Accepted Manuscript

Title: Of bugs and men: How forest pests and their
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Authors: Martin Gutsch, Neele Larondelle, Dagmar Haase

Please cite this article as: Gutsch M, Larondelle N, Haase D, Of bugs and
men: How forest pests and their management strategies are perceived by
visitors of an urban forest, *Urban Forestry and amp; Urban Greening* (2019),
https://doi.org/10.1016/j.ufug.2019.03.003

Of bugs and men: How forest pests and their management strategies are perceived by visitors of an urban forest

Martin Gutsch[2], Neele Larondelle[1] & Dagmar Haase[1,3]

[1]Institute of Geography, Humboldt University Berlin, Germany

[2]Potsdam Institute for Climate Impact Research, Germany

[3]Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Abstract

Larger forest patches in urban areas are highly valuable recreation sites that provide the urban population with various ecosystem services. Yet they are highly vulnerable to biological pests, especially in the light of climate change. The growing need to intervene against forest pests needs to be clearly but carefully communicated to the urban forest visitors in order to minimize conflicts. In this paper, a survey with 554 complete responses, conducted in the forest district of the "Teufelssee" in south-east Berlin, Germany, sheds first light on visitors' perceptions of biological pests and their management. Results of Chi square statistics and a series of Logit models indicate a clear predisposition against pesticide or biocide interventions, while at the same time, showing remarkable positive tendencies towards mechanical interventions or measures taken on the individual-tree level. There are positive correlations between the age and the knowledge about pests (Kendall-Tau-b τ_B=0.165) and between the age and the knowledge about pest regulation (τ_B=0.182). Positive correlations also exist between level of education and pest knowledge (τ_B=0.1) and knowledge about their regulation (τ_B=0.08), respectively. Elderly respondents tend to vote for faster interventions. Overall, a large majority of the respondents would be willing to participate in a volunteer mapping of pests while visiting the forest. The results of this study can be used to inform urban forest management to modify and optimize their communication and information policies concerning pests and substantiated interventions.

Keywords

1. Introduction

Larger urban forest patches are a most valuable part of the urban green infrastructure (Konijnendijk et al., 2005; Tyrväinen et al., 2005) providing a full range of ecosystem services to urban citizens. In addition to a multitude of well-researched provisioning (Poe et al., 2013; Tyrväinen, 2001) and regulating services (Dobbs et al., 2011; Janhäll, 2015), cultural ecosystem services including recreation to improve human mental and physical well-being have highest priority in urban areas (Hörnsten and Fredman, 2000; Konijnendijk, 2003; Martens and Bauer, 2010).

In the light of recent urbanization pressure, the health of the urban population and climate change impacts such as longer drought periods and increasing mean air temperatures, larger urban forests and trees in general are as valuable as they are in danger. Forest patches in and around cities are under increasing pressure (EASAC, 2009; U.S. EPA, 2000) as cities in many parts of the world grow, expand and partly increase in density (Angel et al., 2011; Seto et al., 2011). Threats are not only posed by land surfacing itself however, but also by the deterioration of tree health from biological pests, which is a common problem all over the world (Zorzenon and Campos, 2015; Lovett et al. 2016).

Biological pests are understood as disturbances caused by biological agents (e.g. herbivore insect, fungi, nematodes, bacteria). The most accepted definition of a disturbance is given by Pickett and White (1986) as: "any relatively discrete event in time that disrupts ecosystem, community or population structure and changes resources, substrate availability, or the physical environment." Hereafter, disturbances put forest management objectives at risk – in case of the urban forest in particular the recreational function. Depending on the affected area and the subsequent damage potential, a cascade of predefined forest measures are at hand. If damage potential is low and the affected area is small, no measures at all or single tree measures are undertaken. Otherwise, measures at the forest-stand scale (e.g. harvest, application of biocides/pesticides) have to be applied to maintain ecosystem services.

