The Socio-Economics of Forest Adaptation to Climate Change

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Structure

- Socio-economics of adaptation – a review
  - Context – database – objectives – methodology
- Perception of stakeholders on CC risks
  - Forest owners – foresters
- Next steps – choice experiments
- Climate Smart Forestry

Objective

Provide an overview of the socio-economic literature on forest adaptation to CC.

- quantitative analysis and categorization of references.
- Analysis in terms of time and space, disturbance, adaptation strategies and methodology.
- Classification in four different categories: risk management, risk assessment, impact of risk and risk perception.
- Discussion underlining the lack of the literature and possible directions for future research.

Definitions

- **Examples of adaptation strategies in forestry (Spittlehouse and Stewart 2003)**
  - more suitable or alternate genotypes through provenance trials, new species
  - technology for better wood quality and size
  - include climate variables in growth and yield models,
  - "fire-smart" landscapes
  - modified seed transfer zones
  - sanitation thinning, increased amount of salvage logging
  - change rotation length
  - landscape planning to minimize spread of insects and diseases.

- **Different categorizations in the literature:**
  - proactive *vs.* reactive adaptation (Ogden and Innes 2007),
  - forward-looking *vs.* trend-adaptive (Yousefpour et al. 2013),
  - active *vs.* passive (Bolte et al. 2009),
  - planned *vs.* reactive adaptation (Bernier and Schoene 2009).

=> Here we refer to this last categorization: **planned adaptation** means to redefine forestry goals and silvicultural practices in advance in view of CC-related risks and uncertainties; while reactive adaptation is a response to already observed CC impacts.

Data collection

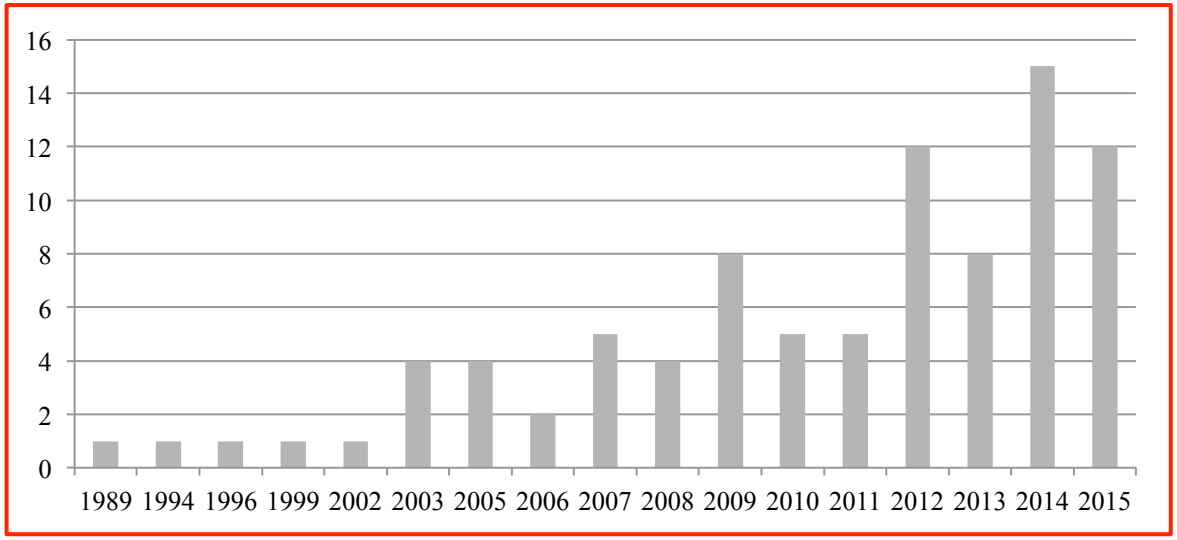
- Literature research on search engines (Google Scholar and Web of Knowledge). Combination of four types of keywords:
  - **Climat*** (*Climate, Climate change, Climatic*) OR **Adapt*** (*Adaptation, Adaptive*)
  - **Forest*** (*Forest, Forestry, Forest management, Forest owner*)
  - **Risk*** (*Risk, Risk perception, Risk management, Risk attitude*)
  - **Econo*** (*Economics, Economy, Socio-economic*)

- Reference lists of the papers used to add relevant articles to database.

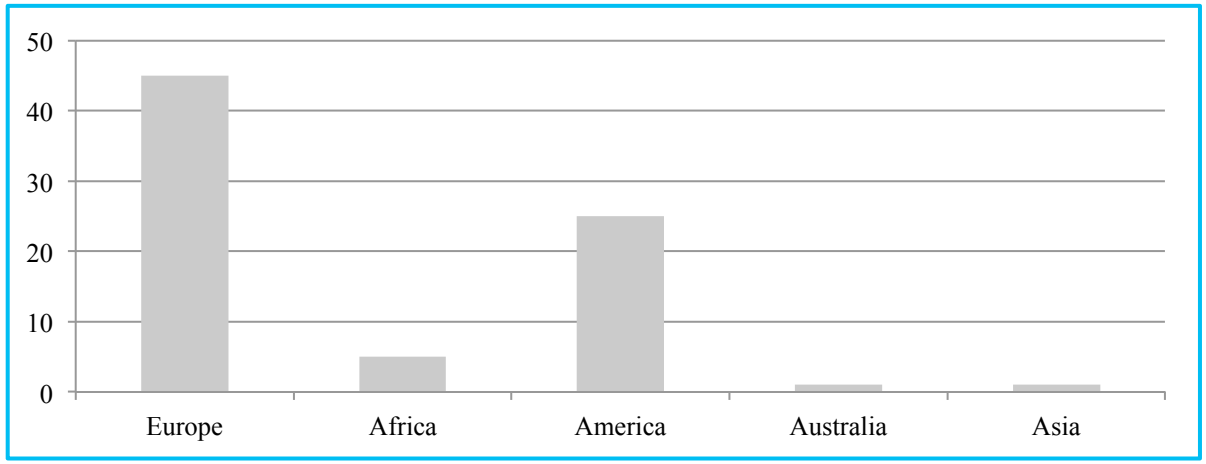
⇒ Search restricted to articles published in English.

⇒ Collection of 89 papers, from 33 different journals (FPE, FEM and Climatic Change gather approximately 30% of our sample).

Evolution in time and space



↗ trend = socio-economic concerns about CC are recent.
+ link with the definition of adaptation in the 2001 IPCC report.



71 papers on developed countries, 6 on developing ones, and 9 not localized.

+ Paasgard and Strange (2013): *"the supply of CC knowledge is biased toward richer countries, which are more stable and less corrupt, have higher school enrolment and expenditures on research and development, emit more carbon and are less vulnerable to CC".*

Risks and disturbances

- frequent risks: fire (37 articles), wind (34) and drought (27); less ones: snow (6), fungi (3) and frost (2).
  ⇒ *Schelhaas et al. (2003): wind and fire are responsible for 53% and 16% respectively, of the damage to European forest by natural hazards.*

- Risks associated to insect and pest infestation in relation to CC are recent (Blennow and Sällnas 2002).

- Risk of invasive species in relation to CC is also recent (Blate et al. 2009), but increasing over time (Grotta et al. 2013; Laatsch and Ma 2015; Lenart and Jones 2014; Ogden and Innes 2009).

- Few Papers with price risk in relation to CC (8): price volatility (Yousefpour et al. 2010; Yousefpour and Hanewinkel 2014), owners perception about price risk (Blennow and Sällnas 2002; Eriksson 2014; Eriksson et al. 2012).

