-associated component was comparatively large relative to the total regional probability difference, particularly for Norrland–Svealand. Given the cross-sectional design, these quantities are interpreted as statistical decompositions rather than evidence of causal mediation.

Table 1. Bayesian logistic regression estimates for the association between subjective attribution and NVEI orientation.

Predictor	*Primary H1 model: Estimate (log-odds)*	*SE*	*95% CrI*	*P(β > 0)*	*H1 + region Estimate (log-odds)*	*SE*	*95% CrI*	*P(β > 0)*
Subjective attribution	0.40	0.13	0.15–0.66	0.999	0.39	0.14	0.12–0.67	0.999

Notes: Positive coefficients indicate higher odds of risk-dominated rather than opportunity-dominated NVEI. CrI = 95% credible interval.

The direction of expected climate-change impacts differed strongly between NVEI orientations for both sudden and gradual impacts (SUPPLEMENTARY INFORMATION, Table S8). Risk-dominated respondents had substantially higher odds of reporting negative expected impacts than opportunity-dominated respondents, whereas opportunity-dominated respondents had substantially higher odds of reporting positive expected impacts than risk-dominated respondents. This pattern was consistent for both sudden and gradual impacts, with odds ratios ranging from approximately 29 to 39 across the four comparisons. All four models provided virtually certain evidence of the respective directional differences (posterior probability >0.999). These results show that NVEI orientations were strongly differentiated by the direction of expected impacts across both temporal components. They do not, however, indicate that sudden or gradual temporal characteristics independently drive adaptation advocacy.

Descriptively, subjective attribution was highest among risk-dominated respondents, followed by opportunity-dominated respondents, whereas respondents with NVEI = 0 showed lower attribution overall. The NVEI = 0 group comprised two substantively distinct cases: respondents with VS = 0, indicating no expected impact value, and respondents with VS > 0, indicating that positive and negative expected-impact values offset one another (Figure 1; SUPPLEMENTARY INFORMATION, Table S9). Subjective attribution was virtually certainly higher among risk-dominated than opportunity-dominated respondents and was also virtually certainly higher among risk-dominated respondents than among those with no expected impact value. The difference between risk-dominated and offset-impact respondents was less certain (SUPPLEMENTARY INFORMATION, Table S10).

3.2 Management preferences and underlying value structures

Advocacy patterns varied across forest management interventions and differed between adaptation advocates in risk- and opportunity-dominated NVEI regimes (Figure 2a). Values represent the posterior probability that advocacy for a given adaptation measure was higher under risk-dominated than under opportunity-dominated NVEI conditions, conditional on respondents being adaptation advocates ($y = 1$). Provenance selection showed the strongest differentiation between regimes, with virtually certain evidence of higher advocacy under risk than opportunity conditions. Several other interventions also showed evidence of higher advocacy under risk, including mixed forest management, continuous cover forestry, strategic planning, lengthening of rotation periods, natural regeneration over planting, exotic tree species, and spacing at planting. However, evidence for these differences was generally weaker than for provenance selection. Other interventions showed limited evidence of directional differences between regimes, including shortening of rotation periods, modification of thinning regimes, crisis management, and timing of felling. A smaller number of measures showed tendencies towards higher advocacy under opportunity conditions, including tree species selection, drainage, and planting rather than natural regeneration.

Overall, respondents with risk-dominated NVEI tended to place greater emphasis on several adaptation measures, particularly provenance-related and measures related to forest composition and management. However, the pattern was selective rather than uniform across interventions, indicating that NVEI orientation was associated with differences in emphasis among adaptation options rather than a general increase in advocacy.

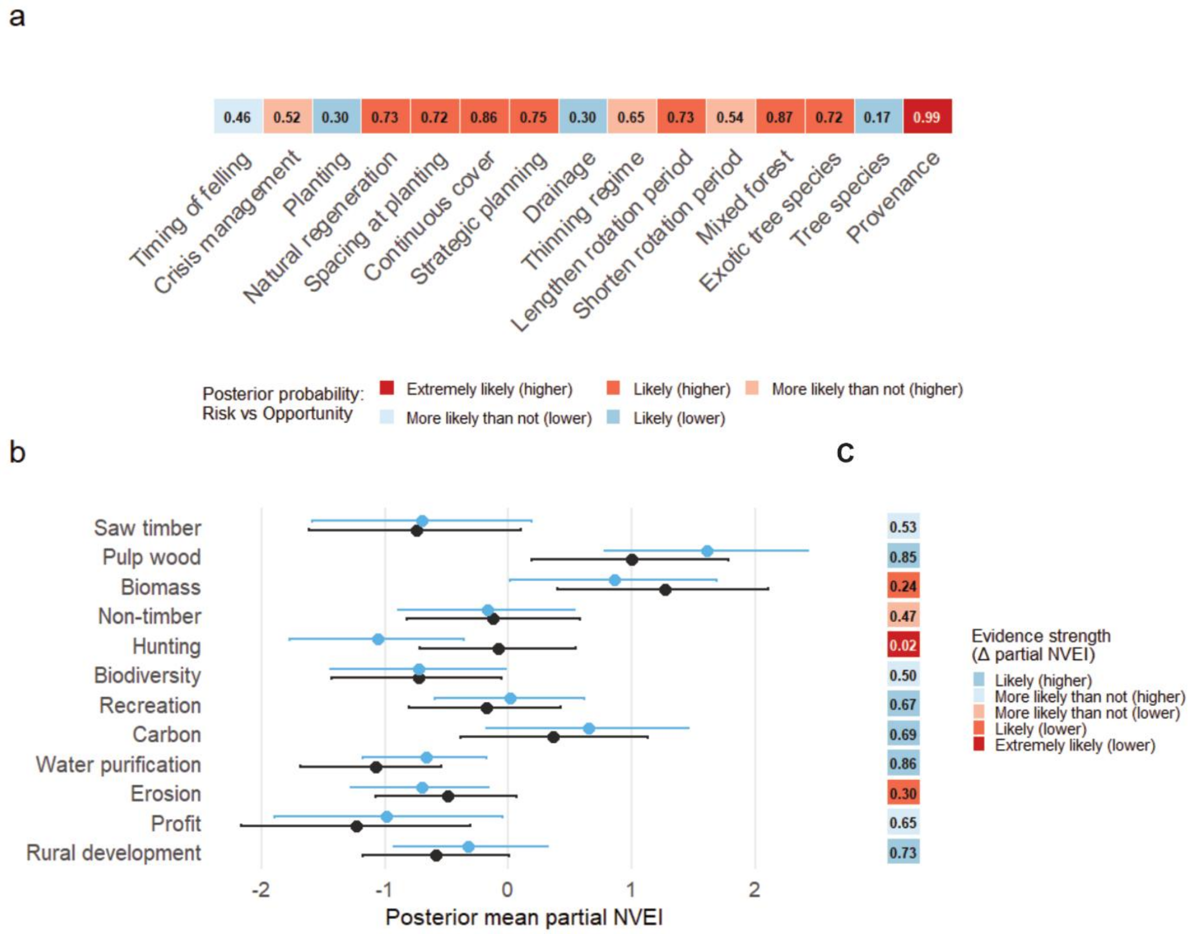

Figure 2. Adaptation advocacy and underlying expected-impact valuation among forestry professionals.
(a) Among adaptation advocates, posterior probabilities that the proportion advocating a given adaptation measure is higher under risk-dominated (NVEI < 0) than opportunity-dominated (NVEI > 0) conditions. Advocacy proportions were estimated using Bayesian binomial inference with independent Beta(1,1) priors for the risk-dominated and opportunity-dominated groups of advocates. Values represent the posterior probability that advocacy is higher under risk than under opportunity conditions; values approaching 1 indicate stronger evidence for higher advocacy under risk-dominated expectations, values approaching 0 indicate higher advocacy under opportunity-dominated expectations, and values near 0.5 indicate weak or inconclusive differences. Results are classified using an IPCC-style likelihood scale, see SUPPLEMENTARY INFORMATION (Table S3). (b) Posterior mean partial NVEI scores for adaptation advocates and non-advocates across forest-value and ecosystem-service domains. Posterior means and 95% credible intervals were estimated using Bayesian bootstrap sampling. Colours distinguish advocates (blue) and non-advocates (dark blue). (c) Posterior probabilities that partial NVEI values are higher among advocates than non-advocates. Values approaching 1 indicate stronger evidence for higher partial NVEI among advocates, values approaching 0 indicate higher partial NVEI among non-advocates, and values near 0.5 indicate weak evidence for differences. Results are classified using the same IPCC-style likelihood scale as in panel (a).

Respondents advocating adaptation and non-advocates differed selectively in their partial NVEI valuations across ecosystem-service and forest-value domains (Figure 2b,c). The direction of these differences varied between domains rather than reflecting a consistent shift towards either more positive or more negative expected climate-change impacts. Pulp wood showed likely evidence of higher partial NVEI among advocates, with advocates expressing more positive expected impacts than non-advocates. Hunting showed the clearest divergence in the opposite direction, with extremely likely evidence that advocates had more negative partial NVEI values. Water purification provided a contrasting case: partial NVEI values were negative in both groups, but advocates showed likely evidence of less negative values than non-advocates. For saw timber, non-timber values, biodiversity, recreation, carbon, erosion control, profit, and rural development, evidence for between-group differences was generally weaker or uncertain.

