Changing forest stakeholders' perception of ecosystem services with linguistic nudging

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Abstract. This paper explores whether the perceptions of forest owners and professionals could be nudged towards more sustainable management practices by adjusting a policy text's metaphorical content. Recent research has demonstrated a link between information interventions and preference change, but there is a need to further explore individuals' reactions to information on forest-based ecosystem services and to link these to the design of policy instruments. We contribute to narrowing this gap by nudging the content of a policy text comparing rotation forest management (RFM) and continuous cover forestry (CCF), and exposing it to forest stakeholders. The research is carried out in Finland, the so-called 'forest nation' of Europe, whose economy and culture is closely tied to forests. The results highlight a deep-rooted opinion divide between Finnish forest owners and professionals: the professionals reacted significantly more negatively towards policy text emphasising continuous cover practice than forest owners. Our results support the use of linguistic nudging as a complement to other policy instruments, but they also highlight the challenges of using one-fits-all approaches to make policies more palatable. In our study, the stakeholders' different reaction to nudge was also explained by their age, and type and degree of prior knowledge on forest management.

Keywords: Forest management, sustainability, nudge, cognitive dissonance, choice architecture, informational intervention.

1. Introduction

The concept of ecosystem services (ES) is central for environmental management and policy (MEA, 2005). First used as a metaphor to introduce environmental issues into the 'dominant paradigms and language of economics, services and values' (Kronenberg, 2014, p. 1), the concept has transformed into a widely-used model that attempts to make conservation and sustainable ecosystem management practices more operational for decision-making (Norgaard, 2010). While economic and biophysical valuation and assessment have dominated the ES scene (Burkhard et al., 2014; Carnol et al., 2014), recent literature has emphasised the concept's suitability for examining the effects that stakeholder values and perceptions have on sustainability (Asah et al., 2014; Matthies et al., 2018; Menzel and Teng, 2010; Urgeson et al., 2013).

ES are defined as 'the benefits people obtain from ecosystems' (MEA, 2005, p. 49). Forests provide a variety of these benefits, ranging from goods (food, fuel), supporting services (biodiversity), provisioning services (biomass, water supply) and regulating services (carbon sequestration) to social and cultural services (recreation, spiritual and cognitive development) (Peters et al., 2015). The perceptions, preferences and values that forest stakeholders hold towards these services have important ramifications for sustainability. This is because forest owners and professionals often control numerous forest-based ES, and are thus able to influence the processes that determine future forest management and use (Häyrinen et al., 2016). Studies have, however, shown that stakeholder perceptions are affected by multiple factors and ownership objectives (Abdoellah et al., 2015; Raymond et al., 2013). These include, for example, emotional attachments to forest lands, heritage

values and economic security, practical benefits from forests, the importance of forests and emotional bonds formed through working within silvicultural systems (Häyrinen et al., 2016; Kearney, 2001). In this paper, we explore whether the values and perceptions of stakeholders in the field of forest management could be shifted towards sustainability by adjusting the metaphorical content of a policy text.

Our study is motivated by two intertwined phenomena. First, a concise but specific literature has already examined the effects that different types of information have on stakeholder perceptions in forest management (Ford et al., 2009; Kearney, 2001; Matthies et al., 2016; Ribe, 2006; Smith et al., 2012). Several studies demonstrate a link between information interventions and preference change, but only to some degree (Kearney, 2001). While the picture of the effects remains mixed, the commonly reported message is intriguing. Reactions to informational interventions depend very much on the ways in which information is adapted to existing internal representations at the individual level (Ford et al., 2009; Matthies et al., 2016). For example, prior research has shown that stakeholders who hold strong opinions or attitudes towards management practices tend to ignore new information, especially if it contradicts their beliefs (Kearney, 2001). We therefore see a need to further explore individuals' reactions to information on forest-based ES and to link these reactions to the design of effective policy instruments. This has sparked our interest in drawing on the concept of cognitive dissonance when applying the behavioural policy instrument of *nudging* (Thaler and Sunstein, 2008).

Second, our motivation has been inspired by an ongoing global trend in forest management. In many places, there has been a gradual transition from rotation forest management (RFM) (*i.e.* clear-felling) to continuous cover forestry (CCF) (Kröger and Raitio, 2017). While the effectiveness and the relative performance of these two management practices is still under scholarly debate, the CCF practice is increasingly discussed in terms of sustainability (Pukkala, 2016)[1]. In addition, there is evidence that, in some cases, CCF offers more ES and yields significantly less negative impacts on biodiversity and on forests' recreational value than its RFM counterpart (Peura et al., 2018). The question then arises: is it possible to nudge stakeholder perceptions towards pro-CCF stances by using informational interventions? We examine this possibility by conducting a nationwide survey focusing on two different forestry stakeholder groups in Finland, forest owners and forest professionals.

We will first critically reflect on the nudge literature and metaphorical framing, and discuss these with respect to the concept of cognitive dissonance. We then present the data, methods and results of our empirical study. We conclude with implications for future work.

2. Informational interventions targeting stakeholder perceptions

2.1 Linguistic nudging

In recent years, a specific literature has examined the effects that different types of information may have on stakeholder perceptions in forest management (Ford et al., 2009; Kearney, 2001; Matthies et

[1] It is important to note that we do not argue CCF being automatically better than RFM from the sustainability perspective in all cases.

al., 2018; Ribe, 2006; Smith et al., 2012). Several studies have been able to demonstrate a link between information interventions and preference change, but this link is found to greatly depend on the ways in which information aligns with the internal representations of the target (Ford et al., 2009; Matthies et al., 2016).

Nudging, subtle interventions designed to guide individuals' decision-making (Thaler and Sunstein, 2008), is a useful concept for linking information interventions with individuals' perceptions to forest-based ES. In essence, a nudge is defined as 'any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives' (Thaler and Sunstein, 2008, p. 6). Nudge theory asserts that designing the context of choice matters because the chooser is often unaware of the context and thus ends up making irrational decisions that are, in many situations, harmful and not necessarily in the chooser's best interest (Thaler and Sunstein, 2008). As a policy instrument that affects the unconscious processes of the human mind, nudging can therefore be seen to offer a means to encourage optimal behaviour and attitudes (Stoknes, 2014, p. 7).

In their original work on nudge theory, Thaler and Sunstein (2008) investigate framing-based nudges, and argue that different ways of presenting information can adjust the way people perceive the implications of their choice. In light of this, our interest is in linguistic nudging devices that seek to induce attitude and perception change through metaphorical framing. Several studies within cognitive linguistics and social psychology assert that even subtle metaphorical modifications in a text can have a powerful influence over how people perceive the information they are exposed to (Lakoff, 2004; Thibodeau and Boroditsky, 2011). However, even if informational nudges could be framed in cognitively attractive ways that reflect an audience's mental models with the help of metaphors, metaphorical framing in a nudge requires an understanding of a given audience's cognitive reactions when exposed to such a frame. We argue that cognitive dissonance is an important element in the unconscious processes of nudging, and thus integral to how a message is perceived and received in informational nudges.

Just like nudging, cognitive dissonance operates within the intuitive processes of decision-making, behaviour and attitude change. A key tenet of dissonance theory is that people have an innate desire to hold their mental representations – their beliefs, attitudes, behaviours, decisions and commitments – in harmony. Cognitive dissonance is a state of tension that emerges when an individual simultaneously holds two or more psychologically inconsistent yet related cognitions (ideas, attitudes, beliefs, opinions, knowledge) (Festinger, 1957, p. 3). The theory holds that the feeling of cognitive dissonance is a motivational state, which will drive the individual to act to restore consonance. In other words, if their beliefs are not in line with their behaviour, people will start to adjust their beliefs or behaviour to reduce dissonance. Given that external interventions have been found to nearly always produce some form of cognitive conflict (Festinger, 1957, p. 262; Festinger and Carlsmith, 1959), it can be suggested that the way audiences accept a message would depend on a nudge's ability to reduce cognitive dissonance in the targets. Put differently, we argue that cognitive dissonance theory helps explain the different ways in which audiences accept a message containing new information.

Empirical work on the dissonance theory has found that individuals most often reduce dissonance in a way that helps maintain business-as-usual (Aronson, 2012; Festinger, 1957). Accordingly, in the nudge literature, reducing cognitive dissonance has been identified as a tool to enhance pro-environmental communication (Carrico et al., 2011; Dröge, 2008; Lehner et al., 2015; Stoknes, 2014; Wolf and Moser, 2011). Cognitive dissonance has also been found to partially explain environmental science denial among publics (McDonald et al., 2015; Stoknes, 2014). Interestingly, it could be argued that scholars in ecosystem management were also operating with the theory of cognitive dissonance in creating the ES concept. When the concept was first introduced, there was a need to create a 'mind changer' for policy – starting from the premise that 'destroying the environment runs counter to humans' interests' (Kronenberg, 2014, p. 1). Hence, the ES concept was used as a metaphor to help introduce environmental issues into the prevailing economic paradigms (Kronenberg, 2014, p. 1), and to help communicate the benefits and harms related to environmental management with less cognitive dissonance.

2.2 Targeting forest stakeholders' perception of CCF with linguistic nudging

As we have explained above, current literature on the effects that different types of information may have on stakeholder perceptions in forest management have found that the reactions to informational interventions depend on the ways in which information is adapted to existing internal representations at individual level (Ford et al., 2009; Kearney, 2001; Matthies et al., 2016; Ribe, 2006; Smith et al., 2012). The perceptions assigned to ecosystems are often found to closely 'relate to different personal objectives, concerns and priorities for ecosystem management' as well as emotional attachment to these services (Asah et al., 2012; Kearney, 2001; Lamarque et al., 2011, p. 1).