=> Yousefpour et al. (2011) "*much of the literature on decision making under risk has focused on price risk, and that we are in a transition from one known stable (but variable) climate state to a new but largely unknown and likely more rapidly changing set of future conditions*".

Adaptation strategies

- 27 papers = reactive adaptation, 50 papers = planned adaptation and 12 with both.

  => Bernier and Schoene (2009):

  3 possible approaches for adaptation: no intervention, reactive and planned adaptation. "*Unfortunately, most current management belongs to the first or at best the second category*".

  Since Bernier and Schoene (2009) more emphasis on planned adaptation.

- **Focus on 1 strategy:**
  - tree migration (Andalo et al. 2005), species shift (Brunette et al. 2014), biome shift (Hanewinkel et al. 2010), species composition (Kienast et al., 1996), planting different tree species (Lidskog and Sjödin 2014), tree species mixture (Neuner et al. 2015), species selection (Yousefpour et al. 2014; Schou et al. 2015), species change (Seidl et al. 2009), conversion strategy (Yousefpour and Hanewinkel 2014).

- Ogden and Innes (2007a, 2007b, 2008, 2009): survey with questions to forestry practitioners about the **likely impact of CC on forest sector and potential adaptation strategies**:

  => List of 65 adaptation options: (conserve biological diversity, productive capacity, health and vitality, to maintain soil and water resources, forest contributions to global carbon cycles, enhance the long-term multiple socio-economic benefits to meet the needs of societies, to adapt the present legal, institutional and economic framework for forest conservation and sustainable management).

Methodology

- Empirical = 64 articles (survey = 32; literature review = 22; synthesis = 9; lab experiment = 1)

  => Survey: forest owners (10), NGOs (8), government (7), stakeholders from the private and public sector.

  => Survey: 47% N< 62; few N > 800 (Blennow and Persson, 2009 - 1950), (Laatsch and Ma, 2015 - 1640), (Lenart and Jones, 2014 - 1029) and (Blennow et al., 2012 - 845) rest: between 103 and 402.

- Theoretical = 2 papers, ecological theory (Bodin and Wiman, 2007) or economic theory through forest economics calculation (Brunette et al. 2014).

- Complex = 23 papers, mix of empirical and theoretical approaches.

  => future climatic scenarios and vegetation distribution model (Kienast et al. 1996)

  => plant types simulation (Siddiqui et al. 1999)

  => theoretical framework (Andalo et al. 2005; Yousefpour et al. 2014; Yousefpour et al. 2015),

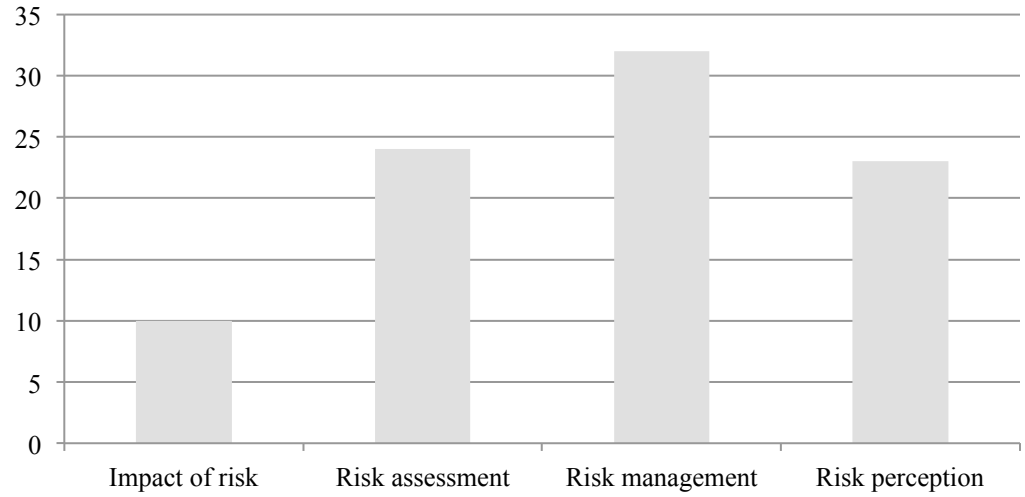
  => optimization of forest management (Yousefpour and Hanewinkel 2014; Yousefpour et al. 2013; Yousefpour et al. 2010; Eriksson et al. 2012)

  => cost-benefit analysis (Ochuodho et al. 2012).

  => comprehensive vulnerability assessment framework (Seidl and Lexer, 2013; Seidl et al. 2011).

  => theoretical framework empirically tested (Neuner et al. 2015; Nitschke and Innes 2008; Falk and Mellert 2011).

Categorization



Risk management
> Risk assessment
> Risk perception
> Impact of risk

Impact of risk: on growth, species composition, productivity, on yield, regeneration, mortality, provisioning of forest ecosystem goods and services.

Risk assessment: of probabilities of risk occurrence and damage, of vulnerability (of the forest sector, communities, stands, in relation to SFM, etc) and/or adaptive capacity (of forest sector, community, countries, etc).

Risk management: adaptation strategies and/or silvicultural management (at the level of the forest manager, enterprise, community, countries, continent), and adaptation and/or mitigation strategies.

Risk perception: CC impacts, potential adaptation options and management options, vulnerabilities, forest resilience and risk.

Discussion: attitude towards risk and uncertainty

- Wagner et al. (2014): increasing interest in uncertainty and CC because "*uncertainty is essentially the condition of not knowing and the future is the great unknown*".

- Numerous uncertainties related to CC: e.g. - main aspects of uncertainty for Swedish forest owners (Lidskog and Sjödin, 2014) : i) implications of CC, ii) alternative management, iii) timber market, iv) expert advice provided by forest consultants.

- However, the distinction between risk and uncertainty as defined by Knight (1921) is generally not considered in the forest economics literature and the two terms are interchangeably used, while they are fundamentally different (Yousefpour et al., 2012).

  => Knight (1921): risk refers to a situation where the probability of the occurrence of a disaster is well-known, whereas uncertainty refers to a situation in which the probability of occurrence is not precisely known.

- All of the papers deal with risk and uncertainty, **none of the 89 papers** analyze the impact of risk and uncertainty preferences on adaptation decisions.
- However, forest economics literature: main role of risk and uncertainty preferences on various type of decisions like insurance (Brunette et al., 2014), rotation length (Alvarez and Koskela 2006; Clarke and Reed 1989; Gong and Löfgren 2003; Uusivuori 2002), forest investments (Kangas 1994), forest owners' consumption (Koskela 1989) and decision to replant or not after a clear cutting (Lien et al. 2007).

=> Then, it seems reasonable to think that individual's risk and uncertainty preferences may be a relevant determinant of adaptation decision.