These results indicate that advocacy was not associated with a uniform directional shift in the expected impacts of climate change across value domains. Rather, advocates and non-advocates occupied different positions within a multidimensional partial-NVEI structure, with the direction of between-group differences varying according to the value domain. In particular, the combination of more positive pulp-wood NVEI, more negative hunting NVEI, and less negative water-purification NVEI illustrates that the relationship between advocacy and expected climate-change impacts cannot be characterised simply as either greater perceived risk or greater perceived opportunity across all domains.

To examine whether these domain-specific differences formed part of a broader difference in the intensity and breadth of partial NVEI, additional Bayesian bootstrap analyses were conducted (SUPPLEMENTARY INFORMATION, Table S11). Advocates showed extremely likely higher overall intensity of expected climate-change impacts, measured as the total absolute magnitude of their negative and positive sudden and gradual expected-impact assessments across value domains. They also showed very likely evidence of greater breadth of valued expected impacts, expressed as a larger number of value domains with non-zero net expected impact values. Furthermore, advocates showed extremely likely higher maximum domain-specific deviations, indicating stronger responses in their most strongly differentiated value domains. In contrast, NVEI concentration was likely lower among advocates, indicating that their stronger overall intensity of expected impacts was distributed across a broader set of value domains. Thus, the broader pattern was not one of advocacy being associated with isolated extreme appraisals in only a few ecosystem services. Instead, advocates tended to express stronger and broader expected-impact appraisals across multiple value domains, irrespective of whether these expectations were positive or negative.

Finally, an exploratory Bayesian logistic regression model examined whether the positive and negative components of partial NVEI within individual value domains were associated with the odds of advocating adaptation when all 12 domains were considered simultaneously (SUPPLEMENTARY INFORMATION, Table S12). Separating the two components allowed the association with advocacy to differ according to the direction of expected climate-change impacts, rather than assuming that positive and negative expectations have symmetric effects. Because the model included 24 predictors in 140 respondents, it was treated as exploratory and hypothesis-generating.

Most domain-specific associations showed substantial posterior uncertainty. However, several patterns were evident. Negative partial NVEI for hunting showed a positive association with advocacy (posterior mean = 0.38; 95% CrI = 0.13–0.66), indicating that stronger negative expectations for hunting were associated with higher odds of advocating adaptation, conditional on the other modelled components. Negative partial NVEI for water purification showed the opposite pattern (posterior mean = −0.38; 95% CrI = −0.69–−0.08), indicating that stronger negative expectations in this domain were associated with lower odds of advocating adaptation. Among positive partial NVEIs, pulp wood showed a positive association (posterior mean = 0.32; 95% CrI = 0.05–0.60), whereas the positive biomass association was weakly negative and its credible interval included zero (posterior mean = −0.28; 95% CrI = −0.60–0.01). For biomass, the posterior strongly favoured a more positive association for increasing magnitudes of negative partial NVEI than for increasing magnitudes of positive partial NVEI ($P(\beta_{-} > \beta_{+}) = 0.99$). The remaining domain-specific positive and negative components generally showed substantial posterior uncertainty.

Comparison of the posterior effects for the positive and negative components provided further evidence that the associations were domain- and direction-specific. For pulp wood, the positive component was substantially more positive than the negative component, with a posterior probability of 0.98 that the positive effect exceeded the negative effect. Hunting showed the opposite pattern, with a posterior probability of only 0.03 that the positive effect exceeded the negative effect. For biomass, the evidence likewise favoured a more positive association for the negative component, although the corresponding component-specific estimates remained uncertain. Water purification showed a positive association for its positive component and a negative association for its negative component, with a posterior probability of 0.90 that the positive component was larger than the negative component. These contrasts indicate that the relationship between expected impacts and advocacy depends not only on the value domain but also on the direction of the expected climate-change impact within that domain. Taken together, these findings indicate that adaptation advocacy is associated with domain- and valence-specific patterns in expected climate-change impacts, rather than a uniform shift in NVEI across all domains. The results do not support a simple interpretation in which greater absolute extremeness, irrespective of direction, systematically increases advocacy. This is consistent with an interpretation in which advocacy is associated with multidimensional appraisal of expected climate-change consequences rather than with a single dominant value domain or a uniform orientation towards either climate-change risk or opportunity. Importantly, these associations concern the appraisal of expected climate-change consequences rather than a fundamental reordering of the underlying hierarchy of forest values.

4. Discussion

This study examined how subjective attribution of experienced forest changes to climate change relates to the direction of expected climate-change impacts, and how these expectations are associated with adaptation advocacy among Swedish forestry professionals. Two findings are particularly important. First, subjective attribution of experienced forest changes to climate change was strongly associated with the direction of expected climate-change impacts, providing virtually certain posterior evidence in support of H1 (Table 1). Respondents who more strongly attributed experienced changes in forest stands to climate change were substantially more likely to hold risk-dominated rather than opportunity-dominated NVEI. This association was essentially unchanged after accounting for geographical region, indicating that it was not simply a consequence of geographical differences in the sample. The finding is consistent with a theoretical proposition that subjective attribution may constitute an interpretive mechanism connecting experienced environmental change with expectations about future climate-change consequences. General recognition that climate change affects the forest was relatively widespread, but attribution of experienced changes to climate change was considerably more heterogeneous. This distinction suggests that expectations about climate-change impacts may depend not only on general recognition of climate change, but also on how professionals interpret changes in their own forest environments. Second, adaptation advocacy was associated with selective and multidimensional differences in expected climate-change impacts across forest-value domains, rather than with a uniform shift towards either perceived risk or opportunity. Advocates also showed greater breadth and overall magnitude of expected impacts across value domains.

4.1 Subjective attribution and geographical variation in net expected-impact valuation

Previous research has shown that subjective attribution of experienced environmental changes to climate change can be associated with adaptation decision-making (Blennow et al., 2012). More broadly, research has linked subjective attribution of experienced climate-related events to pro-environmental attitudes, behavioural intentions, and climate-policy support (Wong-Parodi & Berlin Rubin, 2022; Thaker & Cook, 2021; Cologna et al., 2025). This literature therefore provides evidence that attribution can connect experienced environmental change with subsequent climate-related responses, but it has paid less attention to the role of attribution in shaping expectations about future climate-change impacts. The present study extends this perspective by examining the relationship between subjective attribution and the direction of net expected climate-change impact valuation. We tested H1, stating that *stronger subjective attribution of experienced forest changes to climate change is associated with more risk-dominated valuation of expected climate-change impacts.*

Most forestry professionals expressed strong local climate-change belief, whereas subjective attribution of experienced changes in forest stands was weaker and substantially more heterogeneous (Figure 1). This distinction is important because recognising that climate change will affect the forest does not necessarily imply interpreting experienced changes as consequences of climate change. This distinction positions subjective attribution as a more specific interpretive step between environmental experience and expectations about future climate-change impacts.

Subjective attribution was strongly associated with the direction of NVEI. A one-point increase on the seven-point attribution scale corresponded to 50% higher odds of belonging to the risk-dominated rather than opportunity-dominated NVEI regime. The association was virtually unchanged after adjustment for region, suggesting that the relationship was not simply a consequence of the uneven geographical composition of the sample (Table 1). These findings corroborate H1 and extend previous work by directly linking climate-change attribution to the direction of expected climate-change impact valuation.

The relevance of attribution may lie in the interpretive knowledge required to translate environmental experience into expectations about future consequences. Recognising that a forest has changed does not, by itself, specify what caused the change, how it may relate to climate change, what consequences may follow, or which management responses may be appropriate. Adaptation therefore involves not only recognising climate change but also understanding how climatic drivers propagate through ecological and management systems and affect valued forest functions. Research on adaptation has similarly emphasised the importance of knowledge about specific climate-change impacts and the mental models through which people connect climate change to local consequences and possible responses (Blennow & Persson, 2021; Semenza et al., 2011). On this basis, we propose that subjective attribution can be conceptualised as an interpretive mechanism linking experienced environmental change to expectations about future climate-change impacts. The present findings are consistent with this proposition because stronger attribution was associated with more risk-dominated NVEI. However, because attribution and NVEI were measured contemporaneously, the present study does not establish the temporal or causal operation of this mechanism.

The regional analyses provide additional context. Respondents in Norrland reported substantially weaker subjective attribution than respondents in both Götaland and Svealand. Regional differences in NVEI orientation were attenuated after accounting for subjective attribution, and the exploratory probability-scale decomposition indicated that a substantial component of the regional contrasts was statistically associated with differences in attribution. These results are consistent with the possibility that geographical variation in NVEI orientation partly reflects differences in how experienced forest changes are interpreted. The attribution-associated component was particularly large for the Norrland–Svealand contrast. However, because attribution and NVEI were measured contemporaneously, the decomposition should not be interpreted as evidence of causal mediation.

The strong differentiation between risk- and opportunity-dominated forest professionals across both sudden and gradual expected impacts indicates that the NVEI regimes represent substantively distinct patterns of expected climate-change consequences rather than orientations confined to a particular temporal component of climate change.

Taken together, these findings support H1 and are consistent with the proposed role of subjective attribution as an interpretive step between experienced environmental change and the formation of risk- versus opportunity-dominated expectations about future climate-change consequences. Stronger attribution was associated with greater emphasis on negative expected consequences. However, the cross-sectional design does not establish that this interpretive sequence operates causally or in the proposed temporal order. Longitudinal research linking documented environmental experience, attribution, subsequent NVEI formation, and later adaptation decisions would be needed to determine whether these processes unfold in the proposed temporal order and whether attribution plays a causal role in this pathway.