Forest pests have strong effects on the forest structure (e.g. tree composition, natural growth/natural rejuvenation, the vertical and horizontal distribution of trees) (Schelhaas et al., 2003) which in turn affect the recreational, ecological and economic function of specific forest stands (Gao et al., 2014; Ishii et al., 2004). There are many potential pests and pathogens but the one outbreak event which poses danger to a specific forest function is difficult to forecast (Royama et al., 2005; Zang et al., 2015). In particular this is true for urban

forests which are embedded in complex and dense human-dominated environments (McPhearson et al., 2016). They show increased numbers of invasive and vector species (Yemshanov et al., 2012) and higher temperatures (heat islands) (Livesley et al., 2016) with beneficial effects on many pest organisms. In addition, urban forest functioning is often highly sensitive to single tree mortality, due to the higher optimization level of ecosystem services compared to large forested areas far away from cities as well as a long-term intensive forest and tree stand management leading to non-natural tree species compositions that are quite far away from potential natural forest stands (Haase and Gläser, 2009). Especially old growth trees, which are highly valuable for recreation, experience a higher probability of standing death due to pathogens (Holzwarth et al., 2013). Climate change further amplifies the risks for a stable urban forest functioning due to temperature stress (Williams et al., 2013), water stress and drought (Allen et al., 2015), as well as abiotic and biotic disturbances (Seidl et al., 2014).

However, there are also advantages to urban forests. They generally have a (man-made/man-influenced) high tree species diversity, which is known to decrease damage from insect herbivores (Mangels et al., 2015), increase resilience (Thompson et al., 2009), and increase the portfolio of management options (Kätzel and Höppner, 2011). Furthermore, there is a potential for cost-effective monitoring programs due to a high availability of volunteers (e.g. "citizen science", Deguines et al., 2012) and good accessibility of trees and forest stands, supporting environmental education for children (Pooley and O'Connor, 2000).

Today, urban forest management needs to take the visitor into account when making decisions in order to minimize conflicts (Konijnendijk, 2000; Liebhold, 2012). Urban residents, especially in large cities of Europe, are very well educated and well-informed persons who know about "their" forests and increasingly also about climate change. Along with the implementation of multi-agent and bottom-up governance structures and forms of co-development, the perceptions and thus the resulting opinions of "the people" and "the stakeholders" are becoming increasingly important for decision-making about the urban environment in cities (Kaczorowska et al., 2015). At the same time, cities as "opinion makers" influence the attitudes on forests and forest/pest management – also in rural and peri-urban areas. However, even though the ecology, the epidemiology and the species dependency of tree pests (Laćan and McBride, 2008; Mindlin et al., 2012; Moraal and Jagers op Akkerhuis, 2011; Tomlinson et al., 2015; Uspensky, 2014) in urban areas came onto the scientific agenda quite recently, no work has been done so far in terms of how pests and their

regulation is perceived by the urban population. This knowledge is extremely useful as a well-adapted communication strategy can solve conflicts before they exist (Konijnendijk, 2000).

To fill this gap, this paper shows the results from a pilot survey on perceptions of tree pests and their management among visitors to urban forests in Berlin, Germany.

2. Methodology

The forest district of "Teufelssee" is located in the south east of the city of Berlin, to the south of the Müggelsee – Berlin's largest lake (Figure 1). The forest district boasts excellent water access, a natural wetland area and a public environmental education centre.

Figure 1 about here

In late August and early September 2015, a ten-day visitor field survey was conducted by four well-trained interviewers.

The main intention of the questions was to get an idea about their knowledge and their attitude about climate change impacts on the forest, forest pests and measures to control/limit these pests. The questionnaire was written in German and included 17 different kinds of questions (open, multiple-choice, Likert-scale and Boolean). Questions included aspects of [1] general well-being in the forest, reasons for visiting the forest, [2] perception and knowledge of tree pests and pest control and [3] basic demographics.