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Climate Change: Believing and Seeing Implies Adapting

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Two perspectives:

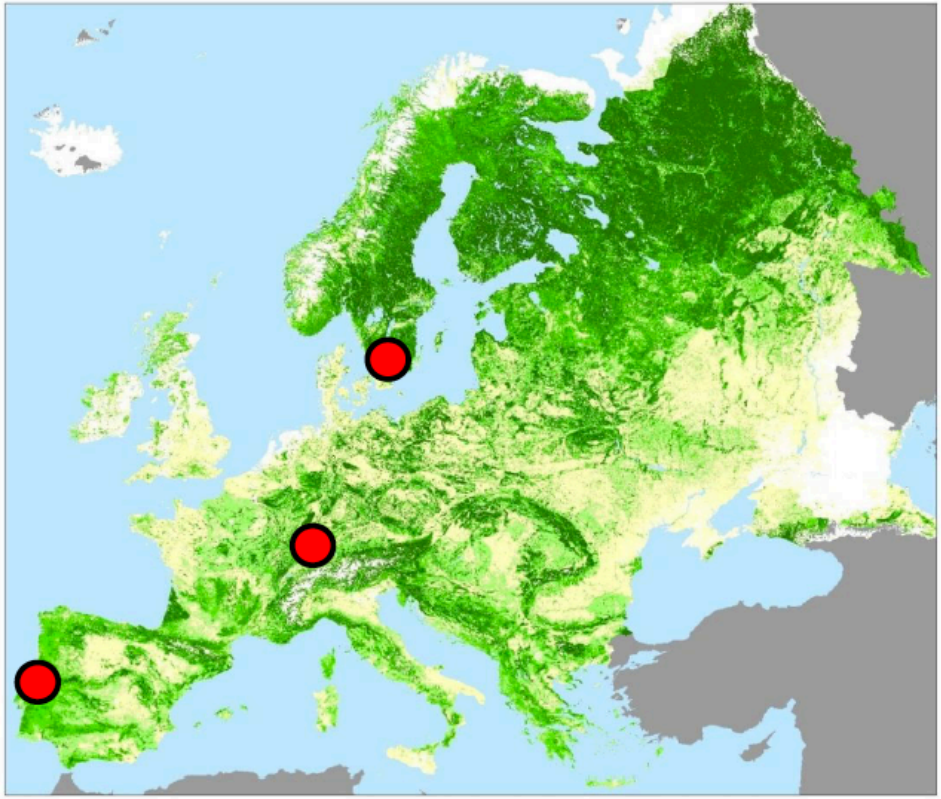
- General structural model predicts:
  Adaptive capacity larger in northern than in southern Europe
- What is the role of cognitive variables?