4.2 Implications for climate-change communication

The attribution finding also provides a concrete rationale for considering climate-change communication. General recognition that climate change will affect the forest was relatively strong, whereas attribution of experienced changes to climate change was weaker and more heterogeneous (Figure 1). Communication that addresses only whether climate change is occurring or will affect the forest may therefore overlook an important part of how climate change-related expectations are formed.

The findings also point to the importance of system knowledge for adaptation. Adaptation requires more than recognising climate change as a general phenomenon; it requires understanding how climatic changes interact with forest conditions, disturbance processes, management practices, and valued forest functions, and how these interactions may create particular risks or opportunities. Blennow and Persson (2021) similarly emphasised the importance of knowledge about specific local climate-change impacts and the mental models through which people understand downstream consequences and adaptation. Semenza et al. (2011) likewise showed that knowledge and perceived personal relevance of climate-change related impacts can contribute to adaptation motivation.

For forestry professionals, communication may benefit from connecting observed forest changes with information about climate trends, disturbance processes, and plausible causal mechanisms. Such communication could help situate locally experienced events within longer-term climatic changes while also acknowledging that individual forest disturbances can have multiple interacting climatic, ecological, and management-related drivers (Blennow et al. 2010; Seidl et al., 2017). This is particularly relevant for sudden and salient disturbances such as storms, droughts, wildfires, and pest outbreaks. The pronounced geographical differences in subjective attribution further suggest that such communication may need to be grounded in local environmental experience and disturbance context. Communication could therefore connect broader climate trends to locally observed forest conditions and explain the pathways through which climatic changes may affect forest systems and management-relevant outcomes. These implications should be regarded as propositions for communication practice rather than experimentally established effects. The present study demonstrates an association between attribution and NVEI orientation but cannot establish that communication changes attribution or that attribution subsequently causes adaptation advocacy. Future research could test whether communication that explicitly links locally experienced forest changes to observations and causal mechanisms related to climate change affects attribution, expectations about future impacts, and subsequent adaptation decisions.

4.3 Multidimensional expected impacts and adaptation advocacy

The results indicate that adaptation advocacy cannot be understood simply as a general response to either climate-change risk or climate-change opportunity. Risk-dominated respondents showed higher advocacy for several management interventions, most clearly provenance selection, but also for measures including mixed forest management, continuous-cover forestry, strategic planning, longer rotations, natural regeneration, exotic tree species, and spacing at planting (Figure 2). The pattern was selective rather than uniform across interventions, indicating that risk-dominated expectations are associated with greater emphasis on particular adaptation measures rather than with a general increase in advocacy.

The partial-NVEI analyses provide a more detailed explanation of this pattern. Advocates and non-advocates differed selectively across value domains, but the direction of these differences was heterogeneous (Figure 2 b,c). Pulp wood showed evidence of more positive expected impacts among advocates, whereas hunting showed the clearest evidence in the opposite direction, with more negative expected impacts among advocates. Water purification provided another important example: partial NVEI was negative in both groups, but advocates had less negative values. Thus, adaptation advocacy was associated with both more positive and more negative expectations, depending on the domain.

This heterogeneity argues against a simple shift towards perceiving climate change as either predominantly harmful or predominantly beneficial. Instead, the relationship between expected impacts and advocacy appears to depend on which forest-value domain is affected and on the direction of the expected impact.

The separate negative- and positive-component model provides a further check on this interpretation (SUPPLEMENTARY INFORMATION, Table S12). Because partial NVEI values were constructed by summing responses measured on a bounded, coarse expected-impact scale, modelling the signed partial NVEI as a single linear predictor would assume that the association with advocacy changes at a constant rate across the observed scale. By estimating the negative and positive components separately, the present model allowed these associations to differ according to the direction of expected impacts.

The clearest patterns concerned pulp wood, hunting, water purification, and biomass. For pulp wood, greater positive expected impacts were associated with higher odds of advocacy. For hunting, greater negative expected impacts were associated with higher odds of advocacy. Water purification showed the opposite pattern from hunting: greater negative expected impacts were associated with lower odds of advocacy, consistent with advocates expressing less strongly negative expectations in this domain. For biomass, greater positive expected impacts were associated with lower odds of advocacy, although the substantive interpretation of this association is less straightforward. These patterns indicate that the relationship between expected-impact value and advocacy depends not only on the forest-value domain but also on whether expected impacts are positive or negative within that domain. Given the substantial posterior uncertainty for most domain-specific associations, these patterns should be interpreted as exploratory rather than as evidence of general motivational effects.

Taken together, these results suggest that adaptation advocacy is associated with the configuration and direction of expected climate-change impacts across forest-value domains rather than with a uniform directional orientation. The results do not support a simple extremeness mechanism in which greater absolute intensity, irrespective of direction, is systematically associated with greater advocacy.

The sign-specific model showed particularly clear positive associations for positive expected impacts in pulp wood and for negative expected impacts in hunting (SUPPLEMENTARY INFORMATION, Table S12). There was also evidence of a negative association between advocacy and the negative component of water-purification impacts, indicating that advocacy was associated with less strongly negative expectations in this domain. Other domain-specific associations were more uncertain.

Importantly, these findings concern the appraisal of expected climate-change consequences rather than a fundamental reordering of the underlying hierarchy of forest values. More specifically, advocates showed greater total absolute partial-NVEI magnitude, greater breadth across value domains, and stronger maximum domain-specific deviations, while showing lower concentration of expected-impact intensity (SUPPLEMENTARY INFORMATION, Table S11). This pattern indicates that their stronger overall differentiation was distributed across a broader set of domains rather than concentrated in a single domain.

4.4 Implications for understanding adaptation advocacy

The findings contribute to a more differentiated understanding of why forestry professionals advocate climate change adaptation. A simple risk-based interpretation would predict that respondents who perceive more negative climate-change impacts should consistently advocate more adaptation. The present results only partly support this expectation. Risk-dominated respondents did show greater advocacy for several management measures, but domain-specific analyses demonstrated that positive and negative partial NVEI values were associated with advocacy, with the direction and strength of these associations varying across forest-value domains. The separate negative- and positive-component analysis further shows that the direction of the association itself can differ between positive and negative expected impacts within a domain. This interpretation is consistent with the IPCC definition of adaptation as adjustment to actual or expected climate and its effects in order to moderate harm or exploit beneficial opportunities (Begum et al., 2022). Adaptation advocacy therefore need not be motivated exclusively by perceived climate-related risks; it may also reflect expectations of beneficial opportunities or other changes that require adjustment.

The stronger and broader differentiation observed among advocates is consistent with the possibility that adaptation advocacy is associated with expecting climate change to have consequential effects across several valued aspects of forestry, rather than primarily in relation to a single domain. This broader appraisal may have implications for adaptation communication and planning, as approaches that acknowledge diverse and potentially competing consequences may be more relevant than those focused solely on aggregate climate-change risk.

4.5 Limitations and future research

Several limitations should be considered. First, the cross-sectional design prevents causal conclusions about the relationship between experience, attribution, NVEI, and advocacy. In particular, the regional decomposition should not be interpreted as causal mediation.

Second, NVEI and partial NVEI were based on self-reported expectations rather than observed future impacts. They therefore represent respondents' subjective appraisals of expected climate-change consequences. Such appraisals are nevertheless directly relevant to decision-making because adaptation decisions are made under expectations about future conditions rather than under knowledge of realised future impacts.

Third, the exploratory sign-specific model included 24 predictors in 140 respondents. Although this model allowed positive and negative expected impacts to have distinct associations with advocacy, many of the resulting estimates were substantially uncertain. The domain-specific associations should therefore be regarded primarily as hypothesis-generating patterns requiring replication in larger samples.

Future research could combine longitudinal measurements of environmental experience, attribution, expected impacts, and adaptation behaviour with more detailed information on actual management decisions. Such designs would help establish whether experienced change influences attribution, whether attribution subsequently alters NVEI, and how these expectations are translated into concrete adaptation actions. Larger samples would also allow more robust investigation of domain-specific and direction-specific relationships between expected climate-change impacts and adaptation advocacy.

5. Conclusion

This study shows that subjective attribution of experienced forest changes to climate change is strongly associated with the direction of expected climate-change impacts among Swedish forestry professionals. Stronger attribution was associated with substantially greater odds of risk-dominated rather than opportunity-dominated NVEI, with virtually certain posterior evidence in support of H1. This association remained essentially unchanged after accounting for geographical region, indicating that it was not simply a consequence of regional differences in the sample. These findings support a theoretical proposition that subjective attribution may constitute an interpretive mechanism connecting experienced environmental change with expectations about future climate-change consequences. At the same time, the cross-sectional design does not establish that this mechanism operates causally or in the proposed temporal order.

The study also shows that adaptation advocacy is not adequately characterised as a response to aggregate climate-change risk or opportunity orientation. Advocacy was associated with selective and multidimensional differences in expected climate-change impacts across forest-value domains, with associations varying both between value domains and according to whether expected impacts were positive or negative. Advocates also showed greater overall magnitude and breadth of partial NVEI, stronger maximum domain-specific deviations, and lower concentration of expected-impact intensity. Thus, adaptation advocacy appears to be associated with a broader and more differentiated configuration of expected climate-change consequences across valued aspects of forestry rather than with a uniform directional shift in expectations.