The field design followed an approach, tested in the previous year at another forest site in Berlin (Bertram & Larondelle 2016, Larondelle & Haase 2017). Interviewers worked in teams over two weekends and six weekdays. The survey did not aim at representativeness, but at addressing a variety of user characteristics. Every visitor willing to participate was questioned in a face-to-face interview that took about 20 minutes. In general, we found that people were being respondent to the interviewers and that only a few visitors refused to be questioned. Four different locations were established in cooperation with the local forest administration and interviewees were addressed at three different times of day ranging from 9am-1pm, 12pm-4pm, and 3pm-7pm.

The interview method of an on-site sampling, times and locations were chosen together with the local forest administration in an attempt to get a complete picture of the various user groups in the forest and their perceptions. In this process other methods, like off-site sampling or online surveys were discussed. However, Larondelle & Haase (2017) tested the different outcomes of on-site versus online sampling in a different forest site in Berlin a year earlier. Here we found, that people answering online surveys tend to visit the forest less often as those asked in the field. As the premise of this study was, to find perceptions towards pest and pest control, it was an advantage to ask people who visit the forest on a frequent basis to get a better informed picture.

Overall, 554 participants gave complete responses which were analyzed using the software package SPSS 22 and the mapping tool ArcGIS, version 10. The statistics that were calculated included basic descriptive statistics, an analysis of open questions, and a non-parametric hypothesis test using Kendall's tau coefficient τ, as these statistics are explicitly advised when dealing with ranked data with unequal intervals.

On the base of these findings we conducted Chi square statistics between factors (e.g. age, level of education) and four selected variables regarding acceptance of using pesticides at the level of single trees or larger area, the question when protection measures should start, and if additional information is required. Hereinafter, we developed a series of Logit models to disentangle the effects of the associated variables. The statistical analysis was carried out using the function *chisq.test* of the package *stats* in R (R Core Team, 2015) and the *nnet* package (Venables & Ripley, 2002) for the Logit models. In particular, the following specific questions will be addressed with the Logit models:

- What are the interrelated effects of factors that influence the acceptance of pesticide application on a single tree or over a larger forest area?
- What are the interrelated effects of factors that influence opinion about the point in time when measures to protect trees should start?
- What group of people wishes additional information on which question?

3. Results

The analysis of some of the recorded demographics is displayed in Table 1. Apparently 70% of the respondents were older than 45 years old, while the group of 25-44 year old visitors ranked third in abundance with about 23%. Only 1.5% of those questioned chose not to

answer the question about their age. As for the level of education; almost 47% of the visitors asked during this survey held a university degree and 24% left school after 10 years of education with the German equivalent of secondary school leaving exams, which agrees with the abovementioned statement about the highly educated population that can be found in cities (Berry et al. 2005, Bacolod et al. 2009, Carlsen et al. 2016).

Table 1 about here

When the respondents were asked to rate their knowledge about biological forest pests in general on a Likert scale between 1 and 6 (1=excellent, 2=very good, 3=good, 4=acceptable, 5=poor, 6=very poor, such as in the German school grading system), they answered as follows: 13% very good (1-2) 44% acceptable (3-4) and 43% poor (5-6). In terms of pest control knowledge was rated even lower as follows: 5% very good (1-2); 30% acceptable (3-4) and 65% poor (5-6; Figure 2).

Figure 2 about here

When asked about their perceptions and opinions on forest interventions against pests in detail, most people agreed to mechanical intervention (69.9% in favour) and the selected felling of infested trees (57.3% in favour). Even the extensive felling of host trees did not generally lead to great opposition (22.3% against vs. 43.2% in favour) although in this respect most people would like more information upon which they can form an opinion. However, when it came to the use of pesticides and biocides (both chemical interventions), most people were strongly against implementing these in "their forest"; and the more extensive the application, the greater the objection (45.6% objections against individual trees compared to 66.9% objections against extensive use). Respondents affirmed with 55.6% that they would like to receive more information (sum of all answers "need more information"), however as many as 37.5% were not interested in more detailed information.