Data collection – mail surveys

Testing the explanatory powers of

Model based on **structural variables**

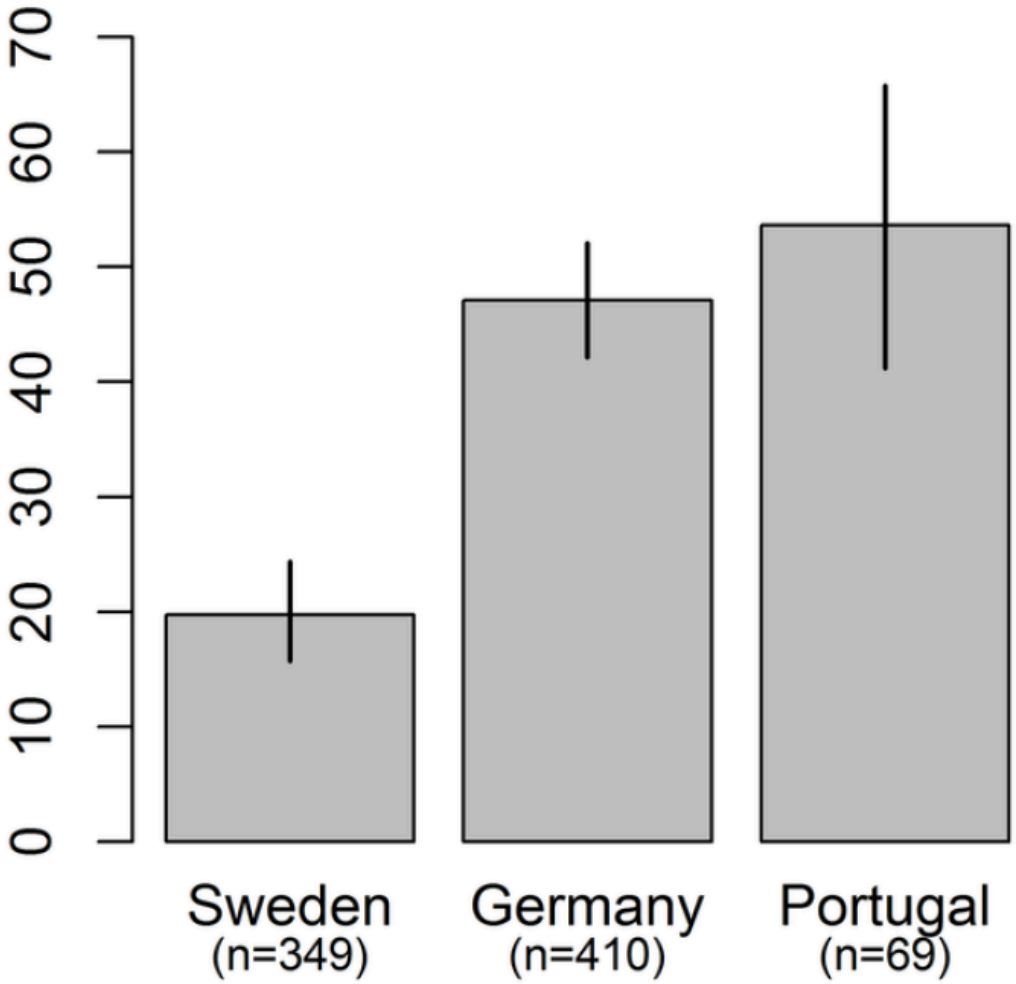
Model based on **cognitive variables**



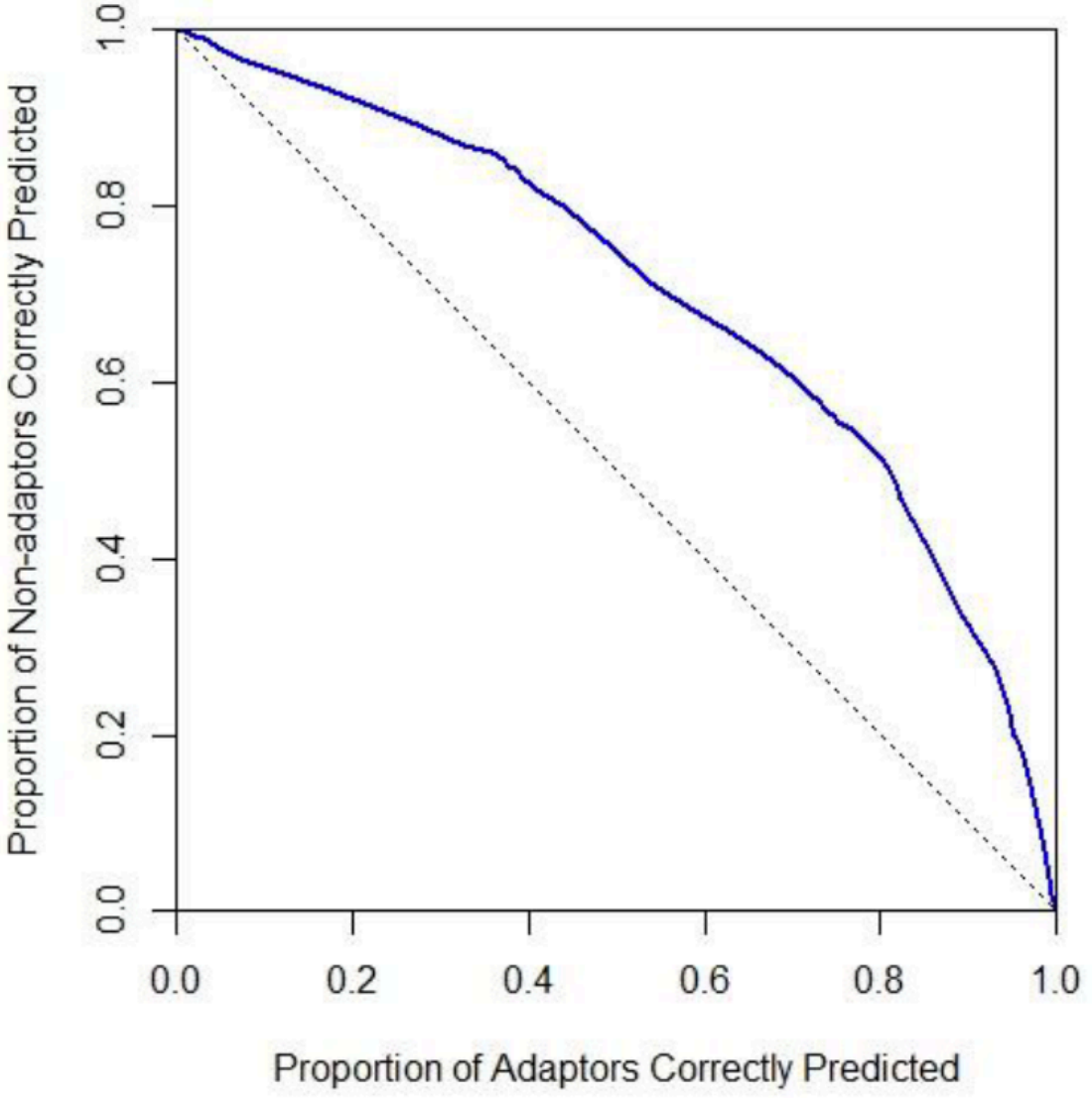
MOTIVE case study areas

- Sweden, Kronobergs län
- Germany, Schwarzwald
- Portugal, Chamusca

Adaptation of forest management to climate change by country



Blennow K, Persson J, Tomé M, Hanewinkel M (2012) Climate Change: Believing and Seeing Implies Adapting. PLoS ONE 7(11): e50182. doi:10.1371/journal.pone.0050182
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0050182

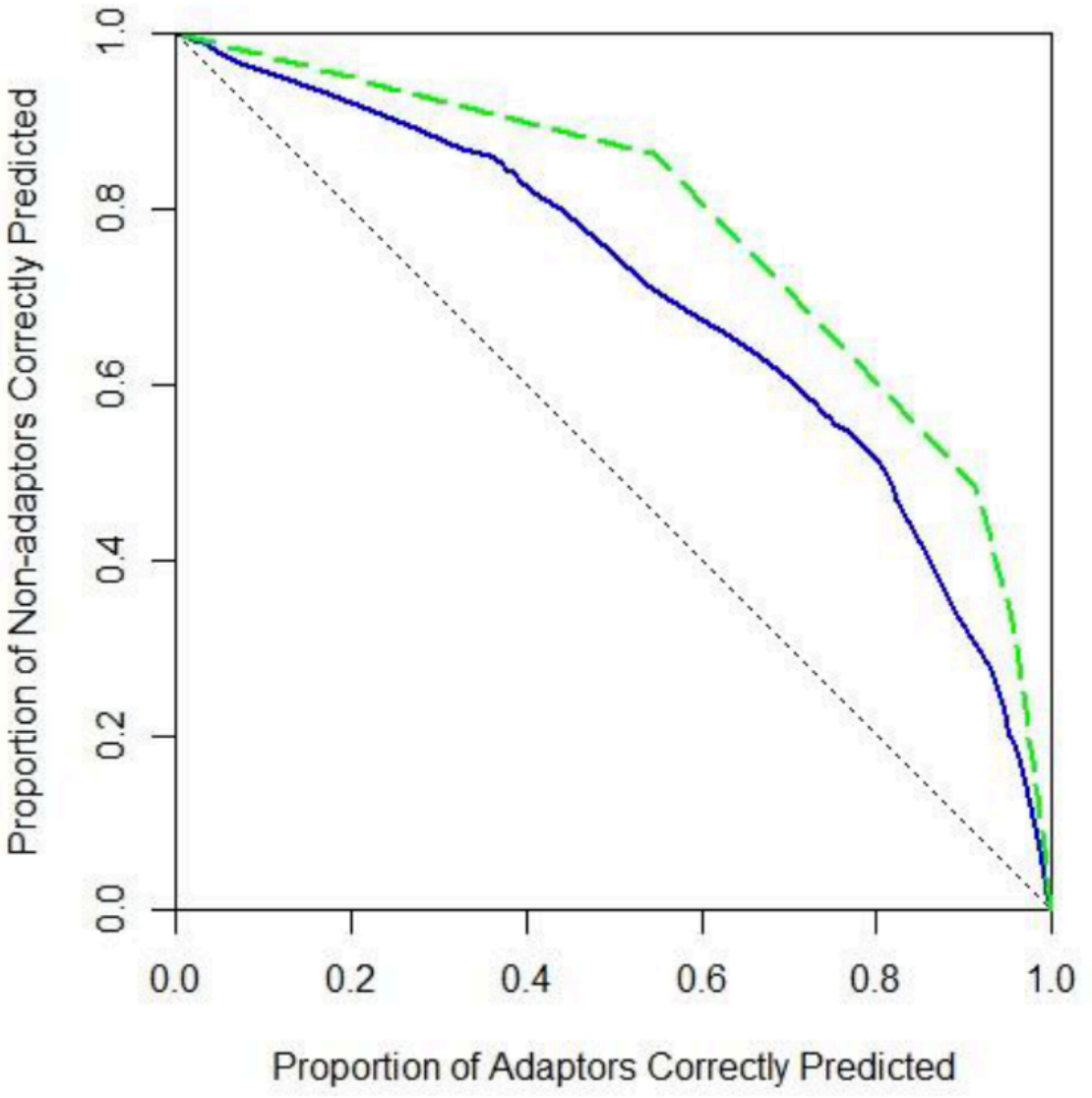


Structural model based on

- gender
- year of birth
- level of education ***
- fraction of household income from forestry ***
- size of holding
- case study area ***

Blennow K, Persson J, Tomé M, Hanewinkel M (2012) Climate Change: Believing and Seeing Implies Adapting. PLoS ONE 7(11): e50182. doi:10.1371/journal.pone.0050182
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0050182

Structural model



Do you think that the climate is changing to such an extent that it will substantially affect your forest? ***