Taken together, the findings suggest that understanding adaptation behaviour requires attention to both the interpretation of experienced environmental change and the multidimensional appraisal of its expected consequences. For forestry professionals, this highlights the potential importance of connecting climate-change information with locally experienced forest changes, while also recognising that expected consequences may differ across valued aspects of forestry and in their direction.

The proposed interpretive mechanism remains to be tested. The cross-sectional design does not establish causal or temporal pathways from experience to attribution, from attribution to NVEI, or from NVEI to adaptation behaviour. Longitudinal research combining environmental experience, subjective attribution, expected climate-change impacts, and subsequent adaptation decisions could test whether attribution operates as the proposed interpretive link and whether these expectations are subsequently translated into adaptation responses.

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Competing Interests
The authors have no relevant financial or non-financial interests to disclose.

Author Contributions
Conceptualisation: K.B.; Methodology: K.B.; Software: K.B.; Formal analysis: K.B.; Investigation: K.B., C.H.; Resources: K.B.; Data Curation: K.B., C.H.; Writing - Original Draft: K.B.; Writing – Review & Editing: K.B., J.P., C.H.; Visualisation: K.B.; Project administration: K.B., C.H.; Funding acquisition: K.B., C.H.

Data Availability
The data can be accessed from the Swedish National Data Repository () by anyone with a legitimate interest in the data, if the transfer of data complies with the Swedish and European regulations on data protection.

Ethics approval
The study complied with Swedish and EU legislation regarding the collection and processing of personal data. No sensitive personal data were collected, and formal ethical approval from an ethics review board was therefore not required under applicable regulations.

Consent to participate
Participants were informed about the study and voluntarily consented to participate.

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SUPPLEMENTARY INFORMATION

Beyond climate-change risk: subjective attribution, multidimensional impact appraisal, and adaptation advocacy among Swedish forestry professionals

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Content:

Supplementary Methods

S2. Statistical modelling and computational details

S2.1 Bayesian logistic regression for H1

H1 was tested using Bayesian logistic regression to estimate the association between subjective attribution of experienced forest changes to climate change and the direction of the net value of expected climate-change impacts (NVEI). The primary H1 model included respondents with directional NVEI values (NVEI < 0 or NVEI > 0). Observations with NVEI = 0 were excluded from this directional outcome because they did not indicate either risk- or opportunity-dominated valuation. They were retained for descriptive analyses of NVEI regimes.

NVEI orientation was coded as a binary outcome, with risk-dominated valuation (NVEI < 0) coded as 1 and opportunity-dominated valuation (NVEI > 0) coded as 0. Subjective attribution (*sb_exp,* Q2) was entered as a continuous predictor using its original 7-point scale. The model therefore estimates the association between a one-point increase in subjective attribution and the odds of risk-dominated rather than opportunity-dominated NVEI.

The model was fitted using Bayesian logistic regression with a Bernoulli likelihood and logit link in *brms* (Bürkner, 2017; 2018). The intercept was assigned a normal(0, 2) prior and the regression coefficient a normal(0, 1) prior. Four chains were run for 4,000 iterations each, with the first 2,000 iterations of each chain discarded as warm-up. The random seed was set to 2025.

A positive posterior coefficient indicates that higher subjective attribution is associated with greater odds of risk-dominated rather than opportunity-dominated NVEI. Odds ratios were calculated by exponentiating posterior coefficient draws. An odds ratio therefore represents the multiplicative change in the odds of risk-dominated rather than opportunity-dominated NVEI associated with a one-point increase in subjective attribution.

A sensitivity model additionally included geographical region (Q8) as a categorical predictor. Because this model required an unambiguous regional classification, respondents reporting activity in more than one geographical region were excluded from the region-adjusted analysis. Götaland was used as the reference category. The region-adjusted model used the same Bernoulli likelihood, logit link, priors, MCMC settings, and random seed as the primary H1 model.

S2.2 Regional model and posterior pairwise contrasts

Geographical region was examined using three broad categories: Götaland, Svealand, and Norrland. Regional analyses were restricted to respondents with an unambiguous single-region classification. Two respondents reporting activity in more than one region were therefore excluded from these analyses. These respondents remained eligible for analyses that did not require a single-region classification, including the primary H1 model.

Regional differences in subjective attribution were estimated using a Bayesian Gaussian regression with subjective attribution (*sb_exp*) as the dependent variable and region as the categorical predictor. The model used a normal(0, 2) prior for the intercept, normal(0, 1) priors for the regional coefficients, and a Student-*t*(3, 0, 2.5) prior for the residual standard deviation. Four chains were run for 4,000 iterations each, with 2,000 warm-up iterations and seed 2025.

Posterior pairwise contrasts in subjective attribution were calculated directly from posterior draws rather than by fitting separate models for each regional comparison. For each posterior draw, the relevant regional coefficients were subtracted to obtain the corresponding pairwise contrast. Posterior means, posterior standard deviations, 95% CrI, and posterior probabilities of directional differences were calculated from the resulting contrast distributions.

Regional differences in NVEI orientation were estimated using a separate Bayesian logistic regression with risk-dominated NVEI orientation as the binary outcome and region as the predictor. The model used a normal(0, 2) prior for the intercept and normal(0, 1) priors for the regional coefficients, with four chains, 4,000 iterations, 2,000 warm-up iterations, and seed 2025. Pairwise regional contrasts were calculated from posterior draws and exponentiated to obtain odds-ratio contrasts.

These regional models were used to characterise regional differences and to provide inputs for the exploratory probability-scale decomposition described in S2.3; they were not interpreted as establishing a causal regional pathway. The regional NVEI-orientation contrasts were exploratory and were not treated as additional hypothesis tests.

S2.3 Exploratory regional probability-scale decomposition

An exploratory probability-scale decomposition was conducted to assess whether regional differences in NVEI orientation were statistically consistent with regional differences in subjective attribution.

The decomposition used posterior draws from two independently fitted Bayesian models: (1) the regional Gaussian model of subjective attribution described in S2.2 and (2) the region-adjusted H1 logistic regression relating subjective attribution to NVEI orientation. No additional outcome model was fitted for the decomposition.

The decomposition focused on the Norrland–Götaland comparison, with the Norrland–Svealand comparison also examined. Posterior draws from the two models were randomly sampled and paired to propagate uncertainty from both model fits. For each paired posterior draw, region-specific predictive distributions of subjective attribution were generated from the estimated regional means and residual standard deviation of the Gaussian attribution model. Monte Carlo integration using 1,000 simulated attribution values per posterior draw was then used to obtain predicted probabilities of risk-dominated NVEI from the region-adjusted logistic model.

For each regional comparison, the difference in predicted probability of risk-dominated NVEI was partitioned into an attribution-associated component and a residual regional component.

For Norrland versus Götaland, the attribution-associated component was calculated as $p_{N,N} - p_{N,G}$, the residual regional component as $p_{N,G} - p_{G,G}$, and the total regional difference as $p_{N,N} - p_{G,G}$. For Norrland versus Svealand, the corresponding quantities were $p_{N,N} - p_{N,S}$, $p_{N,S} - p_{S,S}$, and $p_{N,N} - p_{S,S}$, respectively.

Here, the first subscript denotes the region for which the predicted probability is calculated, and the second denotes the region whose estimated mean subjective attribution is used in the prediction. Thus, the attribution-associated component represents the portion of the regional probability difference statistically consistent with the estimated regional difference in subjective attribution, whereas the residual regional component represents the remaining regional difference under the fitted models.

Because the data were cross-sectional and subjective attribution and NVEI orientation were measured contemporaneously, these components were interpreted as statistical decompositions rather than causal indirect, direct, or total effects. In particular, the analysis does not establish temporal ordering, causal mediation, or causal effects.

Results were summarised using posterior means, 95% credible intervals (CrI), and posterior probabilities of directional effects. Negative values indicate a lower probability of risk-dominated NVEI in Norrland relative to the comparison region under the corresponding decomposition.

S2.4 Bayesian logistic regression of sudden and gradual expected-impact direction

Differences in the direction of sudden and gradual expected climate-change impacts between overall NVEI orientations were examined using four Bayesian logistic regression models. Respondents with overall NVEI = 0 were excluded because they could not be classified as either risk- or opportunity-dominated. Sudden and gradual NVEI values of zero were retained and coded as 0 in both the negative- and positive-direction indicators. For each temporal component, separate binary outcomes indicated whether the component-specific NVEI was negative or positive. Overall NVEI orientation was used as the predictor, with the reference category chosen according to the direction of the outcome. Thus, the models examined whether overall risk- or opportunity-oriented NVEI was associated with the presence of negative or positive sudden and gradual expected impacts.

Sudden NVEI was calculated from respondents' valuations of sudden expected climate-change impacts only, while gradual NVEI was calculated analogously from gradual expected-impact valuations. These analyses were used to describe whether the occurrence of negative and positive expected sudden and gradual impacts differed between respondents classified as risk- or opportunity-dominated based on their overall NVEI. They were treated as descriptive and exploratory analyses and were not intended to test whether the temporal characteristics of expected impacts independently caused differences in adaptation advocacy or to establish causal relationships between overall NVEI orientation and component-specific impact direction.

S2.5 Bayesian bootstrap comparisons of partial NVEI

Bayesian bootstrap analyses were used for exploratory comparisons of partial NVEI structures underlying expected climate-change impact valuation.