The dissonance theory would predict that these personal objectives, concerns and affect will motivate stakeholders to choose different dissonance reduction strategies when exposed to an informational nudge. In informational interventions targeting attitude change, it is mainly possible to operate with strategies to reduce belief-based cognitive elements. The methods for eliminating dissonant beliefs are well defined (Aronson, 2012; Festinger, 1957; Steele, 1988). People often choose between (1) reducing or denying the importance of the dissonant beliefs (e.g. new information is weighted as less important than existing information or knowledge about the topic); (2) adding more consonant beliefs that outweigh the dissonant beliefs; or (3) changing the dissonant beliefs so that they are no longer inconsistent (Festinger, 1957, p. 264).

The remaining paper therefore investigates how two different stakeholder groups react to a linguistically nudged policy text communicating pro-CCF management practices. We explore the nudge effect between and among Finnish forest owners and professionals. Finland offers a fruitful context in which to explore linguistic nudging in forest management communication. Finnish official silvicultural instructions currently recommend RFM practice, which has been predominant for decades and fiercely promoted at the expense of uneven-aged management. Today, however, owners and professionals in the country have more alternatives and flexibility to manage their forest land sustainably (Pukkala et al., 2011). Moreover, and importantly, current research points to a clear opinion divide regarding forest management practices in Finland. Forest professionals have been found to hold more antagonistic attitudes towards CCF than forest owners (Haltia et al., 2017).

Professionals' attitudes favour business as usual with RFM management practices. Conversely, forest owners have been found to embrace more objectives than before, such as gaining recreational value and maintaining the biodiversity of forests. It is reported that a gradual approval of high thinning and uneven-aged management practices has given owners more freedom to manage their forests and, as a consequence, has led to CCF gaining popularity and societal acceptance among owners (Hallikainen et al., 2010; Häyrinen et al., 2016; Matthies et al., 2018). Given these contrary attitudes, examining the two groups' reactions to a linguistically nudged policy text on CCF is likely to inform us on the dissonance effect and reduction strategies in informational nudging.

Based on our earlier pilot experiments on linguistic nudging of laymen and professionals (Lonkila, 2017) as well as the theoretical perspectives and empirical findings presented above, we hypothesise that

1) *Finnish forest professionals reject the CCF frame* due to their business-as-usual and RFM-favouring prior attitudes (i.e., reduce cognitive dissonance by downplaying the importance of the CCF frame).
2) *Finnish forest owners adopt a consonant element that would render the CCF frame preferable* due to the group embracing broader objectives for forest management, including preference for social and cultural ES and emotional attachment to forest land (i.e., reduce cognitive dissonance by adding more consonant beliefs that outweigh the dissonant beliefs).

We tested these hypotheses in a nationwide study.

3. Background: Finnish forest ownership and management

In Finland, forest ownership is fragmented. Non-industrial private forest owners constitute the largest segment of the forest sector, owning over 60 per cent of the productive forests and supplying over 80 per cent of round-wood for industrial use. The government owns 25, forest industries 10, and municipalities and parishes five per cent of the forest cover (Finnish Statistical Yearbook of Forestry, 2014).

The non-industrial private forest owner group can be further divided into active and passive owners, the latter referring to owners who have not engaged in forest management practices in the past ten years (Haltia et al., 2017). The private forest owners consist largely of an older generation (representing 10 per cent of forest land in industrial use), but a generational shift is expected to take place in the coming decades as forests are passed on to younger generations in families (Hujala et al., 2007). The sex ratio among forest owners in the 2010s has been estimated to be 38 per cent female 62 per cent male, and 44 per cent female and 56 per cent male when co-operatives are also taken into account. In general, women have been found to own smaller areas of forest land than men (Karppinen and Hänninen, 2017).

In 2017, the forest sector provided employment for 59 000 people (Luonnonvarakeskus, 2018). Forestry professionals are defined here as individuals holding positions within silviculture practices but also within administration, marketing and communication in the field of forest management. In the Finnish forest management system, the interaction between professionals and private forest

owners is key. The professionals are responsible for passing information and advice about management practices on to owners. All new private forest owners are also invited to develop forest management plans together with professionals and with the help of a state-funded field inventory. It has been found that in cases where professionals' and owners' interest conflict, often no management plan is agreed upon (Hujala and Tikkanen, 2008).

Between the mid- to late-1900s, even-aged rotation forest management (RFM) combined with low thinning was the dominant silviculture practice in Finland, and alternative forms of management were discouraged. One major reason for the intensive promotion of RFM was its capacity to produce cheap raw material for the Finnish pulp and paper industry (Kröger and Raitio, 2017). However, reflecting the global paradigm shift on forestry practices and concerns over the ecological and climatic consequences of intensive management, the regulations on Finnish forest management have gradually been changing. In 2014, the government passed the new Forest Act, which increased forest owners' freedom to manage their own land, and thus offered an avenue to diversify forest management practices. The Forest Act was expected to increase the popularity of CCF, yet, to date, the shift to new management practices has been slow. Only 3.7 percent of forest land was under CCF in 2018 (measured between January-May) (Metsäkeskus, 2018).

4. Data and Methods

To test our hypotheses, we invited Finnish private forest owners and forestry professionals to participate in a nationwide survey. We sent the survey to 6466 private forest owners and to 7236 forest professionals. We received a total of 2807 complete responses (private forest owners n=1552; forest professionals n=1255).

The survey comprised of two parts: a questionnaire collecting background information on the participants and *the nudge*. The first part asked for basic information on the respondents (age, gender, level of education) but also included specific questions on their level of knowledge in forest management, forest economy and environmental issues.

In the latter part, the participants were asked to read a short policy text written by an expert on various issues related to RFM and CCF silviculture practices. The text discussed growth and regeneration, economic and environmental impacts as well as risks and vulnerability to damage. The participants were then asked to estimate the preference (1. worth striving for), plausibility (2. convincing, 3. feels real, 4. realistic) and understandability of the text (5. clear, 6. coherent, 7. well written) on a scale of one to five. Our measure of the respondent's *stance* on CCF was the sum of all these seven variables. This variable was then converted to a range from -1 to 1 for more clarity, with 1 representing a person totally agreeing on the text content.

To see if stakeholder perception or valuation can be influenced with linguistic nudging, we designed four versions of the text presented in the questionnaire. Each text had a different emphasis, either neutral (NEUTRAL), emphasis towards RFM (RFM), minor favouring towards CCF (MINOR) or major emphasis towards CCF (MAJOR. See Appendix A). The MINOR text was nudged to favour

CCF by emphasising economic factors, whereas the MAJOR one was modified to emphasise both economics and ecology.

The original text (RFM) was extracted and shortened from the guidelines published by the Forestry Development Centre Tapio, which is a stated-owned company under the auspices of the Finnish Ministry of Agriculture and Forestry. The Tapio guidelines were chosen because of their key role in providing up-to-date scientific information and advice for both forest owners and professionals. We will next explain the process of developing the nudges in detail.

4.1. The Nudge

We use metaphorical framing, a linguistic nudging device that seeks to induce attitude and perception change. Metaphors activate emotional states and patterns of thought that can nudge people's reactions toward certain directions (Hukkinen, 2012; Thibodeau and Boroditsky, 2011).This is because adjusting a text's metaphorical content deals both with the wording of the message as well as the dispositional perceptions of the recipients (Bao and Ho, 2015; Ferraro and Price, 2013; Thaler and Sunstein, 2008). In other words, given that emotion-based evaluations have been shown to be activated prior to reflective judgements (Slovic et al., 2007), intuitive inputs as responses to interventions can influence the reflective accounts of the human mind directly (Kahneman, 2011; Michalek et al., 2016).

We used the metaphor identification procedure (MIP) to design the nudged policy texts. MIP is a systematic method for linguistic metaphor identification, developed by the Pragglejaz Group and tested for its reliability (Steen et al., 2010). In modifying the original Tapio text, we first identified lexical items as metaphorical in accordance with the procedure described by Steen et al. (2010), and then changed the wording to make the metaphors explicit to the desired version of the nudge. For example, for the MINOR nudge, we characterized the costs of forest management in terms of "flows" of money, and in the MAJOR nudge, we added to this the characterization of CCF in terms of "denser networks of habitats" and the "richness" of forests in terms of biodiversity as well as health benefits for humans. In changing the wordings, we based our shifts of terms on the work on primary and secondary metaphors by Lakoff and Johnson (1999). Thus, the first nudge is premised on the metaphorical assumption that MONEY IS A LIQUID (and therefore able to "flow"), while the other nudge is based on the metaphorical assumption of WELL-BEING IS WEALTH (the attribute of "density" as synecdoche for "richness" and "richness" itself therefore applying to both environmental and human well-being)[2] (see Appendices B and C).

It is important to note that during the identification phase for finding metaphorical content in lexical items, the original Tapio text was found to favour business-as-usual. Therefore, the original text became the RFM nudge, and we balanced all biased facts between RFM and CCF to design the neutral nudge. In practical terms, we first abbreviated the original Tapio text comparing even-aged and uneven-aged forestry, keeping both the content and the wordings (this is the RFM). Then, in close collaboration with experts on uneven-aged forestry, we changed the informational content of this

[2] see also the Master Metaphor List produced by the Cognitive Linguistics Research Group, University of California, in 1991.

original text to place the two forestry management practices on a par (this became the NEUTRAL; the RFM was informationally biased towards even-aged management). Next, we proceed with the nudge to also change the contents of the text. In the third nudge – that is, the MINOR – we changed the wordings pertaining to economic aspects of the two forestry management practices so that they emphasize "flows", as explicated above. Finally, to produce the fourth nudge, – the MAJOR –we added emphasis on both economics and ecology. In sum, thus, RFM and NEUTRAL are on a par (with informational changes only) and MINOR and MAJOR are on a par (with linguistic nudge changes as well). With this strategy, we achieved a way of testing for both the change in informational contents only as well as, additionally, for the effects of linguistic nudging (for a more detailed explanation and illustrative examples, see Appendices B and C).