Blennow K, Persson J, Tomé M, Hanewinkel M (2012) Climate Change: Believing and Seeing Implies Adapting. PLoS ONE 7(11): e50182. doi:10.1371/journal.pone.0050182
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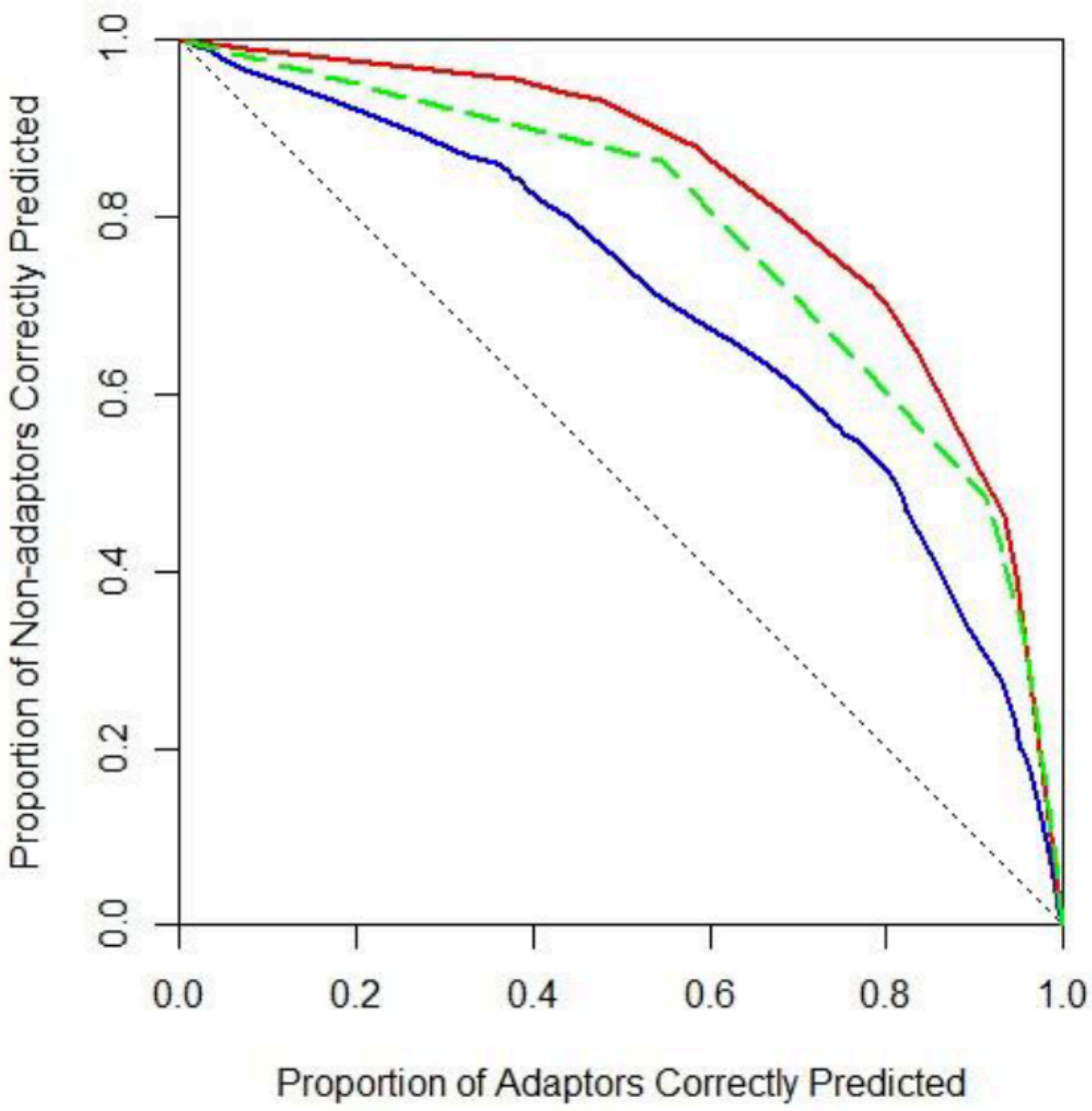
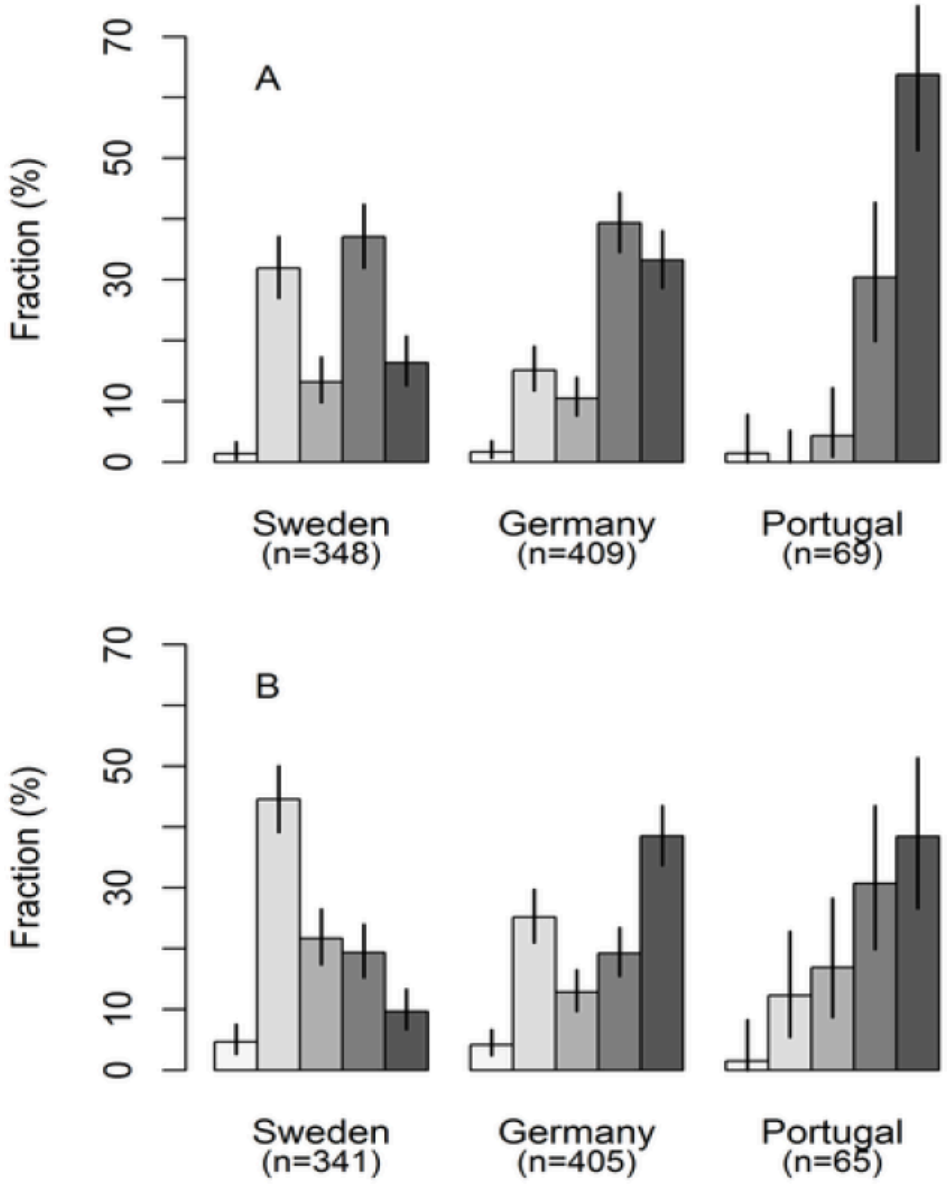


Structural model

Model based on
- Strength of belief in local effects of climate change***

Model based on
- Strength of belief in local effects of climate change***
- Have you experienced any extreme weather conditions that you interpret as caused by long-term, global climate change? ***

Blennow K, Persson J, Tomé M, Hanewinkel M (2012) Climate Change: Believing and Seeing Implies Adapting. PLoS ONE 7(11): e50182. doi:10.1371/journal.pone.0050182
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0050182



Strength of belief in local effects of climate change

- No, definitely not
- Probably not
- Do not know
- Yes, probably
- Yes, definitely