Partial NVEI indices were calculated by separating positive and negative expected impacts and aggregating them across forest-value and ecosystem-service domains. The bootstrap analyses were primarily used to compare partial NVEI values between adaptation advocates and non-advocates.

For each bootstrap iteration, independent exponential random weights were generated for observations within each comparison group and normalised to sum to one. Weighted group means were then calculated for each partial NVEI domain, and the difference between the corresponding group means was recorded. This procedure is equivalent to a Bayesian bootstrap using Dirichlet(1, …, 1) weights within each comparison group. A total of 20,000 bootstrap iterations was used.

Bayesian bootstrap distributions of group differences were summarised using the mean difference and the posterior probability that the difference was greater than zero.

The same bootstrap framework was used to derive and compare individual-level summaries of the breadth and intensity of partial NVEI. These summaries included the total absolute magnitude of partial NVEI across domains, the number of domains with non-zero partial NVEI, the maximum absolute domain-specific deviation, and the concentration of NVEI intensity across domains. Higher concentration values indicate that a larger proportion of total absolute expected-impact magnitude was concentrated in the single most extreme value domain.

These analyses were used to characterise differences in the structure, breadth, and intensity of expected climate-change impact valuation. They were treated as descriptive exploratory analyses rather than as formal hypothesis tests.

S2.6 Posterior inference and robustness

Bayesian inference throughout the analyses was summarised using posterior means, 95% CrI, and posterior probabilities of directional effects. For an effect of interest, the posterior probability of a positive or negative effect was calculated directly from the posterior draws.

For the measure-specific adaptation-advocacy comparisons, analyses were restricted to respondents classified as adaptation advocates ($y = 1$). Within the risk-dominated (NVEI < 0) and opportunity-dominated (NVEI > 0) groups, each adaptation measure was represented as a binary advocacy outcome, with a value of 1 corresponding to “Yes, always”. For each group, the advocacy proportion was assigned an independent Beta(1,1) prior and updated using a binomial likelihood. Posterior draws were obtained from the corresponding Beta posterior distributions. The posterior probability that advocacy was higher under risk-dominated than opportunity-dominated NVEI conditions was calculated as the proportion of posterior draws in which the risk-dominated advocacy proportion exceeded the opportunity-dominated advocacy proportion.

Posterior probabilities were interpreted using adapted IPCC-style likelihood categories following Mastrandrea et al. (2010). The thresholds used for these classifications are reported in Supplementary Table S3.

Posterior pairwise regional contrasts were calculated directly from posterior draws as described in Section S2.2. This approach propagates posterior uncertainty in the underlying model parameters when estimating regional differences.

Robustness of the H1 association was assessed by comparing the primary model with the model additionally adjusting for geographical region. Respondents reporting activity across multiple regions were retained in analyses that did not require a single-region classification and excluded from analyses requiring assignment to a single region.

The exploratory regional probability-scale decomposition was treated as a statistical decomposition rather than as a causal mediation analysis because subjective attribution and NVEI were measured contemporaneously. The attribution-associated and residual regional components were therefore not interpreted as causal indirect or direct effects. Likewise, the Bayesian bootstrap analyses were treated as descriptive exploratory analyses rather than as confirmatory hypothesis tests.

The domain-specific analysis of adaptation advocacy included an exploratory sign-specific Bayesian logistic regression with 24 predictors representing the negative and positive components of partial NVEI across the 12 forest-value domains. For each domain, negative and positive expected-impact magnitudes were entered as separate predictors, with all 24 components included simultaneously. The model therefore estimated domain-specific associations between the magnitude of negative or positive expected impacts and advocacy conditional on the corresponding components of the other domains. Because the model included 24 predictors in a sample of 140 respondents, it was treated as exploratory and hypothesis-generating rather than as a confirmatory test. Regularising Normal(0,1) priors were assigned to regression coefficients and a Normal(0,1.5) prior to the intercept. The model was fitted using four chains with 4,000 iterations per chain, including 2,000 warm-up iterations, adapt_delta = 0.95, and maximum treedepth of 12. For each value domain, the negative-effect coefficient ($\beta-$) and positive-effect coefficient ($\beta+$) were summarised using posterior means, 95% CrI, and posterior probabilities that the coefficient was greater than zero, $P(\beta- > 0)$ and $P(\beta+ > 0)$, respectively.

For analyses requiring NVEI orientation, observations with NVEI = 0 were excluded because they did not indicate either risk or opportunity dominance.

Supplementary Figures

Supplementary Figure S1. Geographic regions of Sweden included in the study.
The map illustrates the regional grouping used for analyses of geographic variation. Respondents were classified according to region of residence as Götaland, Svealand, or Norrland. These regions were used as categorical predictors in Bayesian models examining regional differences in subjective attribution and expected climate impact orientation.

Supplementary Tables

Supplementary Table S1. Full list of survey questionnaire items used in the study, including ecosystem services and forest values, adaptive capacity, and forest management adaptation measures.

Number	***Question***	***Response option per item***
1	Climate change will affect the forest	-3 Definitely not -2 -1 0 Don't know 1 2 3 Yes, definitely
2	I have experienced changes in forest stands resulting from climate change	-3 Definitely not -2 -1 0 Don't know 1 2 3 Yes, definitely
3	To what extent do you advocate the following adaptations for sustainable timber production in response to climate change? • Change of tree provenance • Change of tree species • Conversion from native to exotic tree species • Conversion to mixed-species forest • Shortening of rotation period • Lengthening of rotation period • Modification of thinning regime • Drainage and/or ditch maintenance • Improvement of strategic planning regarding the order and timing of stand harvesting, and where different tree species are placed in the terrain (based on wind exposure, fire protection, diseases, etc.) • Continuous cover forestry instead of final felling • Final felling instead of continuous cover forestry [a] • Changed planting spacing • Planting instead of natural regeneration • Natural regeneration instead of planting	Always Often Rarely Never Don't know
4	According to you, does a gradual change in climate in your area of activity have a negative impact on the following? • Sustainable production of sawlogs • Sustainable production of pulpwood • Sustainable production of biomass for energy purposes • Production of mushrooms and/or berries • Hunting • Biodiversity, from bacteria to plants and animals • Recreational opportunities such as forest walks • Carbon storage • The role of forests in water purification	Yes, always Often Rarely No, never Don't know

	• The role of forests in erosion protection • Economic returns from forestry and forest ownership • Rural development	
5	According to you, does climate change in your area of activity lead to increased negative impacts from sudden events (including extreme events) on the following? • Sustainable production of sawlogs • Sustainable production of pulpwood • Sustainable production of biomass for energy purposes • Production of mushrooms and/or berries • Hunting • Biodiversity, from bacteria to plants and animals • Recreational opportunities such as forest walks • Carbon storage • The role of forests in water purification • The role of forests in erosion protection • Economic returns from forestry and forest ownership • Rural development	Yes, always Often Rarely No, never Don't know
6	According to you, does a gradual change in climate in your area of activity have a positive impact on the following? • Sustainable production of sawlogs • Sustainable production of pulpwood • Sustainable production of biomass for energy purposes • Production of mushrooms and/or berries • Hunting • Biodiversity, from bacteria to plants and animals • Recreational opportunities such as forest walks • Carbon storage • The role of forests in water purification • The role of forests in erosion protection • Economic returns from forestry and forest ownership • Rural development	Yes, always Often Rarely No, never Don't know
7	According to you, does climate change in your area of activity lead to increased positive impacts from sudden events (including extreme events) on the following? • Sustainable production of sawlogs • Sustainable production of pulpwood • Sustainable production of biomass for energy purposes • Production of mushrooms and/or berries • Hunting • Biodiversity, from bacteria to plants and animals • Recreational opportunities such as forest walks • Carbon storage • The role of forests in water purification • The role of forests in erosion protection • Economic returns from forestry and forest ownership • Rural development	Yes, always Often Rarely No, never Don't know
9	What is your geographical area of work? (select one or more)	Norrland Svealand Götaland Abroad

[a] Adaptation regarding silvicultural system was defined as conversion from final felling to continuous cover forestry. Reverse transitions were excluded, as final felling constitutes the dominant baseline system in Sweden and is not treated as an adaptive alternative within the present decision framework.

Supplementary Table S2. Bayesian estimates of adaptation advocacy at the national and regional levels.

Group	*n*	*Advocating adaptation, n*	*Not advocating, n*	*Posterior adaptation rate (%)*	*95% CrI (%)*
Overall	140	77	63	55	47–63
Götaland	102	59	43	58	48–67
Svealand	19	9	10	48	27–68
Norrland	17	9	8	53	31–74

Notes: Adaptation advocacy was coded as a binary outcome (1 = adaptation advocated; 0 = not advocated). Posterior estimates are based on a Beta(1,1) prior and a binomial likelihood. CrI = 95% credible interval. Regional estimates include respondents assigned unambiguously to one region; respondents classified as reporting multiple regions are excluded from the regional estimates.

Supplementary Table S3. Adapted IPCC-style likelihood categories for directional posterior probabilities (*cf.* Mastrandrea et al. 2010).

Posterior probability	*Posterior probability classification*
≥ 0.99	Virtually certain (higher)
0.95–<0.99	Extremely likely (higher)
0.90-<0.95	Very likely (higher)
0.66-<0.90	Likely (higher)
0.50-<0.66	More likely than not (higher)
0.33-<0.50	More likely than not (lower)
0.10-<0.33	Likely (lower)
0.05-<0.10	Very likely (lower)
0.01-<0.05	Extremely likely (lower)
< 0.01	Virtually certain (lower)

Supplementary Table S4. Regional differences in subjective attribution.