4.2. Data analysis

To investigate the effect of respondent characteristics and nudging intensity on reported stance on CCF, we fitted the following linear regression:

$$\begin{aligned} \textit{Stance to CCF} \sim\ & \textit{Nudge} * \textit{Stakeholder} * \textit{Age} + \\ & \textit{Nudge} * \textit{Stakeholder} * \textit{Gender} + \\ & \textit{Nudge} * \textit{Stakeholder} * \textit{Knowledge} * \textit{Knowledge bias} \end{aligned}$$

The variable *Nudge* represents an intensity of intervention, and hence we expected that its effect would change gradually from the RFM nudge to the Major CCF nudge. It was therefore modelled as a numerical variable and included in the model as a second-degree polynomial to allow for the effect of the nudge to change in a non-linear manner. We used the function *poly* from package *stats* in R-software 3.5.0 (R Core Team, 2018) to include the uncorrelated orthogonal polynomial in the model. Age was standardized before being included in the model.

The reported knowledge on forest management, forestry economics and forest environment were highly correlated among each other, with respondents with high reported knowledge of, e.g., economics, also reporting high knowledge of forest management and environmental issues. Highly correlated explanatory variables placed in the model can affect the performance of the model. To overcome this, we created independent variables by running a principal component analysis on the three measures of knowledge. This yielded three uncorrelated principal components: General *Knowledge level* (explaining 91.4% of variance in the three original knowledge variables), as a measure of general knowledge level; *Knowledge bias* (6.4% of variance explained), with low values representing respondents with more knowledge of forest management and economics than environmental aspects, and vice versa for high values; and the remaining third component (2.2% of variance explained) depicting bias between management knowledge and forest economics. Only the first two components were included in the model and bundled as an interaction with the rationale that if the bias is important, that effect should depend on how much knowledge is reported.

5. Results

On average, forest professionals rated the description of CCF (i.e. stance on CCF) in the nudged text with 10% lower values than the forest owners (Fig. 1, $t = -10.427$, $p < 0.001$). Women tended to prefer

CCF more than men by 4% (Table 1, t = -3.226, p = 0.001), regardless of being an owner or a professional (Table 1).

The nudge had opposite effects among the two types of stakeholders: While the professionals provided more negative feedback as the nudging in favour of CCF increased, the forest owners' opinion became more positive (Fig. 1, Table 1). Our results also indicate that age had an effect on the nudge process. The stance on CCF shifted with age, although in a different manner than between stakeholder type. Older forest professionals were more critical towards CCF than younger professionals, whereas old forest owners tended to be more positive about CCF than young owners (Fig. 1, Table 1).

Table 1. *F*-tests on whether the added variables or interactions significantly reduced the residual sum of squares in the model. In bold: the variables or interactions that contributed significantly to explaining the variance in the data.

Model term	*df*	*Sum of Squares*	*Mean Square*	*F*	*p-value*
Nudge	2	0,180	0,090	0,639	0,277
Stakeholder	**1**	**55,722**	**55,722**	**395,883**	**< 0,001**
Gender	**1**	**0,767**	**0,767**	**47,917**	**< 0,001**
Age	1	0,021	0,021	0,101	0,488
Knowledge	**1**	**0,764**	**0,764**	**54,562**	**< 0,001**
Knowledge bias	**1**	**0,628**	**0,628**	**33,139**	**< 0,001**
Stakeholder : Gender	1	0,075	0,075	0,372	0,323
Stakeholder : Age	**1**	**0,533**	**0,533**	**0,524**	**0,020**
Stakeholder : Knowledge	1	0,020	0,020	0,100	0,489
Stakeholder : Knowledge bias	1	0,124	0,124	0,233	0,180
Knowledge : Knowledge bias	1	0,257	0,257	0,520	0,073
Nudge : Stakeholder	**2**	**0,354**	**0,503**	**1,035**	**< 0,001**
Nudge : Gender	2	0,042	0,021	0,103	0,599
Nudge : Age	2	0,156	0,078	0,556	0,312
Nudge : Knowledge	2	0,349	0,174	0,588	0,117
Nudge : Knowledge bias	2	0,397	0,199	2,033	0,091
Stakeholder : Knowledge : Knowledge bias	1	0,043	0,043	0,212	0,403
Nudge : Stakeholder : Gender	2	0,421	0,210	0,190	0,081
Nudge : Stakeholder : Age	**2**	**0,641**	**0,320**	**0,317**	**0,038**
Nudge : Stakeholder : Knowledge	2	0,106	0,076	0,374	0,406
Nudge : Stakeholder : Knowledge bias	2	0,182	0,091	0,645	0,274
Nudge : Knowledge : Knowledge bias	**2**	**0,287**	**0,469**	**0,726**	**0,008**
Nudge : Stakeholder : Knowledge : Knowledge bias	2	0,144	0,072	0,510	0,333
Residuals	2771	390.027	0,097		

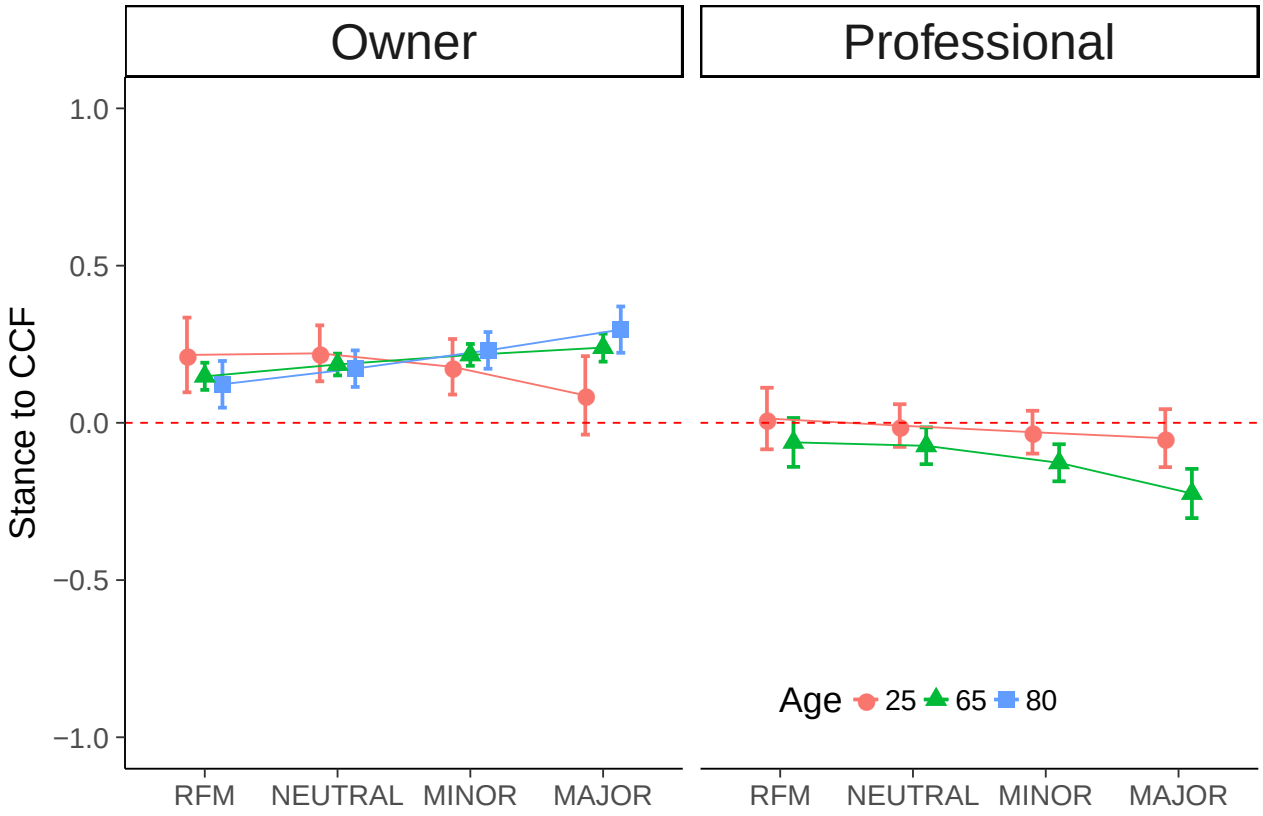

Figure 1. Estimated stance on CFF (95% confidence intervals) by forest owners (left) and professionals (right) after reading one of the four nudged texts, and according to their age and the nudged text that they read. Note that there were no 80-year old respondents among professionals.

Respondents with high self-reported knowledge on forest issues were more critical about CCF than people reporting low general knowledge (Fig. 2, Table 1). Respondents with knowledge biased toward forest economics (or forest management) were more negative about CCF as compared to those respondents whose knowledge was biased towards forest ecology (Fig. 2, Table 1). The reaction to the nudge with the two knowledge variables was significant, good knowledge respondents being more negative towards CCF as the nudge increased towards CCF, and vice-versa for knowledgeable respondents biased towards ecological issues (Fig. 2, Table 1). Respondents that reported to know little typically had opposite reaction to the nudge than respondents in the same bias category (Fig. 2, Table 1). The interaction of knowledge variables and the nudge with stakeholder was not significant (Table 1)