Strength of belief in having eperienced effects of climate change***

Blennow K, Persson J, Tomé M, Hanewinkel M (2012) Climate Change: Believing and Seeing Implies Adapting. PLoS ONE 7(11): e50182. doi:10.1371/journal.pone.0050182
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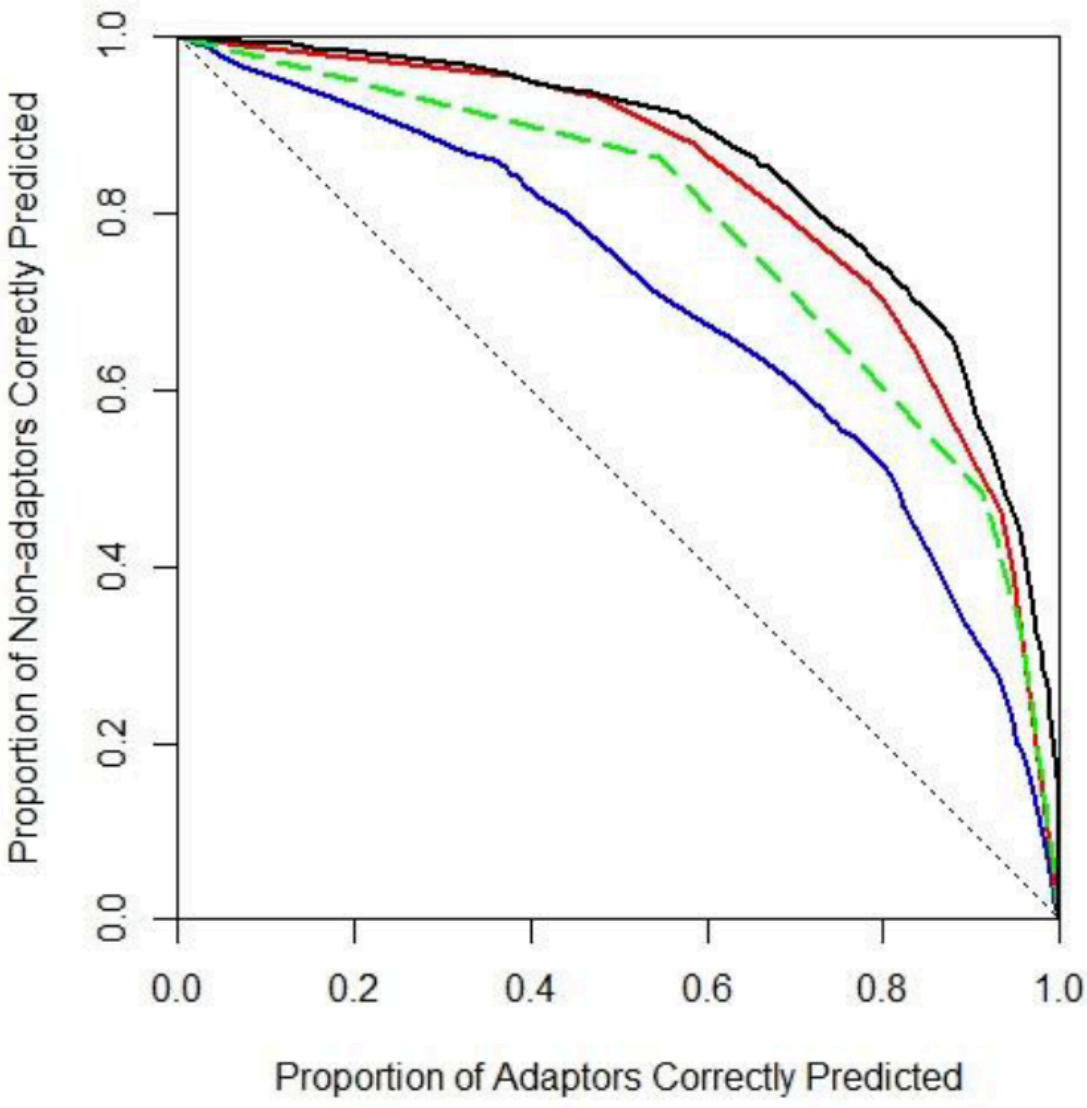

Structural model

Model based on
- 1 cognitive variable

Model based on
- 2 cognitive variables

Combination model
- 2 cognitive variables
- level of education
- % household income from forestry

Blennow K, Persson J, Tomé M, Hanewinkel M (2012) Climate Change: Believing and Seeing Implies Adapting. PLoS ONE 7(11): e50182. doi:10.1371/journal.pone.0050182
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0050182

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RESEARCH ARTICLE

Forest Owners' Response to Climate Change: University Education Trumps Value Profile

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- Culture cognition thesis (CCT) recently challenged the „knowledge deficit model (kdm)“
- kdm: scientific literatecy and numeracy are positively correlated with education level
- and play an important role in adapting to CC
- CCT: instead of education – „value profiles“ are more important (Kahan et al. NCC 2013)