Figure 3 about here

Table 2 about here

The majority of respondents could name at least 1-2 (forest) organisms and species which they considered to be a biological pest. Only 10% could not name any organism at all and around 20% could name 3 or more. Those named most frequently were the "bark beetle" (*Scolytinae*) (n=313), the "oak processory moth" (*Thaumetopoea processionea*) (n=219) and the "leafminer" (*Gracillariidae*) (n=117). Furthermore, 42 different existing and invented species names were named 144 times. Humans and their influence as origins of the pest species were named 27 times; among the named influences were "pollution", "acid rain", "monocultures" and "humans" in general. Mammals (including the "beaver", "deer", "red fox", "raccoon" and "grazers" in general) were listed 18 times.

Figure 4 about here

If we understand Figure 4 as a range of risk-escalation, 34.5% of the respondents would start intervention as early as possible at the first sign of the pest. Only very few people, however, regard economic damage or reduced aesthetic value as reasons that are strong enough for forestry intervention. However, the majority (56.1%) would agree to intervention if forest health and biodiversity is at stake.

By running further statistical analyses we found a weak positive correlation between the age of the respondents and the level of knowledge about biological pests (Kendall-Tau-b τ_B=0.165) and the level of knowledge about the regulation of these pests (τ_B=0.182). A weak negative correlation was found between the age and the latest point of intervention (τ_B= -0.293). Furthermore, we found a weak positive correlation between the level of education and the knowledge about pests (τ_B=0.1) as well as the knowledge about their regulation (τ_B=0.08). A weak positive correlation was found between the level of education and the answers about the most recent point of intervention (τ_B=0.094) and the number of pests that could be named (τ_B=0.092).

Not surprisingly a strong positive correlation was found between the knowledge about pests and the knowledge about their regulation (τ_B=0.495) and less strong the number of pests that could be named (τ_B=0.292). The correlation between the knowledge about the regulation of pests shows a positive but weaker connection to the number of pests named during the survey (τ_B= 0.236). All correlations proved to be significant on the 1% level.

Significant factors influencing the acceptance of pesticide application on a single tree level are the level of education and age class (Table S1). The results of the Logit model show that people from age class 1 (<18 years), 4 (45-64 years) and 5 (65-75 years) tend to take a more positive view of this measure than people from age class 2 (18-24 years), 3 (25-44 years) and 6 (>75 years). Highest acceptance values can be found for people with the highest worker's degree (master craftsman certificate) (Figure S1). At the level of larger area the significant factors are knowledge of regulation and age class (Table S1). In Figure S2, for practical reasons we grouped the factor 'knowledge of regulation' into two categories (low=1-3, high=4-6): The results show a general trend of increasing acceptance with increasing age. A much stronger pattern is clearly shown by the factor 'knowledge of regulation'. Our classification of the age into classes 4-6 leads to doubling the probability to accept pesticide application on larger area. In comparison to application at the single tree level, also the need for more information is much more pronounced (Figure S2). In case of the most recent point of intervention the significant influencing factors are age class and level of education (Table S1). The older people become, the more they prefer the intervention at the first onset of the pest. The Logit model also reveals that people with a degree of a grammar school or university prefer interventions when biodiversity is affected (Figure S3). The question if 'more information (about pest control in forests) is required' is determined by the factors age class, level of education and knowledge of regulation (Table S1). There is a lower information need with increasing age which is in agreement with general lower knowledge increase in older ages due to information repetition and knowledge saturation. At the same, time the need for information increases with the level of education but decreases with increasing knowledge of regulation which can have similar reasons as discussed above (Figure S4).