Regional contrast	*Estimate*	*SE*	*95% CrI*	*P(β > 0)*	*Interpretation*
Norrland vs Götaland	−1.24	0.35	−1.95–−0.55	<0.001	Virtually certain that subjective attribution was lower in Norrland
Svealand vs Götaland	0.36	0.34	−0.30–1.03	0.854	Likely higher subjective attribution in Svealand
Norrland vs Svealand	−1.60	0.46	−2.51–−0.72	<0.001	Virtually certain that subjective attribution was lower in Norrland

Notes. Estimates are posterior contrasts from a Bayesian Gaussian regression of subjective attribution on region. Götaland was the reference category in the underlying model; pairwise posterior contrasts are reported for all three regional comparisons. Subjective attribution was measured on a 7-point scale, with higher values indicating stronger attribution of experienced forest changes to climate change. Positive estimates indicate higher subjective attribution in the first region relative to the second. Posterior probabilities are interpreted according to the adapted IPCC-style likelihood scale presented in Supplementary Table S3. CrI = 95% credible interval.

Supplementary Table S5. Total regional differences in NVEI orientation.

Regional contrast	*Estimate (log-odds)*	*SE*	*95% CrI*	*P(β > 0)*	*OR*	*95% CrI for OR*	*Interpretation*
Norrland vs Götaland	−0.84	0.49	−1.84–0.11	0.040	0.49	0.16–1.11	Extremely likely lower odds of risk-dominated NVEI in Norrland
Svealand vs Götaland	−0.30	0.45	−1.18–0.58	0.257	0.82	0.31–1.78	Likely lower odds of risk-dominated NVEI in Svealand
Norrland vs Svealand	−0.54	0.64	−1.82–0.68	0.199	0.71	0.16–1.97	Likely lower odds of risk-dominated NVEI in Norrland

Notes. Estimates are posterior contrasts from a Bayesian logistic regression model predicting risk-dominated rather than opportunity-dominated NVEI without subjective attribution as a predictor. Götaland was the reference category in the underlying model; pairwise posterior contrasts are reported for all three regional comparisons. Negative coefficients indicate lower odds of risk-dominated NVEI in the first region relative to the second. OR = posterior odds ratio; CrI = 95% credible interval. Posterior probabilities are interpreted according to the adapted IPCC-style likelihood scale presented in Supplementary Table S3.

Supplementary Table S6. Regional differences in NVEI orientation after adjustment for subjective attribution.

Regional contrast	*Estimate (log-odds)*	*SE*	*95% CrI*	*P(β > 0)*	*OR*	*95% CrI for OR*	*Interpretation*
Norrland vs Götaland	−0.49	0.54	−1.55–0.55	0.180	0.71	0.21–1.73	Likely lower odds of risk-dominated NVEI in Norrland, but with substantial uncertainty
Svealand vs Götaland	−0.44	0.46	−1.35–0.48	0.172	0.72	0.26–1.61	Likely lower odds of risk-dominated NVEI in Svealand, but with substantial uncertainty
Norrland vs Svealand	−0.05	0.68	−1.39–1.27	0.473	1.19	0.25–3.57	More likely than not lower odds of risk-dominated NVEI in Norrland, but highly uncertain

Notes. Estimates are posterior contrasts from the region-adjusted Bayesian logistic regression model predicting risk-dominated rather than opportunity-dominated NVEI. Subjective attribution was included as a predictor. Götaland was the reference category in the underlying model; pairwise posterior contrasts are reported for all three regional comparisons. Negative coefficients indicate lower odds of risk-dominated NVEI in the first region relative to the second. OR = posterior odds ratio; CrI = 95% credible interval. Posterior probabilities are interpreted according to the adapted IPCC-style likelihood scale presented in Supplementary Table S3.

Supplementary Table S7. Statistical decomposition of regional differences in NVEI orientation associated with subjective attribution.

Regional contrast	***Component***	***Estimate (probability difference)***	***95% CrI***	***Posterior probability of stated direction***	***Interpretation***
Norrland vs Götaland	Attribution-associated component	−0.10	−0.17 to −0.03	0.999	Virtually certain lower probability
Norrland vs Götaland	Residual regional component	−0.11	−0.34 to 0.12	0.820	Likely lower probability
Norrland vs Götaland	Total regional difference	−0.21	−0.41 to 0.01	0.970	Extremely likely lower probability
Norrland vs Svealand	Attribution-associated component	−0.13	−0.21 to −0.04	0.999	Virtually certain lower probability
Norrland vs Svealand	Residual regional component	−0.01	−0.31 to 0.28	0.527	More likely than not higher probability
Norrland vs Svealand	Total regional difference	−0.14	−0.41 to 0.14	0.851	Likely lower probability

Notes: Estimates are posterior probability differences obtained from the exploratory regional probability-scale decomposition described in Supplementary Section S2.3. The attribution-associated component represents the portion of the regional probability difference statistically consistent with differences in the regional predictive distributions of subjective attribution. The residual regional component represents the remaining regional difference under the fitted models. The total regional difference is the sum of the attribution-associated and residual regional components. Negative estimates indicate a lower probability of risk-dominated NVEI in Norrland relative to the comparison region. Because subjective attribution and NVEI orientation were measured contemporaneously in cross-sectional data, these components are interpreted as statistical decompositions rather than causal indirect, direct, or total effects. Posterior probabilities are directional probabilities and are classified according to the adapted IPCC-style likelihood categories presented in Supplementary Table S3. CrI = 95% credible interval.

Supplementary Table S8. Bayesian logistic regression of sudden and gradual expected impact direction by NVEI orientation.

Outcome	*Predictor contrast*	*Estimate (log-odds)*	*SE*	*95% CrI*	*Posterior P(β > 0)*	*Odds ratio*	*95% CrI for OR*
Negative sudden impacts	Risk-dominated vs Opportunity-dominated	3.33	0.44	2.49–4.21	>0.999	30.7	12.1–67.6
Positive sudden impacts	Opportunity-dominated vs Risk-dominated	3.23	0.53	2.24–4.31	>0.999	29.2	9.4–74.8
Negative gradual impacts	Risk-dominated vs Opportunity-dominated	3.50	0.50	2.58–4.51	>0.999	37.8	13.2–91.3
Positive gradual impacts	Opportunity-dominated vs Risk-dominated	3.56	0.45	2.72–4.48	>0.999	39.1	15.2–88.5

Notes: Outcomes were coded as binary indicators of the corresponding expected-impact direction (1 = negative or positive impact, respectively; 0 = otherwise). NVEI orientation was coded separately for each model. For negative-impact models, opportunity-dominated respondents formed the reference category, with the predictor contrast being Risk-dominated vs Opportunity-dominated. For positive-impact models, risk-dominated respondents formed the reference category, with the predictor contrast being Opportunity-dominated vs Risk-dominated. Positive coefficients therefore indicate higher odds of the respective impact direction among the contrasted group. Odds ratios are calculated as exp(β), and their 95% credible intervals were calculated from the posterior distribution of exp(β). CrI = 95% credible interval.

Supplementary Table S9. Subjective attribution across NVEI regimes.

NVEI regime	*Definition*	*n*	*Mean subjective attribution*	*Median*	*SD*
Risk-dominated	NVEI < 0	70	5.64	6.0	1.33
Opportunity-dominated	NVEI > 0	61	4.87	5.0	1.52
Offset	NVEI = 0, VS > 0	5	4.40	5.0	0.89
No expected impact value	NVEI = 0, VS = 0	4	2.25	1.5	1.89

Notes: Subjective attribution was measured on a 7-point scale, with higher values indicating stronger attribution of experienced forest changes to climate change.

Supplementary Table S10. Bayesian bootstrap comparisons of subjective attribution of experienced forest changes to climate change across NVEI orientation groups. Mean differences are reported as first group minus second group. Positive values indicate higher subjective attribution in the first group. Credible intervals (95% CrI) and posterior probabilities refer to the probability that the mean difference is greater than zero. NVEI groups comprise risk-dominated (NVEI < 0), opportunity-dominated (NVEI > 0), no value (NVEI = 0, VS = 0), and offset impact values (NVEI = 0, VS > 0).

Comparison	*Mean difference*	*95% CrI*	*P(effect > 0)*
Risk-dominated − Opportunity-dominated	0.79	0.32 to 1.26	>0.999
Risk-dominated − No value	2.48	1.27 to 3.66	>0.999
Risk-dominated – Offset impact values	1.09	-0.01 to 2.14	>0.974
No value − Opportunity-dominated	-1.69	-2.85 to -0.52	0.003
Offset impact values – Opportunity-dominated	-0.30	−1.35 to 0.78	0.287
Offset impact values − No value	1.40	-0.16 to 2.97	0.960

Supplementary Table S11. Individual-level differences in partial NVEI structure between advocates and non-advocates. Bayesian bootstrap comparisons of individual-level partial NVEI characteristics between respondents who advocated adaptation (y = 1) and non-advocates (y = 0). Differences are calculated as advocates minus non-advocates. Posterior probabilities indicate the probability that the difference is greater than zero.