Value profiles

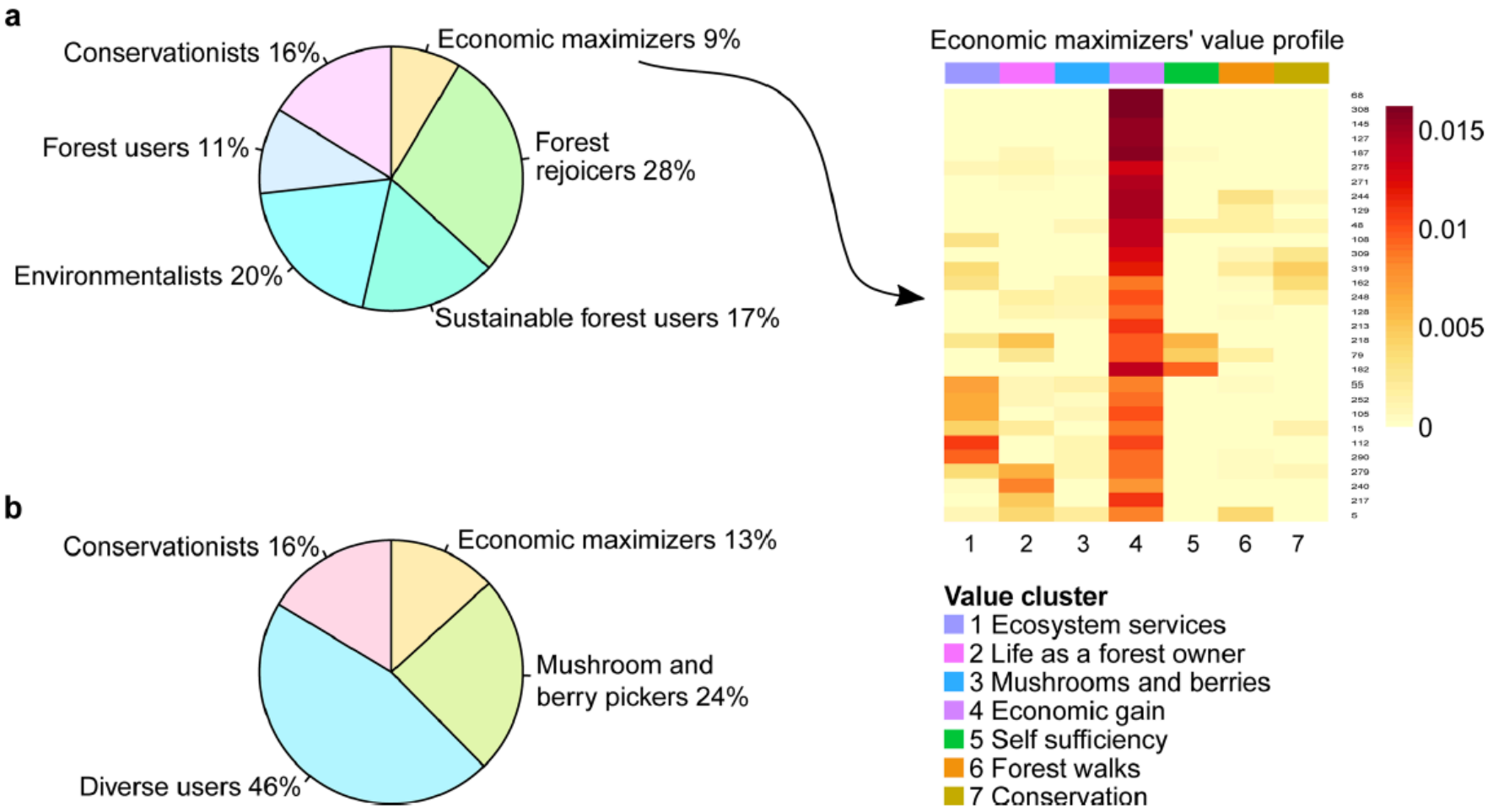


Fig 2. Value profiles and percentage of respondents by country. Value profiles for identified groups in Sweden (a) and Germany (b) based on individual respondents' preference loadings (S2 Fig) on all value clusters identified in each country (S1 Fig). Inserted example shows loadings on value clusters for the 30 Swedish respondents with an "Economic maximizer" value profile.

doi:10.1371/journal.pone.0155137.g002

Results – effect of education

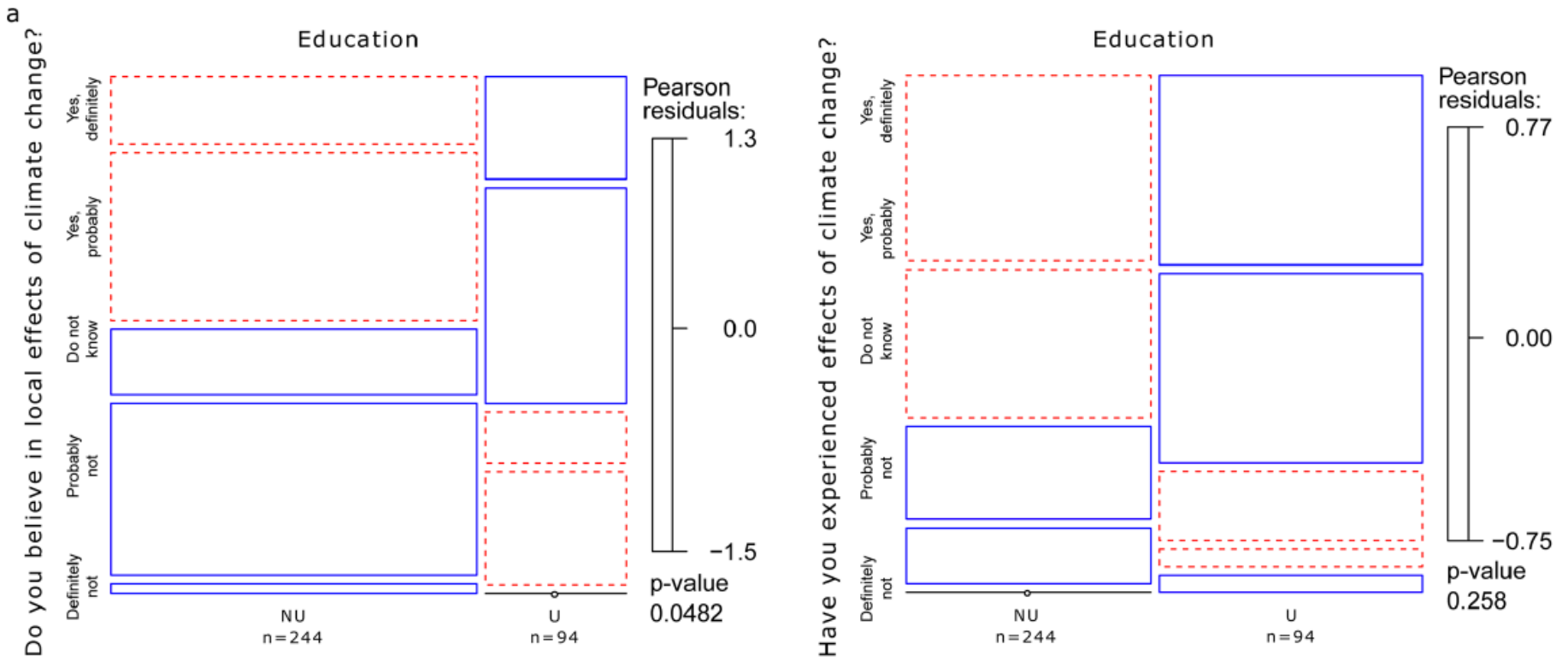


Fig 1. Relationship of climate change risk perception with university education. Relationships of risk perception in terms of the strength of belief in the local effects of climate change, the strength of belief in having experienced the effects of climate change and university education for Swedish (a) and German (b) respondents. The size of the respective compartment is proportional to the number of observations in the respective category. Pearson residuals outside of ±2 correspond to a significant difference for individual cells at approximately $\alpha = 0.05$. Positive Pearson residuals are delineated in blue and negative residuals in red. The graphs are based on raw data before imputation. NU–No university education; U–University education.

doi:10.1371/journal.pone.0155137.g001

- University education increased perception of risk of climate change
- Effect of university education was not dependent on individual‘s value profile
- Culture Cognition Thesis (CCT) had no explanatory power on German and Swedish forest owner’s climate change perception

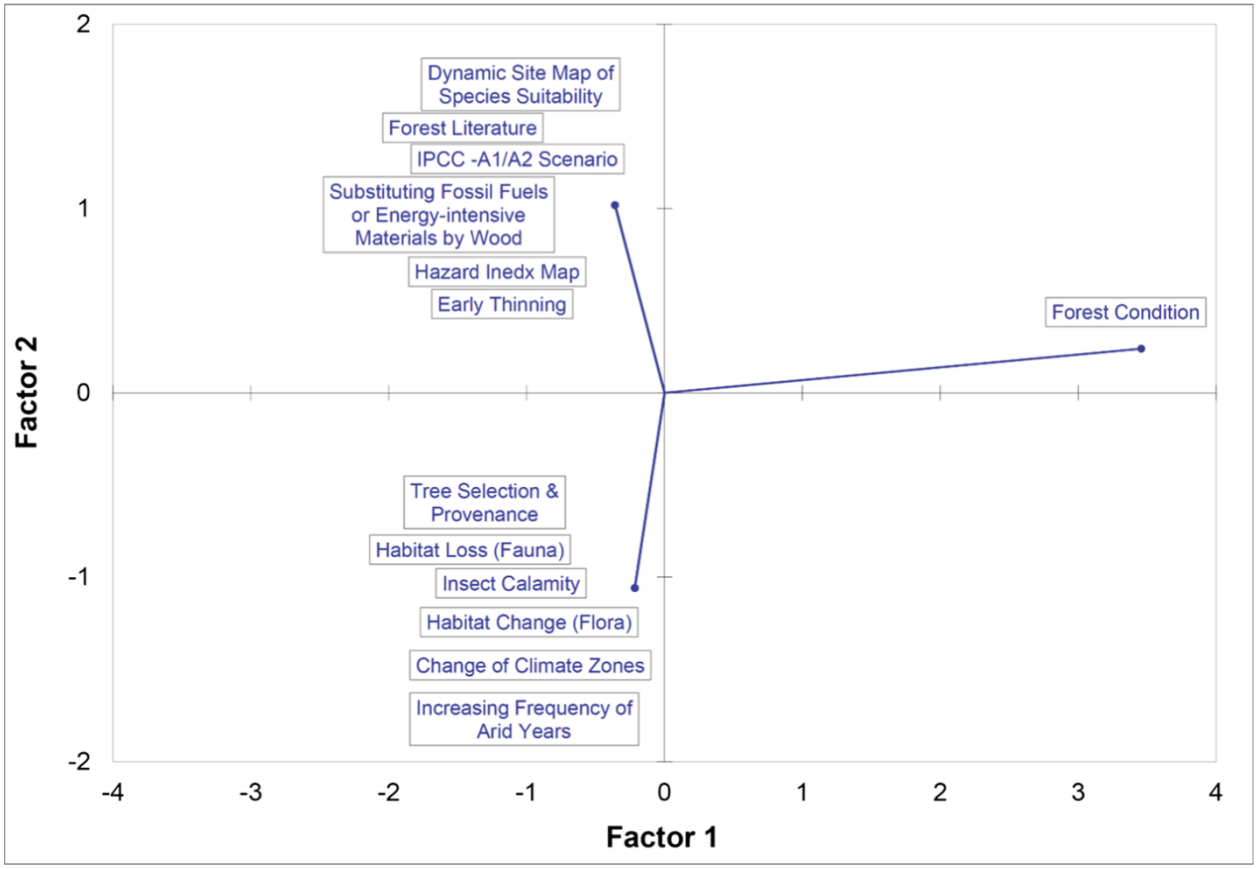
Some conclusions from empirical studies with forest owners (Blennow et al. 2012, 2016)