4. Discussion

Knowledge about pests and their regulation

In general, the visitors to the Berlin forest see themselves as acceptably informed when it comes to biological pests, and only poorly informed about topics regarding pest-regulation. The results suggest that knowledge increases with age and the level of education. People with a relatively high knowledge about pests are also more likely to have knowledge about the respective regulations and can most probably name some of the pests as well. It also shows that urban dwellers have extent certain knowledge about their urban ecosystem and that

general knowledge is an important factor towards higher acceptance. This was also found by a national survey in the UK where acceptance increased with increasing awareness (which is comparable to 'knowledge' in our study) (Fuller et al. 2016). This is in agreement with surveys conducted with professional farmers which also found a positive correlation between the perception and knowledge of pesticide use of the farmers and the level of education and farming experience (Midega et al. 2016). This general positive relationship between level of education, knowledge and awareness of environmental issues was already mentioned 30 years ago by Ostman and Parker (1987).

Perception of forest interventions

As in studies without the urban focus (Canada: Hajjar et al. 2014, UK: Fuller et al. 2016, Jepson and Arakelyan 2017) our results show a general positive commitment with respect to interventions and no fundamental opinion. People are not generally against forest measures but almost completely against chemical treatments. Most of the interviewees, regardless of age or educational background agreed to mechanical interventions and had very critical opinions concerning the use of pesticides and biocides – even when limited to individual trees. Again, this is in line with the results of Fuller et al. 2016 where the felling of only those trees that were infested, had the highest acceptance. The reported lowest acceptance was for the management options of aerial spraying and the felling of all trees as well as taking no action at all.

The low acceptance of pesticides and biocides in our study might be a result of the regulatory failures in the past, very negative media coverage of biocide interventions over recent decades (Gustafsson and Lidskog, 2012) or the no-pesticides-policy of the Berlin forest administration over recent years, due to its FSC certification. The debate on ecological standards is often a very emotional one with either limited or without sufficient information. Damalas (2009) argue that there is a general trend of seeing life as risky and full of more general concerns about environmental quality which, in combination, also lead towards a critical reflection of pesticide use. Moreover, the general awareness of problems related to the permanent pesticide use in agricultural management might also play a role (Ahmed et al. 2011).

The position is less critical when asked about when interventions should start at the latest. The majority of respondents agree to act fast and at the latest when biodiversity is threatened and most certainly way before human health is in danger (91% counting all steps of the risk-

escalation before "human health is in danger"). This also explains the relatively small number of only 4%, who only agreed to start intervention when human health is in danger. Not surprisingly, the results of the Logit models suggest that younger and more highly educated citizens tend to disagree with a fast intervention and at least not with the first appearance of the pest. This finding supports the results of Fuller et al. 2016. In their representative survey for the UK, they found lower acceptance values for interventions if wildlife or recreation factors are considered as ecosystem functions. These two functions are most important for our respondents who mainly come from the city. However, older and average educated people agree with interventions at the first signs of a pest outbreak. The answers here reflect an almost paradox pattern. Early interventions are desirable, but without the use of any pesticides. Instead, measures such as suction and cutting of single trees are more preferred for early interventions. This might be explained by the perception that these mechanic measures cause only short-term effects which seem to be reversible over the longer term of the forest stand development. In contrast, the use of pesticides is attributed with longer-lasting negative effects. Many respondents added that if new trees were planted, then they would be in favour of clear cut interventions. Meanwhile, the use of pesticides might be (irrationally) considered as a threat, in that they could get into the ground water of residential areas. The long-term consequences of pesticide application are not known and not clear for the visitor. Here, more information and better communication of integrated pest management techniques (Bombosch 1991) could enhance knowledge and the acceptance of pesticide application on a small spatial and time scale. This information is particular desired by young people and people with higher educational level.