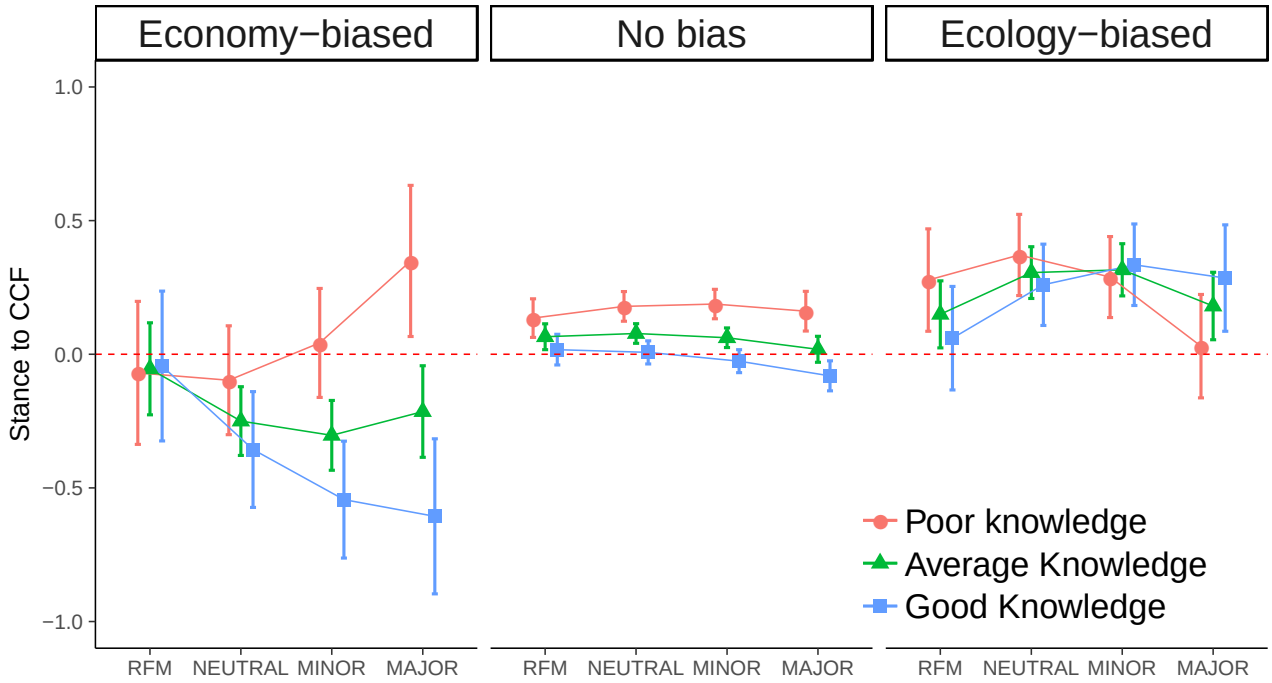

Figure 2. Estimated stance on CFF (95% confidence intervals) in relation to general level of knowledge reported and to the bias of knowledge towards forest economy knowledge (left) or towards forest ecology knowledge (right) and by the nudged text that they read. For the sake of illustration, we sliced the bi-dimensional space of knowledge: "average knowledge" and "no bias" are the central values of the first and second components in the PCA, respectively. "Poor knowledge" and "economy-biased" correspond to the lowest 10th percentile of the corresponding PCA component, "while good knowledge" and "ecology-based" correspond to the upper 10th percentile.

6. Discussion

Our results show that forest professionals and owners reacted to CCF-nudged text in opposite ways. Forest professionals generally reacted negatively to the text whereas forest owners accepted the CCF frame. Whilst this demonstrates that metaphorical nudging can have an influence on stakeholder perceptions, there is no straightforward path: simply changing the emphasis on a policy text towards CCF is not the same thing as making the text more palatable.

From our results, we contend that exploring the elements that induce cognitive dissonance in linguistic nudging is important in understanding how the acceptance of an informational intervention can be increased. To a large extent, our findings support the hypotheses set down in section 2.2. First, a significant segment of the professionals seems to reject the CCF frame by downplaying the information that CCF may be sometimes better than RFM in terms of environmental and cultural values. Hence, it could be argued that forest professionals reduce the importance of the belief that is causing dissonance (in this case the CCF frame). Second, forest owners generally adhere to their social and cultural perceptions of forest-based ES and emotional attachments to forest land to make the CCF frame more appealing. They can be seen as adding more cognitive elements to support the ecological argument put forward in the CCF nudge.

Nevertheless, and importantly, our findings also provide more specificity than what our hypotheses presumed. Age is a determining factor that affects the acceptance of the message, although in opposite

ways for the two groups. Older professionals and young owners were more critical towards the nudged CCF text than young professionals and older owners. While the average young professional was not affected by the nudge, the older professionals clearly reacted negatively to the pro-CCF nudge. In this context, it might be counterproductive to expose forest professionals to pro-CCF texts if one aims to increase the implementation of CCF in the short term. With regards to owners, it could be that young owners are under more pressure than older owners to obtaining economic profit from forests and therefore are more critical about CCF (as most information they get likely discourages CCF). In addition, younger owners are more likely to have been more recently exposed to the RFM view than older owners, for example, as part of training they may have received. Old professionals might be more imprinted with the idea of CCF having a negative effect on the benefits they get from forests than young professionals, and therefore react more (negatively) to the nudge.

Furthermore, our results highlight that it is important to consider how previous knowledge and the core values of the audience are linked to the substance of what is presented. For example, when one targets a forest stakeholder with high self-reported knowledge, the pro-CCF nudged text appears to be accepted only when the metaphorical emphasis is aligned with the core values of the nudged. Stakeholders' prior knowledge of different forest management practices also seems to contribute to the cognitive dissonance reduction strategies adopted by the individuals. Both owners and professionals with high self-reported knowledge reacted more critically to CCF than those reporting low general knowledge. However, we find that the way in which this knowledge is tied to priorities towards forest management steers the nudging effect. When high knowledge of forest aspects was combined with a reported knowledge bias towards forest management and economics, the acceptance of the CCF frame decreased. The pro-CCF frame therefore appears to have created a state of dissonance in the targets with economic values, and holding on to their espoused beliefs has led them to downplay the importance of the information on ecological arguments for CCF. In comparison, those respondents who had high knowledge about forest aspects but reportedly mastering forest ecology better than economics, were less negative about the CCF frame. For these respondents, the dissonance created by the nudge intervention seems to be reduced by adhering to their existing preferences towards ecological and cultural ES.

These findings have interesting repercussions for the Finnish context. As our results highlight that professionals remained significantly more antagonistic towards CCF than owners, a pro-CCF framing in informational nudging is likely to have an effect among the owner group. The design of such informational instruments should however take into account that currently over half of the private owners represent the older generation. In the coming decades the owner distributions are expected to go through a generational change (Hujala et al., 2007). This shift is likely to directly influence the prevailing attitudes and perceptions among owners in the country. The new owners are not only younger, with potentially different priorities regarding forest-based ES, but they are also likely to have less experience or personal history with forests. They are likely to closely consult forest professionals about different alternatives for management plans and practices (Hänninen et al., 2011; Rämö et al., 2009). If, as our study suggests, the younger owners are also more critical towards a pro-CCF policy text, the professionals' influence on them may become crucial for the promotion of sustainability.

We acknowledge that our focus has been on attitudinal and not behavioural change. The advantage of this approach is that attitudinal reactions to different policy texts enhance our understanding of the effectiveness of informational nudging, and subsequently of its use as a communicational policy instrument. However, empirical applications of dissonance theory have generally found that people are more likely to alter their cognitions than their behaviour – *i.e.* that behaviour determines attitudes (Festinger, 1957; Tavris and Aronson, 2007). Another limitation of this approach is that it may also be difficult to estimate the length of a favourable nudging effect: if a forest stakeholder is nudged towards sustainability, will the attitude remain changed over time? Despite these limitations, we argue that targeting attitude change with informational nudging remains relevant for environmental policy and communication. If we consider that instead of a linear value-action model, attitude and behaviour change operate within a self-reinforcing circle, in which attitude modifies action and vice versa (Kaaronen, 2017), we can see informational nudging as one way of contributing to the multiple processes that eventually lead to pro-environmental behaviour. Moreover, cognitively-grounded research on environmental policy has highlighted that effective communication of pro-ecological knowledge requires the reinforcement and repetition of statements and the values underlying them 'across a wide range of issue areas' (Antal and Hukkinen, 2010). In other words, for new information to have effect, it must be repeated multiple times and in different arenas. Thus, even if the actual duration of a metaphorical nudging effect is likely to vary, it can contribute to a more consistent communication of sustainable practices.

7. Conclusions

The perceptions of forest owners and forestry professionals of forest-based ES have important ramifications for sustainability (Asah et al., 2014). This has mainly to do with the reciprocal links between perception of ES and forest management objectives: forest owners' management decisions are often aligned with their attitudes, values and motivations related to forest-based services. However, appropriate policy mechanisms for incorporating stakeholder perceptions of ES in decision-making are still lacking (Poppenborg and Koellner, 2013). This paper contributes to narrowing this gap by providing insight into the possibilities of utilising linguistic nudging in forest management policy.

Our findings about nudging forest stakeholders' perceptions towards sustainability support the use of metaphorical modification in informational interventions. We have shown that modifying a policy text targeted to stakeholders in forest management can concretely incorporate considerations of ES into decision-making on future forest management practices. When they possess sufficient knowledge of forest owners' age, expertise and personal motivations, policy makers can use linguistic nudging as a complementary tool in their policy instrument mix – and potentially alter forest owners' perceptions and eventually their attitudes.

At the same time, such policy interventions need to be conducted with prudence over the message. To achieve concrete changes in forest management practices with linguistic nudging, it is important to consider how the targets 'tick' metaphorically. In the Finnish case, the results show that age and type and degree of knowledge were determining variables in the nudge. In general, the contrary

reactions of the stakeholder groups to the nudge highlights the challenges of using one-fits-all policy instruments to make policies more palatable.

Finally, this study complements earlier social-psychological and cognitive scientific work on nudging and other unconscious dimensions of human behaviour. A more fundamental understanding of linguistic nudging effects is needed for at least two reasons. First, since nudging is an inevitable fact of all environmental governance, better analytical capabilities are needed to open up conscious and unconscious influences to public scrutiny (Hukkinen, 2016). Second, nudging devices are often introduced as if they were more or less universally applicable – or at least the boundaries of their applicability are often not articulated. It is important to consider the extent to which nudges can be incorporated into a policy-mix without constraining the set of choice options (Thaler and Sunstein, 2008). As our work has shown, theoretically grounded research has the potential to identify the specific situations in which linguistic nudging might work.