- Risk perception regarding CC touches psychological (philosophical) issues in all aspects
- Need for including beliefs and personal experience of the respondents
- Despite the limited impact of „structural variables“: Don‘t rule out education level
- Clear need for quantitative analysis

Climatic Change (2015) 130:273–286
DOI 10.1007/s10584-015-1330-5

Forestry professionals' perceptions of climate change, impacts and adaptation strategies for forests in south-west Germany

Rasoul Yousefpour • Marc Hanewinkel



" We used the correlation matrix among the responses as independent and correlated variables and applied principal axis factoring to extract the main factors from the original correlation matrix".

"Canonical analysis visualizes the relationships between a single criterion variable and a set of predictor variables derived from significant factors".

Petr et al. (2014) : uncertainty assessment framework for forest planning adaptation to CC.

- Survey on 33 British forest planners: characterization of the type of uncertainty: economic (on timber production), social (on recreation use) or climatic (on the effect of wind).
- passive or active consideration of uncertainty in the forest planning.
- Focus on CC risk perception through a Likert judgement scale.

⇒ This methodology allows having a qualitative approach of the uncertainty in forest planning.

⇒ However, a quantitative approach with a measurement of the decision maker's preferences towards risk and uncertainty is a fundamental piece of information to improve the understanding of the decision maker's adaptation options (probability to adapt, type of strategies implemented, timing of adaptation, etc). For that purpose, methods coming from experimental economics may be useful (Brunette et al. 2015).

Table 4 The ten-paired lottery-choice decisions under risk (adapted from Holt and Laury 2002)

Decisions	Option A				Option B				Choice
	Prob. p (%)	Gains	Prob. (1-p) (%)	Gains	Prob. p (%)	Gains	Prob. (1-p) (%)	Gains	
1	10	7 €	90	5 €	10	13 €	90	0 €	A B
2	20	7 €	80	5 €	20	13 €	80	0 €	A B
3	30	7 €	70	5 €	30	13 €	70	0 €	A B
4	40	7 €	60	5 €	40	13 €	60	0 €	A B
5	50	7 €	50	5 €	50	13 €	50	0 €	A B
6	60	7 €	40	5 €	60	13 €	40	0 €	A B
7	70	7 €	30	5 €	70	13 €	30	0 €	A B
8	80	7 €	20	5 €	80	13 €	20	0 €	A B
9	90	7 €	10	5 €	90	13 €	10	0 €	A B
10	100	7 €	0	5 €	100	13 €	0	0 €	A B

Risk preferences through lottery choices

=> The higher the number of Option A, the higher the risk aversion.

Uncertainty preferences through lottery choices

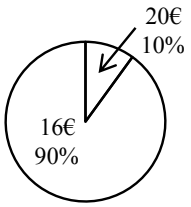
=> The higher the number of Option A, the higher the uncertainty aversion.

Table 5 The ten-paired lottery-choice decision under ambiguity (adapted from Chakravarty and Roy 2009)

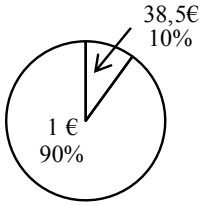
Decisions	Option A: urn A		Option B: urn B		Choice
	In urn A, the distribution of balls is 5 black and 5 white		In urn B, the possible distribution of balls is not known		
	The chosen color is obtained Gains	The chosen color is not obtained Gains	The chosen colour is obtained Gains	The chosen colour is not obtained Gains	
1	13 €	0 €	9 €	0 €	A B
2	12 €	0 €	9 €	0 €	A B
3	11 €	0 €	9 €	0 €	A B
4	10 €	0 €	9 €	0 €	A B
5	9 €	0 €	9 €	0 €	A B
6	8 €	0 €	9 €	0 €	A B
7	7 €	0 €	9 €	0 €	A B
8	6 €	0 €	9 €	0 €	A B
9	4 €	0 €	9 €	0 €	A B
10	2 €	0 €	9 €	0 €	A B

Choose a colour: BLACK ○ WHITE ○

Choice experiment

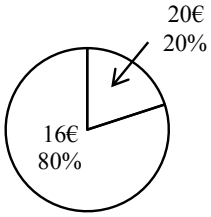


Option 1 ☐

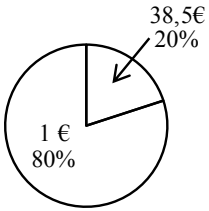


Option 2 ☐

Question 2. Which option do you prefer?

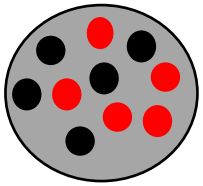


Option 1 ☐



Option 2 ☐

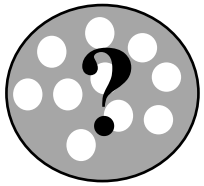
Question 1. Which option do you prefer?



Urn A: 5 red balls and 5 black balls.

- Chosen color obtained: 35 euros
- Chosen color not obtained: 0 euros

Option A ☐



Urn B: 10 balls, we don't know the number of black balls and red balls.

- Chosen color obtained: 25 euros
- Chosen color not obtained: 0 euros

Option B ☐

Next step for this paper

Factorial analysis: codification of the variables in order to observe potential correlation between them.

Examples of questions:

- Is there a correlation between the year of publication and the type of adaptation strategies ? Methodology ?
- Is the category (risk management, risk assessment, etc) linked to the journal ? Year of publication ? Disturbances ?
- Is the country considered in the analysis correlated with the objective of the paper? Methodology?

Next step for the project

- Questionnaire to forest owners in Germany (Bade Wurttemberg) /France (Vosges ?)

- First step: quantification of risk and uncertainty preferences through lottery choices.

- Second step: questions about adaptation strategies (type, degree, timing, etc).

- Third step: socio-demographico-economics questions.

=> Determinants of adaptation decision with a focus on risk and uncertainty preferences.