However, information made available could also be misconceived with the increasing mistrust of information from official sites and experts (Gustafsson and Lidskog, 2012) due to the excessive contradictory information that can be accessed through modern media today. That said, conservative intervention strategies are most likely to be accepted (Hajjar et al. 2014, Fuller et al. 2016, Jepson and Arakelyan 2017). Gustafsson and Lidskog, (2012) studied a case of an insect outbreak of the Northern Pine Processionary Moth in Gotland, Sweden. The case showed similar results: "Given the human nuisance involved and the possible long-term effects on tourism, local residents were demanding intervention to reduce the insect population. At the same time, there were warnings about the uncertainties regarding the wider ecological consequences of spraying." (Gustafsson and Lidskog, 2012:588). Gustafson and Lidskog (2015) make a strong point for establishing trust between citizens and researchers in their study. Given the positive correlation between knowledge and acceptance (Fuller et al.

2016), Citizen Science projects might be the key to foster self-made and trustworthy knowledge among interested forest user groups.

Communication and support

The majority of respondents desire more information on topics concerning pest and pest control. This might be explained by the strong personal sense of space that people have, when frequently visiting the same forest patch.

Tomlinson et al. (2015) analyzed the case of the management of the Oak Processionary Moth in London between the years 2006 and 2012. They looked into the question as to why eradication in this case proved to be so difficult. One main outcome of the qualitative study is that the communication strategy with the public was not very well selected and did not point out the threats to human health. Furthermore, managing the wide range of stakeholders (both public and private) as normally found in urban settings proved to be difficult.

In our case in Berlin, over 80% of the participants would be willing to report occurrences of pests during their forest visits, which is a huge potential number of volunteers for spotting pests during their forest walks. An example from Oakville in Canada shows how effective urban forest health monitoring with volunteers can be. For example, BioForest in Canada provides community involvement and education programs in combination with professional forest monitoring (BioForest Technologies Inc., 2015). This leads to an increased number of people to help with the early detection of threats to urban forest health and "a knowledgeable and active community that recognizes the economic and environmental contributions made by the urban forest and that will support municipal urban forest health initiatives" (BioForest Technologies Inc., 2015:2).

Uncertainties

As is typical for other survey-type studies, this study includes a number of uncertainties that may have an effect on the results obtained. The choice of the field days may provide another source of uncertainty. Moreover, on-site sampling neglects those who do not visit the forest at all and underestimates fast-moving, 'passing through' groups such as horseback riders and (mountain-)bikers, who are difficult to interview and are therefore missing in the sample. As

for the mixed times, locations and different sampling days – these proved to be successful in order to question a considerably wide range of different forest users. While some times and locations turned out to be excellent to interview many people at one time, others were more successful to question those people, who liked to avoid crowds, such as early-morning joggers and nature-lovers (Larondelle and Haase 2017).

5. Conclusions

This study of the perception of pests and pest control in an urban forest in Berlin showed that the sensitization of forest management towards reservations against certain interventions is tremendously useful. A good communication strategy is key to a successful forest management, not only but especially in urban areas. Resentments against biocide and pesticide interventions might result from a poor understanding and/or only partially-reflected historical events. The majority of the respondents preferred an early response towards pests and was not generally against strict and broad measurements (e.g. the extensive felling of host-trees). "Citizens create meaning and construct knowledge by organizing personal experience and articulated knowledge claims into coherent narratives—a practice that needs to be recognized in the context of efforts to make environmental regulations more socially robust." (Gustafsson and Lidskog, 2012:599). In this way an adjusted communication strategy and the access to comprehensive information material in combination with well managed citizen science projects can offset animosities against substantiated forestry interventions at an early stage.