Metric	*Difference (Advocates – Non-dvocates)*	*Posterior probability*	*Interpretation*
Total absolute partial NVEI across domains	4.44	0.95	Extremely likely higher among advocates
Number of domains with non-zero partial NVEI	0.74	0.92	Very likely higher among advocates
Maximum absolute domain-specific partial NVEI	0.60	0.98	Extremely likely higher among advocates
NVEI concentration (maximum absolute value / total absolute value)	−0.03	0.19	Likely lower concentration among advocates

Interpretation: Advocates showed greater overall differentiation in expected climate impacts, expressed across a larger number of domains and with stronger individual-domain deviations. However, the lack of evidence for higher concentration indicates that these differences were not primarily driven by one dominant ecosystem-service valuation.

Supplementary Table S12. Sign-specific domain-specific partial NVEI associations with adaptation advocacy. Bayesian logistic regression model estimating the simultaneous associations between negative and positive components of partial NVEI and the probability of advocating adaptation across all 12 forest-value domains. Negative and positive components were entered simultaneously for all 12 domains; predictors were retained on their original partial-NVEI scale and were not standardised. Positive coefficients indicate higher odds of advocacy with increasing magnitude of the respective negative or positive component, conditional on the components of all other value domains.

Value domain	*Negative effect*	*95% CrI*	*P(β− > 0)*	*Positive effect*	*95% CrI*	*P(β+ > 0)*	*P($β_−$ > $β_+$)*
Saw timber	0.17	−0.08, 0.42	0.90	0.21	−0.12, 0.55	0.90	0.42
Pulpwood	−0.12	−0.46, 0.23	0.25	0.32	0.05, 0.60	0.98	0.02
Biomass	0.12	−0.18, 0.44	0.78	−0.28	−0.60, 0.01	0.03	0.99
Mushrooms	0.12	−0.14, 0.38	0.82	−0.13	−0.46, 0.19	0.19	0.89
Hunting	0.38	0.13, 0.66	0.99	0.02	−0.31, 0.36	0.55	0.97
Biodiversity	0.03	−0.20, 0.27	0.60	0.13	−0.18, 0.46	0.78	0.30
Recreation	−0.12	−0.41, 0.17	0.21	−0.14	−0.51, 0.22	0.06	0.54
Carbon	0.09	−0.20, 0.39	0.72	0.17	−0.08, 0.43	0.90	0.33
Water purification	−0.38	−0.69, −0.08	0.01	0.06	−0.51, 0.67	0.59	0.10
Erosion control	0.27	−0.03, 0.58	0.96	−0.04	−0.48, 0.42	0.42	0.87
Profit	−0.01	−0.25, 0.23	0.47	−0.07	−0.41, 0.26	0.34	0.64
Rural development	−0.24	−0.57, 0.08	0.08	0.09	−0.31, 0.49	0.71	0.10

Note. For each respondent and value domain, the signed Partial NVEI was decomposed into a negative component and a positive component. The negative component represents the magnitude of negative partial NVEI values, whereas the positive component represents the magnitude of positive partial NVEI values; a partial NVEI of zero contributed zero to both components. Thus, a positive coefficient for the negative component indicates higher odds of advocacy with increasingly negative expected impacts, whereas a positive coefficient for the positive component indicates higher odds of advocacy with increasingly positive expected impacts. CrI = credible interval.

Supplementary Appendix A

Survey: Forest Management and Climate Change

1. Your organization (select one or more)

☐ Authority (e.g. Swedish Forest Agency)
☐ State-owned company (e.g. Sveaskog)
☐ Private forest company
☐ Forest owners' association
☐ Consulting company
☐ Other public owner (e.g. Swedish Church, National Property Board)
☐ Other: _______

2. What is your geographical area of work? (select one or more)

☐ Northern Sweden
☐ Central Sweden
☐ Southern Sweden
☐ Abroad

3. What are your main work tasks? (select one or more)

☐ Advising forest owners
☐ Ordering forestry operations (e.g., planting material, site preparation, planting, cleaning)
☐ Stand planning of purchased/private forest
☐ Stand planning of company-owned forest
☐ Forest or damage inventory
☐ Forest management planning (company forest)
☐ Forest management planning (purchased/private forest)
☐ Strategy work in forestry
☐ I do not work with planning, implementation or advisory in forestry
☐ Other main forestry related tasks: _______

4. Number of years of professional experience in forestry

____

5. What is your education?

☐ University degree in forestry
☐ University degree in ecology/environmental science/physical geography
☐ Forestry school
☐ Other education in forestry or ecology
☐ No education in forestry or ecology

6. What is your legal gender?

☐ Male
☐ Female
☐ Prefer not to say

7. In my work area, forest damage is caused by:
Rate each statement on a scale from 0 to 6 or select 'don't know'.

	0 - never causes damage	1	2 – rare cause of damage	3	4 - common cause	5	6 – dominating cause	DK
Drought	☐	☐	☐	☐	☐	☐	☐	☐
Heat and heat stress	☐	☐	☐	☐	☐	☐	☐	☐
Waterlogging or flooding	☐	☐	☐	☐	☐	☐	☐	☐
Storm/wind	☐	☐	☐	☐	☐	☐	☐	☐
Snow	☐	☐	☐	☐	☐	☐	☐	☐
Frost	☐	☐	☐	☐	☐	☐	☐	☐
Fire	☐	☐	☐	☐	☐	☐	☐	☐
Insects	☐	☐	☐	☐	☐	☐	☐	☐
Root rot	☐	☐	☐	☐	☐	☐	☐	☐
Diseases (excluding root rot)	☐	☐	☐	☐	☐	☐	☐	☐
Wildlife browsing	☐	☐	☐	☐	☐	☐	☐	☐

8. Final felling can reduce forest damage caused by (−3 strongly disagree to +3 strongly agree)
Rate each statement on a scale from 0 to 6 or select 'don't know'.

	0 - never causes damage	1	2 – rare cause of damage	3	4 - common cause	5	6 – dominating cause	DK
Drought	☐	☐	☐	☐	☐	☐	☐	☐
Heat and heat stress	☐	☐	☐	☐	☐	☐	☐	☐
Waterlogging or flooding	☐	☐	☐	☐	☐	☐	☐	☐
Storm/wind	☐	☐	☐	☐	☐	☐	☐	☐
Snow	☐	☐	☐	☐	☐	☐	☐	☐
Frost	☐	☐	☐	☐	☐	☐	☐	☐
Fire	☐	☐	☐	☐	☐	☐	☐	☐
Insects	☐	☐	☐	☐	☐	☐	☐	☐
Root rot	☐	☐	☐	☐	☐	☐	☐	☐
Diseases (excluding root rot)	☐	☐	☐	☐	☐	☐	☐	☐
Wildlife browsing	☐	☐	☐	☐	☐	☐	☐	☐

9. Mixed forests can reduce risk of forest damage caused by (−3 to +3)
Rate each statement on a scale from 0 to 6 or select 'don't know'.

	0 - never causes damage	1	2 – rare cause of damage	3	4 - common cause	5	6 – dominating cause	DK
Drought	☐	☐	☐	☐	☐	☐	☐	☐
Heat and heat stress	☐	☐	☐	☐	☐	☐	☐	☐
Waterlogging or flooding	☐	☐	☐	☐	☐	☐	☐	☐
Storm/wind	☐	☐	☐	☐	☐	☐	☐	☐
Snow	☐	☐	☐	☐	☐	☐	☐	☐
Frost	☐	☐	☐	☐	☐	☐	☐	☐
Fire	☐	☐	☐	☐	☐	☐	☐	☐
Insects	☐	☐	☐	☐	☐	☐	☐	☐
Root rot	☐	☐	☐	☐	☐	☐	☐	☐
Diseases (excluding root rot)	☐	☐	☐	☐	☐	☐	☐	☐
Wildlife browsing	☐	☐	☐	☐	☐	☐	☐	☐

10. Climate change and forests (−3 to +3)

In my opinion:

	-3 Definitely not	-2	-1	0 Don’t know	1	2	3 Yes, definitely
Climate change will affect the forest	☐	☐	☐	☐	☐	☐	☐
I have experienced changes in forest stands resulting from climate change	☐	☐	☐	☐	☐	☐	☐

11. In your opinion, are the following forestry measures effective for adapting sustainable timber production in your region to a changing climate?
Please select the appropriate response option for each item, using the scale: always–never, I don't know."

	Always	Often	Seldom	Never	DK
Change of tree provenance	☐	☐	☐	☐	☐
Change of tree species	☐	☐	☐	☐	☐
Conversion from native to exotic species	☐	☐	☐	☐	☐
Conversion to mixed forest	☐	☐	☐	☐	☐
Shortening of rotation period	☐	☐	☐	☐	☐
Lengthening of rotation period	☐	☐	☐	☐	☐
Modified thinning regime	☐	☐	☐	☐	☐
Drainage/ditch maintenance	☐	☐	☐	☐	☐
Improvement of strategic planning regarding the order and timing of stand harvesting, and where different tree species are placed in the terrain (based on wind exposure, fire protection, diseases, etc.)	☐	☐	☐	☐	☐
Continuous cover forestry instead of final felling.	☐	☐	☐	☐	☐
Final felling instead of continuous cover	☐	☐	☐	☐	☐

Changed planting density	☐	☐	☐	☐	☐
Planting instead of natural regeneration	☐	☐	☐	☐	☐
Natural regeneration instead of planting	☐	☐	☐	☐	☐
Modified crisis management measures such as early harvesting after storm damage and post-fire regeneration	☐	☐	☐	☐	☐
Modified harvest timing/method, for example during thaw periods or on waterlogged soils	☐	☐	☐	☐	☐

12. In my future forest management recommendations, I intend to recommend a transition to forestry practices adapted to prevent...
Please indicate the extent to which you agree with each statement. Scale: -3 to +3.