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Appendix A: The four nudges

1 RFM

Even- or unevenaged forestry. The starting points for choosing forestry management are the aims of the foresters and the preconditions given by the site type and the existing trees. Changing from even-aged stands to unevenaged stands usually requires a long transition phase. In contrast, an uneven-aged stand can be turned into an even-aged one quickly with regeneration felling and subsequent regeneration duties. With even-aged forestry, you can distinguish between the regeneration and growth phases. With continuous-cover forestry, the forest remains mainly covered. Forest regeneration is usually based singularly on naturally grown undergrowth and the further development of this. For even-aged forestry, there are established and well-researched silvicultural and felling methods, of which there is also practical experience. Knowledge of methods pertaining to uneven-aged forestry still rest on a narrow research base and there is relatively little long-term experience.

Economic effects. Even-aged forestry presupposes investments into the regeneration of forests, especially if the area is regenerated artificially. Income focuses on regeneration felling. With uneven-aged forest management, the aim is mainly to harvest logs. In even-aged forestry, regeneration and tending of seedling stands are a significant cost. With uneven-aged forestry, the regeneration of forests when successful does not imply costs and the need for tending of seedling stands is smaller. With even-aged forestry, you can collect logging residues and stumps for energy wood from regeneration felling.

Environmental and multifunctionality effects. In even-aged forestry, the cultivated forest area forms a mosaic of forest stands. Different forest stands in different developmental stages provide different habitats, the diversity of which are promoted by nature management. The variability of uneven-aged forests is beneficial for biodiversity, but does not in itself guarantee the preservation or formation of structural features.

Damage risks. With the selection cutting of uneven-aged tree stands the risk for harvesting damage is especially high, when large trees are picked out among smaller trees which are left to grow. The risks for damage from moose, voles and wind depend on forest management practies and local conditions for both even- and uneven-aged tree stands. There are possibly differences between the two differing forest management practices when it comes to these kinds of risk, but there is little proven knowledge on the topic. In even-aged forests the risk for root-rot is smaller.

2 NEUTRAL

Even- or unevenaged forestry. The starting points for choosing forestry management are the aims of the foresters and the preconditions given by the place of growht and the existing tree stands. Changing from even-aged stands to unevenaged stands usually requires a long transition phase. In contrast, an uneven-aged stand can be turned into an even-aged on quickly with regeneration felling and subsequent regeneration measures. Current growth models show that both can be economically profitable. With even-aged forestry, you can distinguish between the regeneration and growth phases. With continuous-cover forestry, the forest remains mainly covered. Forest regeneration is usually based singularly on naturally grown undergrowth and the further development of this. For even-aged forestry, there are established and well-researched silvicultural and felling methods, of which there is also practical experience. Internationally there is much knowledge on uneven-aged forestry, and also in Finland there are experts on continuous-cover forestry.

Economic effects. Even-aged forestry presupposes investments into the regeneration of forests. Income focuses on regeneration felling. With even-aged forestry, you can collect logging residue and stumps for energy for forest energy wood from regeneration felling. With uneven-aged forest management, the aim is mainly to harvest timber, which is far more valuable than forest energy wood. In even-aged forestry, regeneration and tending of seedling stands are a significant cost. In uneven-aged forestry forest regeneration usually does not imply costs.

Environmental and multifunctionality effects. In even-aged forestry, the cultivated forest area forms a mosaic of forest compartments. Different forest compartments in different developmental stages provide different habitats, the diversity of which are promoted by nature care. It is probable that a combination of uneven- and even-aged forestry management produces the greatest benefits for biodiversity.

Damage risks. In both even- and uneven-aged forestry, there are risks of harvesting damage from fellings. The risks for damage from moose, voles and wind depend on forest management practies and local conditions for both even- and uneven-aged tree stands. There are possibly differences between the two differing forest management practices when it comes to these kinds of risk, but there is little tested knowledge on the topic. With uneven-aged forestry the risk for root-rot can be lessened with winter fellings, becayse snow and ice protect the trees left standing.

3 MINOR

Even- or unevenaged forestry. The starting points for choosing forestry management are the aims of the foresters and the preconditions given by the place of growht and the existing tree stands. Changing from even-aged stands to unevenaged stands usually requires a long transition phase. In contrast, an uneven-aged stand can be turned into an even-aged on quickly with regeneration felling and subsequent regeneration measures. Current growth models show that both can be economically profitable. With even-aged forestry, you can distinguish between the regeneration and growth phases. With continuous-cover forestry, the forest remains mainly covered. Forest regeneration is usually based singularly on naturally grown undergrowth and the further development of this. For even-aged forestry, there are established and well-researched silvicultural and felling methods, of which there is also practical experience. Internationally there is much knowledge on uneven-aged forestry, and also in Finland there are experts on continuous-cover forestry.

Economic effects. Even-aged forestry presupposes investments into the regeneration of forests Income focuses on regeneration felling. With even-aged forestry, you can collect logging residue and stumps for energy for forest energy wood from regeneration felling. With uneven-aged forest management, the aim is mainly to harvest timber, wherefore income flows are significantly higher than in the case of e.g. harvesting of energy wood. In even-aged forestry, regeneration and tending to seedling stands cause significant cost flows. In uneven-aged forestry forest regeneration usually does not imply costs. The saved cost is freed for other use. In even-aged forestry regeneration fellings give rise to small income flows by harvesting logging residue and stumps into energy wood.

Environmental and multifunctionality effects. In even-aged forestry, the cultivated forest area forms a mosaic of forest compartments. Different forest compartments in different developmental stages provide different habitats, the diversity of which are promoted by nature care. It is probable that a combination of uneven- and even-aged forestry management produces the greatest benefits for biodiversity.

Damage risks. In light of recent Finnish research, forest management practices impacts the risk of wind damage. Uneven-aged forests have been observed to lessen the risk for wind damage. With uneven-aged forestry the risk for root-rot can be lessened with winter fellings, becayse snow and ice protect the trees left standing.Root-rot also does not spread under temperatures below zero.

4 MAJOR

Even- or unevenaged forestry. The starting points for choosing forestry management are the aims of the foresters and the preconditions given by the place of growht and the existing tree stands. Changing from even-aged stands to unevenaged stands usually requires a long transition phase. In contrast, an uneven-aged stand can be turned into an even-aged on quickly with regeneration felling and subsequent regeneration measures. Current growth models show that both can be economically profitable. With even-aged forestry, you can distinguish between the regeneration and growth phases. With continuous-cover forestry, the forest remains mainly covered. Forest regeneration is usually based singularly on naturally grown undergrowth and the further development of this. For even-aged forestry, there are established and well-researched silvicultural and felling methods, of which there is also practical experience. Internationally there is much knowledge on uneven-aged forestry, and also in Finland there are experts on continuous-cover forestry.

Economic effects. Even-aged forestry presupposes investments into the regeneration of forests Income focuses on regeneration felling. With even-aged forestry, you can collect logging residue and stumps for energy for forest energy wood from regeneration felling. With uneven-aged forest management, the aim is mainly to harvest timber, wherefore income flows are significantly higher than in the case of e.g. harvesting of energy wood. In even-aged forestry, regeneration and tending to seedling stands cause significant cost flows. In uneven-aged forestry forest regeneration usually does not imply costs. The saved cost is freed for other use. In even-aged forestry regeneration fellings give rise to small income flows by harvesting logging residue and stumps into energy wood.

Environmental and multifunctionality effects. In even-aged forestry, the cultivated forest area forms a mosaic of forest compartments. Different forest compartments in different developmental stages provide different habitats, the diversity of which are promoted by nature careAn area with uneven-aged forest compartments enables a more unified end dense network of forest habitats, which according to modern research is beneficial for biodiversity. Uneven-aged forestry brings with it environmental and multifunctionality benefits also when combined with traditional even-aged forestry. The more rich forest in terms of biodiversity, the more numerous are also the health benefits provided to humans.

Damage risks. In light of recent Finnish research, forest management practices impacts the risk of wind damage. With uneven-aged forestry the risk for root-rot can be lessened with winter fellings, becayse snow and ice protect the trees left standing. Root-rot also does not spread under temperatures below zero.

Appendix B: Comparision between the four nudges

Below, we present the translations of the four nudges and their original Finnish versions (in brackets).

Reading instructions

GREY HIGHLIGHT: indicates that an information change has been made.

~~STRIKE THROUGH~~: indicates that a removal has been made.

GREY HIGHLIGHT IN BOLD: indicates that a linguistic nudge has been made.

1 RFM

EN-RFM1. Even- or unevenaged forestry. The starting points for choosing forestry management are the aims of the foresters and the preconditions given by the site type and the existing trees. Changing from even-aged stands to unevenaged stands usually requires a long transition phase. In contrast, an uneven-aged stand can be turned into an even-aged one quickly with regeneration felling and subsequent regeneration duties. With even-aged forestry, you can distinguish between the regeneration and growth phases. With continuous-cover forestry, the forest remains mainly covered. Forest regeneration is usually based singularly on naturally grown undergrowth and the further development of this. For even-aged forestry, there are established and well-researched silvicultural and felling methods, of which there is also practical experience. Knowledge of methods pertaining to uneven-aged forestry still rest on a narrow research base and there is relatively little long-term experience.