Acknowledgements

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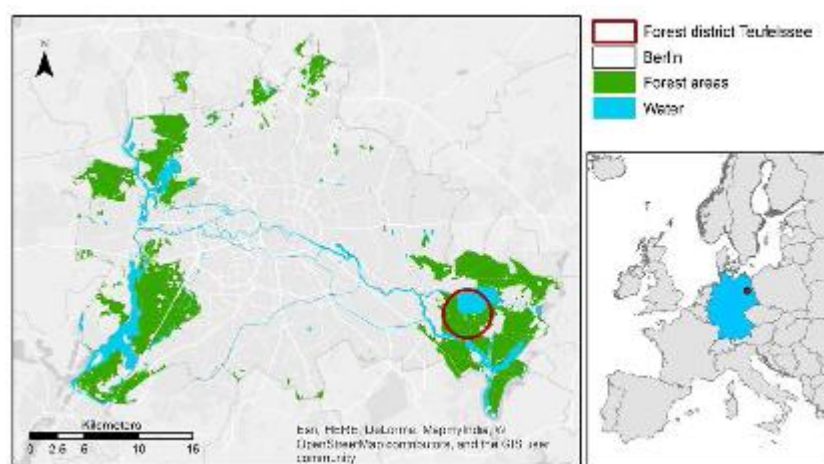Figure 1: Location of the study site

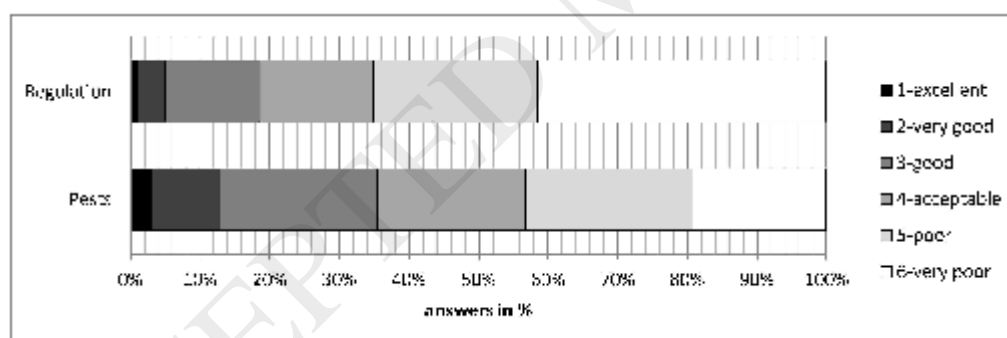Figure 2: Awareness and knowledge concerning biological pests and their regulation

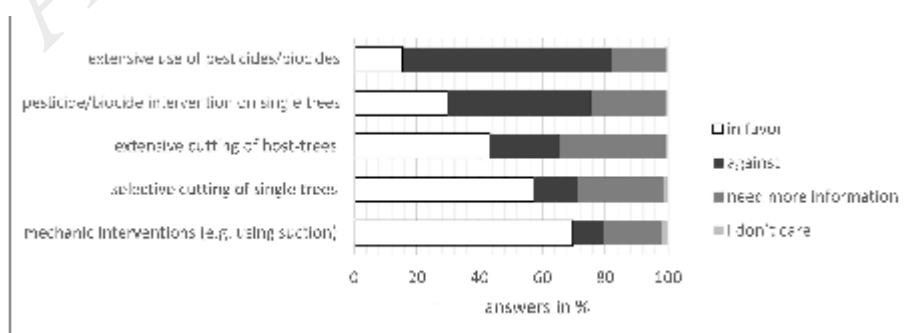Figure 3: Opinions on different forestry interventions

Figure 4: Answers on the multiple-choice question: "When should interventions start latest?" ordered by level of escalation.
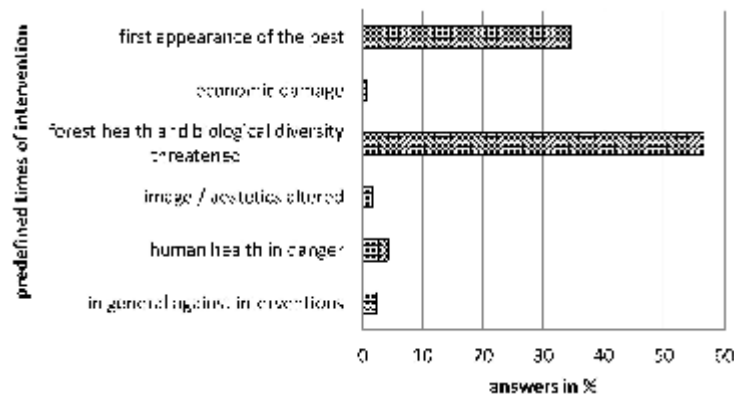