	-3 Strongly disagree	-2	-1	0	1	2	3 Strongly agree
Drought	☐	☐	☐	☐	☐	☐	☐
Heat and heat stress	☐	☐	☐	☐	☐	☐	☐
Waterlogging or flooding	☐	☐	☐	☐	☐	☐	☐
Storm/wind	☐	☐	☐	☐	☐	☐	☐
Snow	☐	☐	☐	☐	☐	☐	☐
Frost	☐	☐	☐	☐	☐	☐	☐
Fire	☐	☐	☐	☐	☐	☐	☐
Insects	☐	☐	☐	☐	☐	☐	☐
Root rot	☐	☐	☐	☐	☐	☐	☐
Diseases (excluding root rot)	☐	☐	☐	☐	☐	☐	☐
Wildlife browsing	☐	☐	☐	☐	☐	☐	☐

13. To what extent do you advocate the following adaptations for sustainable timber production in response to climate change?
Please select the appropriate response option for each item, using the scale: always–never, I don't know.

	Always	Often	Seldom	Never	DK
Change of tree provenance	☐	☐	☐	☐	☐
Change of tree species	☐	☐	☐	☐	☐
Conversion from native to exotic species	☐	☐	☐	☐	☐
Conversion to mixed forest	☐	☐	☐	☐	☐
Shortening of rotation period	☐	☐	☐	☐	☐
Lengthening of rotation period	☐	☐	☐	☐	☐
Modified thinning regime	☐	☐	☐	☐	☐
Drainage/ditch maintenance	☐	☐	☐	☐	☐
Improvement of strategic planning regarding the order and timing of stand harvesting, and where different tree species are placed in the terrain (based on wind exposure, fire protection, diseases, etc.)	☐	☐	☐	☐	☐
Continuous cover forestry instead of final felling	☐	☐	☐	☐	☐
Final felling instead of continuous cover	☐	☐	☐	☐	☐

Changed planting density	☐	☐	☐	☐	☐
Planting instead of natural regeneration	☐	☐	☐	☐	☐
Natural regeneration instead of planting	☐	☐	☐	☐	☐
Modified crisis management measures such as early harvesting after storm damage and post-fire regeneration	☐	☐	☐	☐	☐
Modified harvest timing/method, for example during thaw periods or on waterlogged soils	☐	☐	☐	☐	☐

Next, we ask about the positive and negative impacts on forests from sudden and gradual changes in the climate. In total, there are 4 questions and 12 forest ecosystem services.
The concepts of gradual and sudden climate change will be presented under each respective question.

The survey then concludes with a few short questions about forest management advice and education."

14. Examples of **gradual climate change** include a warmer or wetter climate, changes in soil frost conditions, and the length of the growing season (earlier budburst and later leaf fall).

In your opinion, does a gradual change in the climate in your area of operation have a negative impact on the following?

Please select the appropriate response option for each item, using the scale: always–never, I don't know.

	Always	Often	Seldom	Never	DK
Sustainable production of saw timber	☐	☐	☐	☐	☐
Sustainable production of pulpwood	☐	☐	☐	☐	☐
Sustainable production of biomass for energy purposes	☐	☐	☐	☐	☐
Production of mushrooms and/or berries	☐	☐	☐	☐	☐
Hunting	☐	☐	☐	☐	☐
Biodiversity – from microorganisms to plants and animals	☐	☐	☐	☐	☐

Recreational opportunities such as forest walks	☐	☐	☐	☐	☐
Carbon storage	☐	☐	☐	☐	☐
The forest's role in water purification	☐	☐	☐	☐	☐
The forest's role in erosion control	☐	☐	☐	☐	☐
Economic returns from forestry and forest ownership	☐	☐	☐	☐	☐
Rural development	☐	☐	☐	☐	☐

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15. Examples of **extreme events** or their effects include storms, wildfires, flooding/waterlogging, insect outbreaks, fungal diseases, frost, and drought.

In your opinion, do climate changes in your area of operation lead to increased negative impacts from sudden events (including extreme events) on the following?

Please select the appropriate response option for each item, using the scale: always–never, I don't know.

	Always	Often	Seldom	Never	DK
Sustainable production of saw timber	☐	☐	☐	☐	☐
Sustainable production of pulpwood	☐	☐	☐	☐	☐
Sustainable production of biomass for energy purposes	☐	☐	☐	☐	☐
Production of mushrooms and/or berries	☐	☐	☐	☐	☐

Hunting	☐	☐	☐	☐	☐
Biodiversity – from microorganisms to plants and animals	☐	☐	☐	☐	☐
Recreational opportunities such as forest walks	☐	☐	☐	☐	☐
Carbon storage	☐	☐	☐	☐	☐
The forest's role in water purification	☐	☐	☐	☐	☐
The forest's role in erosion control	☐	☐	☐	☐	☐
Economic returns from forestry and forest ownership	☐	☐	☐	☐	☐
Rural development	☐	☐	☐	☐	☐

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16. Examples of **gradual climate change** include a warmer or wetter climate, changes in soil frost conditions, and the length of the growing season (earlier budburst and later leaf fall).

In your opinion, does a gradual change in the climate in your area of operation have a positive impact on the following?

Please select the appropriate response option for each item, using the scale: always–never, I don't know.

	Always	Often	Seldom	Never	DK
Sustainable production of saw timber	☐	☐	☐	☐	☐
Sustainable production of pulpwood	☐	☐	☐	☐	☐

Sustainable production of biomass for energy purposes	☐	☐	☐	☐	☐
Production of mushrooms and/or berries	☐	☐	☐	☐	☐
Hunting	☐	☐	☐	☐	☐
Biodiversity – from microorganisms to plants and animals	☐	☐	☐	☐	☐
Recreational opportunities such as forest walks	☐	☐	☐	☐	☐
Carbon storage	☐	☐	☐	☐	☐
The forest's role in water purification	☐	☐	☐	☐	☐
The forest's role in erosion control	☐	☐	☐	☐	☐
Economic returns from forestry and forest ownership	☐	☐	☐	☐	☐
Rural development	☐	☐	☐	☐	☐

17. Examples of sudden and extreme events or their effects include storms, wildfires, flooding/waterlogging, insect outbreaks, fungal diseases, frost, and drought.

In your opinion, do climate changes in your area of operation lead to increased positive impacts from sudden events (including extreme events) on the following?

Please select the appropriate response option for each item, using the scale: always–never, I don't know.

	Always	Often	Seldom	Never	DK
Sustainable production of saw timber	☐	☐	☐	☐	☐
Sustainable production of pulpwood	☐	☐	☐	☐	☐
Sustainable production of biomass for energy purposes	☐	☐	☐	☐	☐
Production of mushrooms and/or berries	☐	☐	☐	☐	☐
Hunting	☐	☐	☐	☐	☐
Biodiversity – from microorganisms to plants and animals	☐	☐	☐	☐	☐
Recreational opportunities such as forest walks	☐	☐	☐	☐	☐
Carbon storage	☐	☐	☐	☐	☐
The forest's role in water purification	☐	☐	☐	☐	☐
The forest's role in erosion control	☐	☐	☐	☐	☐
Economic returns from forestry and forest ownership	☐	☐	☐	☐	☐

Rural development	☐	☐	☐	☐	☐

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18. Challenges associated with providing adaptive forest management advice to prevent forest damage

Please indicate the degree to which you agree with each statement (scale: -3 to +3).

	-3 Strongly disagree	-2	-1	0	1	2	3 Strongly agree
The time horizon in forest owners' management plans may hinder their ability to implement adaptive forestry practices to prevent forest damage	☐	☐	☐	☐	☐	☐	☐
Forest owners' financial conditions may prevent them from implementing adaptive forestry practices to prevent forest damage	☐	☐	☐	☐	☐	☐	☐
The size of forest owners' holdings may strongly limit their choice of adaptive management measures to prevent forest damage	☐	☐	☐	☐	☐	☐	☐
Current forest policy may act as a barrier to implementing adaptive forest management to prevent forest damage	☐	☐	☐	☐	☐	☐	☐

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19. Education and knowledge

Please indicate the extent to which you agree with the statement (scale: -3 to 3).

	-3 Strongly disagree	-2	-1	0	1	2	3 Strongly agree
I would like to receive more education and training on adaptive forestry practices to prevent forest damage.	☐	☐	☐	☐	☐	☐	☐

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20. Personal experiences of providing forest advisory services to forest owners and how the advice is received and followed

Please indicate the degree to which you agree with each statement (scale: -3 to +3).

	-3 Strongly disagree	-2	-1	0	1	2	3 Strongly agree
Generally, forest owners trust forest management advice and manage their forests accordingly.	☐	☐	☐	☐	☐	☐	☐
Forest owners' own knowledge and perceptions often conflict with professional forest management advice.	☐	☐	☐	☐	☐	☐	☐
Having the knowledge to provide adaptive forest management advice to prevent forest damage is appreciated by forest owners.	☐	☐	☐	☐	☐	☐	☐
"Having the knowledge to provide adaptive forest management advice to prevent forest damage is appreciated within my organization.	☐	☐	☐	☐	☐	☐	☐

Thank you for your participation!