(RFM1. Kasvatus tasa- tai eri-ikäisrakenteisena. Kasvatustavan valinnan lähtökohtana ovat metsänomistajan tavoitteet sekä kasvupaikan ja olemassa olevan puuston luomat edellytykset. Tasaikäisrakenteisen metsän kehittäminen eri-ikäisrakenteiseksi vaatii useimmiten pitkän siirtymävaiheen. Eri-ikäisrakenteinen metsä voidaan sen sijaan muuttaa nopeasti tasaikäisrakenteiseksi uudistushakkuulla ja sen jälkeisillä uudistamistöillä. Tasaikäisrakenteisen metsän kasvatuksessa on erotettavissa metsiköiden uudistamis- ja kasvatusvaihe. Eri-ikäisrakenteisena kasvatettaessa metsä säilyy pääosin peitteisenä. Metsän uudistuminen perustuu yleensä yksinomaan luontaisesti syntyneeseen alikasvokseen ja sen jatkokehittämiseen. Tasaikäisrakenteisen metsän kasvatuksessa käytettävissä ovat vakiintuneet ja hyvin tutkitut hoito- ja hakkuumenetelmät, joista on myös käytännön kokemusta. Tiedot eri-ikäisrakenteisen metsän kasvatuksessa käytettävistä menetelmistä ovat vielä kapean tutkimustiedon varassa ja pitkäaikaiset kokemukset ovat suhteellisen vähäiset.)

EN-RFM2. Economic effects. Even-aged forestry presupposes investments into the regeneration of forests, especially if the area is regenerated artificially. Income focuses on regeneration felling. With uneven-aged forest management, the aim is mainly to harvest logs. In even-aged forestry, regeneration and tending of seedling stands are a significant cost. With uneven-aged forestry, the regeneration of forests when successful does not imply costs and the need for tending of seedling stands is smaller. With even-aged forestry, you can collect logging residues and stumps for energy wood from regeneration felling.

(RFM2. Talousvaikutuksia. Tasaikäiskasvatus edellyttää investointeja metsän uudistamiseen erityisesti, jos alue uudistetaan viljellen. Tulot painottuvat uudistushakkuuseen. Eri-ikäiskasvatuksessa tavoitteena on korjata hakkuissa pääasiassa tukkipuuta. Tasaikäiskasvatuksessa uudistaminen ja taimikonhoito ovat merkittävä kustannuserä. Eri-ikäisrakenteisen metsän kasvatuksessa metsän uudistaminen ei onnistuessaan aiheuta kustannuksia ja tarve taimikonhoidolle on vähäisempi. Tasaikäisrakenteisen metsän uudistushakkuualoilta voidaan korjata hakkuutähdettä ja kantoja energiapuuksi.)

EN-RFM3. Environmental and multifunctionality effects. In even-aged forestry, the cultivated forest area forms a mosaic of forest stands. Different forest stands in different developmental stages provide different habitats, the diversity of which are promoted by nature management. The variability of uneven-aged forests is beneficial for biodiversity, but does not in itself guarantee the preservation or formation of structural features.

(RFM3. Ympäristö- ja monikäyttövaikutuksia. Tasaikäisrakenteisena kasvatettava metsäalue muodostaa metsikkökuvioiden mosaiikin. Eri kehitysvaiheissa olevat metsikkökuviot tarjoavat toisistaan poikkeavia elinympäristöjä, joiden monipuolisuutta edistetään luonnonhoidolla. Eri-ikäisrakenteiseen metsään liittyvä vaihtelevuus on eduksi luonnon monimuotoisuudelle, mutta se ei sinällään vielä takaa rakennepiirteiden säilymistä tai muodostumista.)

EN-RFM4. Damage risks. With the selection cutting of uneven-aged tree stands the risk for harvesting damage is especially high, when large trees are picked out among smaller trees which are left to grow. The risks for damage from moose, voles and wind depend on forest management practies and local conditions for both even- and uneven-aged tree stands. There are possibly differences between the two differing forest management practices when it comes to these kinds of risk, but there is little proven knowledge on the topic. In even-aged forests the risk for root-rot is smaller.

(RFM4. Tuhoriskit. Eri-ikäisrakenteisen puuston poimintahakkuussa korjuuvaurioiden riski on erityisen suuri, kun suuria puita poimitaan kasvamaan jätettävien pienempien puiden seasta. Tasa- ja eri-ikäisrakenteisen puuston hirvi-, myyrä- ja tuulituhoriskit vaihtelevat puuston käsittelystä ja paikallisista oloista riippuen. Kasvatusmenetelmien välillä on mahdollisesti eroja näiden tuhojen riskissä, mutta todennettua tietoa tästä on niukasti. Tasaikäismetsässä juurikäävän riski on pienempi.)

2 NEUTRAL

EN-NEU1. ***Even- or unevenaged forestry***. The starting points for choosing forestry management are the aims of the foresters and the preconditions given by the place of growht and the existing tree stands. Changing from even-aged stands to unevenaged stands usually requires a long transition phase. In contrast, an uneven-aged stand can be turned into an even-aged on quickly with regeneration felling and subsequent regeneration measures. ADDED: Current growth models show that both can be economically profitable. With even-aged forestry, you can distinguish between the regeneration and growth phases. With continuous-cover forestry, the forest remains mainly covered. Forest regeneration is usually based singularly on naturally grown undergrowth and the further development of this. For even-aged forestry, there are established and well-researched silvicultural and felling methods, of which there is also practical experience. ADDED: Internationally there is much knowledge on uneven-aged forestry, and also in Finland there are experts on continuous-cover forestry. ~~REMOVED: Knowledge of methods pertaining to uneven-aged forestry still rest on a narrow research base and there is relatively little long-term experience.~~

(NEU1. Kasvatus tasa- tai eri-ikäisrakenteisena. Kasvatustavan valinnan lähtökohtana ovat metsänomistajan tavoitteet sekä kasvupaikan ja olemassa olevan puuston luomat edellytykset. Tasaikäisrakenteisen metsän kehittäminen eri-ikäisrakenteiseksi vaatii useimmiten pitkän siirtymävaiheen. Eri-ikäisrakenteinen metsä voidaan sen sijaan muuttaa nopeasti tasaikäisrakenteiseksi uudistushakkuulla ja sen jälkeisillä uudistamistöillä. Nykyiset kasvumallit osoittavat, että molemmat voivat olla taloudellisesti kannattavia. Tasaikäisrakenteisen metsän kasvatuksessa on erotettavissa metsiköiden uudistamis- ja kasvatusvaihe. Eri-ikäisrakenteisena kasvatettaessa metsä säilyy pääosin peitteisenä. Metsän uudistuminen perustuu yleensä yksinomaan luontaisesti syntyneeseen alikasvokseen ja sen jatkokehittämiseen. Tasaikäisrakenteisen metsän kasvatuksessa käytettävissä ovat vakiintuneet ja hyvin tutkitut hoito- ja hakkuumenetelmät, joista on myös käytännön kokemusta. Eri-ikäisrakenteisen metsän kasvatuksesta on kansainvälisesti paljon tietoa ja Suomessakin löytyy jo jatkuvan kasvatuksen osaavia toimijoita.**)**

EN-NEU2. Economic effects. Even-aged forestry presupposes investments into the regeneration of forests ~~REMOVED:, especially if the area is grown artificially.~~ Income focuses on regeneration felling. ~~REMOVED: With uneven-aged forest management, the aim is mainly to harvest logs. In even-aged forestry, regeneration and tending of seedling stands are a significant cost. With uneven-aged forestry, the regeneration of forests when successful does not imply costs and the need for tending of seedling stands is smaller. With~~ even-aged forestry, you can collect logging residue and stumps for energy for forest energy wood from regeneration felling. ADDED: With uneven-aged forest management, the aim is mainly to harvest logs, which is far more valuable than forest energy wood. In even-aged forestry, regeneration and tending of seedling stands are a significant cost. ADDED: In uneven-aged forestry forest regeneration usually does not imply costs.

(NEU2. Talousvaikutuksia. Tasaikäiskasvatus edellyttää investointeja metsän uudistamiseen. Tulot painottuvat uudistushakkuuseen. Tasaikäisrakenteisen metsän uudistushakkuualoilta voidaan korjata hakkuutähdettä ja kantoja energiapuuksi. Eri-ikäiskasvatuksessa tavoitteena on korjata hakkuissa pääasiassa tukkipuuta, joka on paljon arvokkaampaa kuin energiapuu. Tasaikäiskasvatuksessa uudistaminen ja taimikonhoito ovat merkittävä kustannuserä. Eri-ikäisrakenteisen metsän kasvatuksessa metsän uudistaminen ei yleensä aiheuta kustannuksia. **)**

EN-NEU3. Environmental and multifunctionality effects. In even-aged forestry, the cultivated forest area forms a mosaic of forest compartments. Different forest compartments in different developmental stages provide different habitats, the diversity of which are promoted by nature care. ~~REMOVED: The variability of uneven-aged forests is beneficial for biodiversity, but does not in itself guarantee the preservation or formation of structural traits.~~ ADDED: It is probable that a combination of uneven- and even-aged forestry management produces the greatest benefits for biodiversity.

(NEU3. Ympäristö- ja monikäyttövaikutuksia. Tasaikäisrakenteisena kasvatettava metsäalue muodostaa metsikkökuvioiden mosaiikin. Eri kehitysvaiheissa olevat metsikkökuviot tarjoavat toisistaan poikkeavia elinympäristöjä, joiden monipuolisuutta edistetään luonnonhoidolla. Eri-ikäisrakenteiseen metsään liittyvä

vaihtelevuus on nykytutkimuksen mukaan eduksi luonnon monimuotoisuudelle. Yhdistelmä eri-ikäis- ja tasaikäisrakenteista kasvatusta tuottaa todennäköisimmin suurimmat hyödyt luonnon monimuotoisuudelle.)

EN-NEU4. Damage risks. ~~REMOVED: With the selection cutting of uneven-aged tree stands the risk for harvesting damage is especially high, when large trees are picked out among smaller trees which are left to grow.~~ ADDED: In both even- and uneven-aged forestry, there are risks of harvesting damage from fellings. The risks for damage from moose, voles and wind depend on forest management practies and local conditions for both even- and uneven-aged tree stands. There are possibly differences between the two differing forest management practices when it comes to these kinds of risk, but there is little tested knowledge on the topic. ~~REMOVED: In even-aged forests the risk for root-rot is smaller.~~ ADDED: With uneven-aged forestry the risk for root-rot can be lessened with winter fellings, because snow and ice protect the trees left standing.