Table 1: Descriptve statistics of the demographics

	Frequency	Percent [%]
highest level of education		
no graduation	2	.4
secondary school (9 years)	33	6.0
secondary school (10 years)	123	24.2
highschool (12-13 years)	70	12.6
master craftsman	28	5.1
university	258	46.6
missing	29	5.2
total	*554*	*100*
age class		
younger then 18	10	1.8
18-24	27	4.9
25-44	125	22.6
45-64	192	34.7
65-75	140	25.3
older than 75	52	9.4
missing	8	1.4

total	554	100

Table 2: Number of pests named by respondents

	Frequency	Percent [%]
# of pests named by respondents	n	% of n
0	60	10.8
1	228	41.2
2	160	28.9
3	78	14.1
4	22	4.0
5	6	1.1
total	554	100

Supplement

Translated survey

1. Please name three words you associate with the forest:
   (1) …
   (2) …
   (3) …
2. How often have you visited the forest in the last month?
   a. Once
   b. Less than once a week
   c. More than once a week
   d. Every second day
   e. Every day
   f. Irregular
   g. Other:
3. How did you arrive at the forest?
   a) Car
   b) Public transport
   c) Bicycle
   d) Walking
   e) Others:
4. What are you missing/what bothers you during your forest visit?

        (1) …

        (2) …

        (3) …

5.   How would you estimate your knowledge about forest pests?

    1 (very well) – 6 (very poor)

6.   Name the forest pests which you know:

        (1) …

        (2) …

        (3) …

7.   How would you estimate your knowledge about forest pest regulation?

    1 (very well) – 6 (very poor)

8.   When do you think, should interventions start latest?

    a)   First appearance of the pest

    b)   When economic damage occurs

    c)   When forest health and biological diversity is threatened

    d)   When image/aesthetics are altered

    e)   When human health is in danger

    f)   I am in general against interventions

9.   How do you think about these interventions?

    (possible answers: against – in favor – I need more information – I don´t care)

    a)   Selective cutting of single trees

    b)   Pesticide/biocide use on single trees

    c)   Mechanic interventions (e.g. using suction)

    d)   Extensive use of pesticides/biocides (e.g. via helicopter)

    e)   Extensive cutting of host-trees

10. Would you like to be better informed?

    (yes – no – I don´t care)

11. Are you willing to inform the forestry about infected trees you see during your regular visit (e.g. through an App)?

    (yes – no)

DEMOGRAPHICS:

12. How old are you?

13. What is your highest level of education?

14. What is your employment status at the moment?

15. Female or male?

16. Postal code?

Table S1: CHI²-statistics of tested factors (rows) which could have an effect on different forest measurements or if additional information is required (columns).

Table S1 about here

Figure S1: Model probability of the Logit model Pesticide_ST~ageClass+levelEducation.

Figure S1 about here

Figure S2: Model probability of the Logit model Pesticide_LA~ageClass+knowledgePests+knowledgeRegulation. The original scale (1-6) of knowledge of regulation has been grouped into two categories "low"=1-3 and "high"=4-6.

Figure S2 about here

Figure S3: Model probability of the Logit model time_intervention~ageClass+levelEducation.

Figure S3 about here

Figure S4: Model probability of the Logit model needInformation~ageClass+levelEducation+knowledgeRegulation. The original scale (1-6) of knowledge of regulation has been grouped into two categories "l"=1-3 and "h"=4-6.

Figure S4 about here