(NEU4. Tuhoriskit. Sekä tasa- että eri-ikäisrakenteisen puuston poimintahakkuussa syntyy korjuuvaurioiden riski. Tasa- ja eri-ikäisrakenteisen puuston hirvi-, myyrä- ja tuulituhoriskit vaihtelevat puuston käsittelystä ja paikallisista oloista riippuen. Kasvatusmenetelmien välillä on mahdollisesti eroja näiden tuhojen riskissä, mutta todennettua tietoa tästä on niukasti. Eri-ikäisrakenteisen kasvatusmenetelmän osalta juurikäävän riskiä voidaan pienentää talvihakkuilla, sillä lumi ja jää suojaavat jäljellejääneitä puita.)

3 MINOR

EN-MIN1. Even- or unevenaged forestry. The starting points for choosing forestry management are the aims of the foresters and the preconditions given by the place of growht and the existing tree stands. Changing from even-aged stands to unevenaged stands usually requires a long transition phase. In contrast, an uneven-aged stand can be turned into an even-aged on quickly with regeneration felling and subsequent regeneration measures. ADDED: Current growth models show that both can be economically profitable. With even-aged forestry, you can distinguish between the regeneration and growth phases. With continuous-cover forestry, the forest remains mainly covered. Forest regeneration is usually based singularly on naturally grown undergrowth and the further development of this. For even-aged forestry, there are established and well-researched silvicultural and felling methods, of which there is also practical experience. ADDED: Internationally there is much knowledge on uneven-aged forestry, and also in Finland there are experts on continuous-cover forestry. ~~REMOVED: Knowledge of methods pertaining to uneven-aged forestry still rest on a narrow research base and there is relatively little long-term experience.~~

(MIN1. Kasvatus tasa- tai eri-ikäisrakenteisena. Kasvatustavan valinnan lähtökohtana ovat metsänomistajan tavoitteet sekä kasvupaikan ja olemassa olevan puuston luomat edellytykset. Tasaikäisrakenteisen metsän kehittäminen eri-ikäisrakenteiseksi vaatii useimmiten pitkän siirtymävaiheen. Eri-ikäisrakenteinen metsä voidaan sen sijaan muuttaa nopeasti tasaikäisrakenteiseksi uudistushakkuulla ja sen jälkeisillä uudistamistöillä. Nykyiset kasvumallit osoittavat, että molemmat voivat olla taloudellisesti kannattavia. Tasaikäisrakenteisen metsän kasvatuksessa on erotettavissa metsiköiden uudistamis- ja kasvatusvaihe. Eri-ikäisrakenteisena kasvatettaessa metsä säilyy pääosin peitteisenä. Metsän uudistuminen perustuu yleensä yksinomaan luontaisesti syntyneeseen alikasvokseen ja sen jatkokehittämiseen. Tasaikäisrakenteisen metsän kasvatuksessa käytettävissä ovat vakiintuneet ja hyvin tutkitut hoito- ja hakkuumenetelmät, joista on myös käytännön kokemusta. Eri-ikäisrakenteisen metsän kasvatuksesta on kansainvälisesti paljon tietoa ja Suomessakin löytyy jo jatkuvan kasvatuksen osaavia toimijoita.)

EN-MIN2. Economic effects. Even-aged forestry presupposes investments into the regeneration of forests ~~REMOVED:, especially if the area is grown artificially.~~ Income focuses on regeneration felling. ~~REMOVED: With uneven-aged forest management, the aim is mainly to harvest logs. In even-aged forestry, regeneration and tending of seedling stands are a significant cost. With uneven-aged forestry, the regeneration of forests when successful does not imply costs and the need for tending of seedling stands is smaller.~~ With even-aged forestry, you can collect logging residue and stumps for energy for forest energy wood from regeneration felling. ADDED: With uneven-aged forest management, the aim is mainly to harvest logs, ~~REMOVED: which is far more valuable than forest energy wood~~ **ADDED: wherefore income flows are significantly higher than in the case of e.g. harvesting of energy wood.** ~~REMOVED: In even-aged forestry, regeneration and tending of seedling stands are a significant cost.~~ **ADDED: In even-aged forestry, regeneration and tending to seedling stands cause significant cost flows.** ADDED: In uneven-aged forestry forest regeneration usually does not imply costs. **ADDED: The saved cost is freed for other use. ADDED: In even-aged forestry regeneration fellings give rise to small income flows by harvesting logging residue and stumps into energy wood.**

(MIN2. Talousvaikutuksia. Tasaikäiskasvatus edellyttää investointeja metsän uudistamiseen. Tulot painottuvat uudistushakkuuseen. Eri-ikäiskasvatuksessa tavoitteena on korjata hakkuissa pääasiassa tukkipuuta, mistä syystä tulovirrat ovat huomattavasti runsaammat kuin esim. energiapuun korjuussa. Tasaikäiskasvatuksessa uudistaminen ja taimikonhoito aiheuttavat merkittäviä menovirtoja. Eri-ikäisrakenteisen metsän kasvatuksessa metsän uudistaminen ei yleensä aiheuta menovirtoja. Säästetty kustannus vapautuu muuhun käyttöön. Tasaikäisrakenteisen metsän uudistushakkuualoilta saadaan pieniä tulovirtoja korjaamalla hakkuutähdettä ja kantoja energiapuuksi.)

EN-MIN3. Environmental and multifunctionality effects. In even-aged forestry, the cultivated forest area forms a mosaic of forest compartments. Different forest compartments in different developmental stages provide different habitats, the diversity of which are promoted by nature care. ~~REMOVED: The variability of uneven-aged forests is beneficial for biodiversity, but does not in itself guarantee the preservation or formation of structural traits.~~ ADDED: It is probable that a combination of uneven- and even-aged forestry management produces the greatest benefits for biodiversity.

(MIN3. Ympäristö- ja monikäyttövaikutuksia. Tasaikäisrakenteisena kasvatettava metsäalue muodostaa metsikkökuvioiden mosaiikin. Eri kehitysvaiheissa olevat metsikkökuviot tarjoavat toisistaan poikkeavia elinympäristöjä, joiden monipuolisuutta edistetään luonnonhoidolla. Eri-ikäisrakenteiseen metsään liittyvä vaihtelevuus on nykytutkimuksen mukaan eduksi luonnon monimuotoisuudelle. Yhdistelmä eri-ikäis- ja tasaikäisrakenteista kasvatusta tuottaa todennäköisimmin suurimmat hyödyt luonnon monimuotoisuudelle.)

EN-MIN4. Damage risks. ~~REMOVED: With the selection cutting of uneven-aged tree stands the risk for harvesting damage is especially high, when large trees are picked out among smaller trees which are left to grow.~~ ADDED: In light of recent Finnish research, forest management practices impacts the risk of wind damage. ~~REMOVED: In both even- and uneven-aged forestry, there are risks of harvesting damage from fellings. REMOVED: The risks for damage from moose, voles and wind depend on forest management practies and local conditions for both even- and uneven-aged tree stands. There are possibly differences between the two differing forest management practices when it comes to these kinds of risk, but there is little tested knowledge on the topic.~~ ADDED: Uneven-aged forests have been observed to lessen the risk for wind damage. ~~REMOVED: In even-aged forests the risk for root-rot is smaller.~~ ADDED: With uneven-aged forestry the risk for root-rot can be lessened with winter fellings, because snow and ice protect the trees left standing. ADDED: Root-rot also does not spread under temperatures below zero.

(MIN4. Tuhoriskit. Sekä tasa- että eri-ikäisrakenteisen puuston poimintahakkuussa syntyy korjuuvaurioiden riski. Tuoreen suomalaisen tutkimustiedon valossa metsän käsittely vaikuttaa tuulituhoriskiin. Eri-ikäisrakenteisen metsän on havaittu vähentävän tuulituhoriskiä. Eri-ikäisrakenteisen kasvatusmenetelmän osalta juurikäävän riskiä voidaan pienentää talvihakkuilla, sillä lumi ja jää suojaavat jäljellejääneitä puita. Juurikääpä ei myöskään leviä nollan asteen alapuolella.)

4 MAJOR

EN-MAJ1. Even- or unevenaged forestry. The starting points for choosing forestry management are the aims of the foresters and the preconditions given by the place of growht and the existing tree stands. Changing from even-aged stands to unevenaged stands usually requires a long transition phase. In contrast, an uneven-aged stand can be turned into an even-aged on quickly with regeneration felling and subsequent regeneration measures. ADDED: Current growth models show that both can be economically profitable. With even-aged forestry, you can distinguish between the regeneration and growth phases. With continuous-cover forestry, the forest remains mainly covered. Forest regeneration is usually based singularly on naturally grown undergrowth and the further development of this. For even-aged forestry, there are established and well-researched silvicultural and felling methods, of which there is also practical experience. ADDED: Internationally there is much knowledge on uneven-aged forestry, and also in Finland there are experts on continuous-cover forestry. ~~REMOVED: Knowledge of methods pertaining to uneven-aged forestry still rest on a narrow research base and there is relatively little long-term experience.~~

(MAJ1. Kasvatus tasa- tai eri-ikäisrakenteisena. Kasvatustavan valinnan lähtökohtana ovat metsänomistajan tavoitteet sekä kasvupaikan ja olemassa olevan puuston rakenteen luomat edellytykset. Tasaikäisrakenteisen metsän kehittäminen eri-ikäisrakenteiseksi vaatii useimmiten pitkän siirtymävaiheen. Eri-ikäisrakenteinen metsä voidaan sen sijaan muuttaa nopeasti tasaikäisrakenteiseksi uudistushakkuulla ja sen jälkeisillä uudistamistöillä. Nykyiset kasvumallit osoittavat, että molemmat voivat olla taloudellisesti kannattavia mutta useimmiten eri-ikäisrakenteinen kasvatus tuottaa metsänomistajalle suuremmat tulot. Tasaikäisrakenteisen metsän kasvatuksessa on erotettavissa metsiköiden uudistamis- ja kasvatusvaihe. Eri-ikäisrakenteisena kasvatettaessa metsä säilyy pääosin peitteisenä. Metsän uudistuminen perustuu luontaisesti syntyneeseen alikasvokseen ja sen jatkokehittämiseen. Tasaikäisrakenteisen metsän kasvatuksessa käytettävissä ovat vakiintuneet ja hyvin tutkitut hoito- ja hakkuumenetelmät, joista on myös käytännön kokemusta. Eri-ikäisrakenteisen metsän kasvatuksesta on kansainvälisesti paljon tietoa ja Suomessakin löytyy jo jatkuvan kasvatuksen osaavia toimijoita.)

EN-MAJ2. Economic effects. Even-aged forestry presupposes investments into the regeneration of forests ~~REMOVED:, especially if the area is grown artificially. Income~~ focuses on regeneration felling. ~~REMOVED: With uneven-aged forest management, the aim is mainly to harvest logs. In even-aged forestry, regeneration and tending of seedling stands are a significant cost. With uneven-aged forestry, the regeneration of forests when successful does not imply costs and the need for tending of seedling stands is smaller.~~ With even-aged forestry, you can collect logging residue and stumps for energy for forest energy wood from regeneration felling. ADDED: With uneven-aged forest management, the aim is mainly to harvest logs, ~~REMOVED: which is far more valuable than forest energy wood~~ **ADDED: wherefore income flows are significantly higher than in the case of e.g. harvesting of energy wood.** ~~REMOVED: In even-aged forestry, regeneration and tending of seedling stands are a significant cost.~~ ADDED: In even-aged forestry, regeneration and tending to seedling stands cause significant cost flows. ADDED: In uneven-aged forestry forest regeneration usually does not imply costs. **ADDED: The saved cost is freed for other use. ADDED: In even-aged forestry regeneration fellings give rise to small income flows by harvesting logging residue and stumps into energy wood.**

(MAJ2. Talousvaikutuksia. Tasaikäiskasvatus edellyttää investointeja metsän uudistamiseen. Tulot painottuvat uudistushakkuuseen. Eri-ikäiskasvatuksessa tavoitteena on korjata hakkuissa pääasiassa tukkipuuta, mistä syystä tulovirrat ovat huomattavasti runsaammat kuin esim. energiapuun korjuussa. Tasaikäiskasvatuksessa uudistaminen ja taimikonhoito aiheuttavat merkittäviä menovirtoja. Eri-ikäisrakenteisen metsän kasvatuksessa metsän uudistaminen ei aiheuta menovirtoja. Säästetty kustannus vapautuu muuhun käyttöön. Tasaikäisrakenteisen metsän uudistushakkuualoilta voidaan saada pieniä tulovirtoja korjaamalla hakkuutähdettä ja kantoja energiapuuksi.)

EN-MAJ3. Environmental and multifunctionality effects. In even-aged forestry, the cultivated forest area forms a mosaic of forest compartments. Different forest compartments in different developmental stages provide different habitats, the diversity of which are promoted by nature care. ~~REMOVED: The variability of uneven-aged forests is beneficial for biodiversity, but does not in itself guarantee the preservation or formation of structural traits. REMOVED: It is probable that a combination of uneven- and even-aged forestry management produces the greatest benefits for biodiversity.~~ **ADDED: An area with uneven-aged forest**

compartments enables a more unified end dense network of forest habitats, which according to modern research is beneficial for biodiversity. Uneven-aged forestry brings with it environmental and multifunctionality benefits also when combined with traditional even-aged forestry. The more rich forest in terms of biodiversity, the more numerous are also the health benefits provided to humans.

(MAJ3. Ympäristö- ja monikäyttövaikutuksia. Tasaikäisrakenteisena kasvatettava metsäalue muodostaa metsikkökuvioiden mosaiikin. Eri kehitysvaiheissa olevat metsikkökuviot tarjoavat toisistaan poikkeavia elinympäristöjä, joiden monipuolisuutta edistetään luonnonhoidolla. Eri-ikäisrakenteisten metsikkökuvioiden alue mahdollistaa yhtenäisemmän ja tiheämmän metsäisten elinympäristöjen verkoston, joka on nykytutkimuksen mukaan eduksi luonnon monimuotoisuudelle. Eri-ikäisrakenteisen metsän kasvatus tuo ympäristö- ja monikäyttöhyötyjä myös yhdistettynä perinteiseen tasaikäisrakenteiseen kasvatustapaan. Mitä monimuotoisuudeltaan rikkaampi metsä, sitä runsaammat ovat myös sen ihmiselle tarjoamat terveyshyödyt.)

EN-MAJ4. Damage risks. ~~REMOVED: With the selection cutting of uneven-aged tree stands the risk for harvesting damage is especially high, when large trees are picked out among smaller trees which are left to grow.~~ ADDED: In light of recent Finnish research, forest management practices impacts the risk of wind damage. ~~REMOVED: In both even- and uneven-aged forestry, there are risks of harvesting damage from fellings. REMOVED: The risks for damage from moose, voles and wind depend on forest management practies and local conditions for both even- and uneven-aged tree stands. There are possibly differences between the two differing forest management practices when it comes to these kinds of risk, but there is little tested knowledge on the topic.~~ ADDED: Uneven-aged forests have been observed to lessen the risk for wind damage. ~~REMOVED: In even-aged forests the risk for root-rot is smaller.~~ ADDED: With uneven-aged forestry the risk for root-rot can be lessened with winter fellings, because snow and ice protect the trees left standing. ADDED: Root-rot also does not spread under temperatures below zero.

(MAJ4. Tuhoriskit. Sekä tasa- että eri-ikäisrakenteisen puuston poimintahakkuussa syntyy korjuuvaurioiden riski. Tuoreen suomalaisen tutkimustiedon valossa metsän käsittely vaikuttaa tuulituhoriskiin. Eri-ikäisrakenteisen metsän on havaittu vähentävän tuulituhoriskiä. Eri-ikäisrakenteisen kasvatusmenetelmän osalta juurikäävän riskiä voidaan pienentää talvihakkuilla, sillä lumi ja jää suojaavat jäljellejääneitä puita. Juurikääpä ei myöskään leviä nollan asteen alapuolella.)

Appendix C: Design of nudges

In the design of our four different versions of the same extract from the Tapio guidelines, we changed both the informational content and the wording of the texts. We did this in a logical and consecutive order and in a way that does not confuse the two. Here is a detailed explanation of the process:

First, we abbreviated the existing text comparing even-aged and uneven-aged forestry, keeping both the content and the wordings (this is the RFM). Then, in close collaboration with experts on uneven-aged forestry, we changed the informational content of this original text to place the two forestry management practices on a par (this became the NEUTRAL; the RFM was informationally biased towards even-aged management).

However, only after having made these informational changes did we proceed with the nudge in the second sense mentioned, that is, only changing the wording but not the contents of the text. In the third and next version of the NEUTRAL – that is, the MINOR – we changed the wordings pertaining to economic aspects of the two forestry management practices so that they emphasize ”flows”. The relevant extracts for NEUTRAL and MINOR are as follows (with the modified sentences highlighted in **bold**):

EN-NEU2: ADDED: With uneven-aged forest management, the aim is mainly to harvest logs, which is far more valuable than forest energy wood. In even-aged forestry, regeneration and tending of seedling stands are a significant cost. ADDED: In uneven-aged forestry forest regeneration usually does not imply costs.

EN-MIN2: ADDED: With uneven-aged forest management, the aim is mainly to harvest logs, ~~REMOVED: which is far more valuable than forest energy wood~~ **ADDED: wherefore income flows are significantly higher than in the case of e.g. harvesting of energy wood.** ~~REMOVED: In even-aged forestry, regeneration and tending of seedling stands are a significant cost.~~ **ADDED: In even-aged forestry, regeneration and tending to seedling stands cause significant cost flows.** ADDED: In uneven-aged forestry forest regeneration usually does not imply costs. **ADDED: The saved cost is freed for other use. ADDED: In even-aged forestry regeneration fellings give rise to small income flows by harvesting logging residue and stumps into energy wood.**

Finally, to this MINOR text we added – in the fourth and final MAJOR text – the following modification (**bolded**):

EN-MIN3: ***Environmental and multifunctionality effects***. In even-aged forestry, the cultivated forest area forms a mosaic of forest compartments. Different forest compartments in different developmental stages provide different habitats, the diversity of which are promoted by nature care. ~~REMOVED: The variability of uneven-aged forests is beneficial for biodiversity, but does not in itself guarantee the preservation or formation of structural traits.~~ ADDED: It is probable that a combination of uneven- and even-aged forestry management produces the greatest benefits for biodiversity.

EN-MAJ3. Environmental and multifunctionality effects. In even-aged forestry, the cultivated forest area forms a mosaic of forest compartments. Different forest compartments in different developmental stages provide different habitats, the diversity of which are promoted by nature care. ~~REMOVED: The variability of uneven-aged forests is beneficial for biodiversity, but does not in itself guarantee the preservation or formation of structural traits. REMOVED: It is probable that a combination of uneven- and even-aged forestry management produces the greatest benefits for biodiversity.~~ **ADDED: An area with uneven-aged forest compartments enables a more unified end dense network of forest habitats, which according to modern research is beneficial for biodiversity. Uneven-aged forestry brings with it environmental and multifunctionality benefits also when combined with traditional even-aged forestry.**

The more rich forest in terms of biodiversity, the more numerous are also the health benefits provided to humans.

In sum, thus, RFM and NEUTRAL are on a par (with informational changes) and MINOR and MAJOR are on a par (with linguistic nudge changes). With this strategy, we achieved a way of testing for both the change in informational contents only as well as, additionally, for effects of linguistic nudging.