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Oddgeir Andersen
Norwegian Institute for Nature Research (NINA), Human Dimension Department,
Fakkelgården, NO-2624 Lillehammer, Norway
Phone: +47 934 66 706
e-mail: oan@nina.no

Applying Typology Analyses to Management Issues: Deer Harvest and Declining Hunter Numbers

ODDGEIR ANDERSEN, *Norwegian Institute for Nature Research (NINA), Human Dimension Department,* Fakkelgården, NO-2624 Lillehammer, Norway.

HILDE K. WAM, *Norwegian Institute for Agricultural and Environmental Research, Organic Food and Farming Division,* Gunnarsveg 6, NO-6630 Tingvoll, Norway.

ATLE MYSTERUD, *University of Oslo, Centre for Evolutionary and Ecological Synthesis (CEES), Department of Biosciences,* P.O. Box 1066 Blindern, NO-0316 Oslo, Norway.

BJØRN P. KALTENBORN, *Norwegian Institute for Nature Research (NINA), Human Dimension Department,* Fakkelgården, NO-2624 Lillehammer, Norway.

ABSTRACT In both North America and Europe, deer populations are increasing and hunter participation is decreasing. This generates concern for our future ability to control deer populations. Information on hunter typologies can help ascertain which licensing regulations are the most useful for either deer population control or activating currently non-active hunters. We used latent class analyses to identify typologies among 1,820 active and non-active red deer hunters in Norway. We found that active hunters could be grouped into mixed visitors (77%), deer enthusiasts (13%), and solitary locals (10%) in regard to their motivation and approach to hunting and landowner acquaintances (47%), less involved locals (40%), and long-term visitors (13%) when considering access to hunting grounds. We found 2 typologies of non-active hunters: likely recruits (79%) and permanently gone (29%). Managers in areas with undesirably dense deer populations should be more flexible in the way hunting is organized and promoted to motivate a diverse group of hunters. We recommend a zone-based management plan based on key factors determining hunter participation, which in our study included location of residence, interest in trophies, willingness to pay, willingness to travel, sociality, landowner relations, and leasing agreements.

KEY WORDS *Cervus elaphus*, human dimensions, hunting, latent class analysis (LCA), ungulate, wildlife.

Many ungulate populations in both North America and Europe have increased to high-density levels during the last several decades (Gill 1990, Côte et al. 2004, Levy 2006). These increases have various causes, including changes in wildlife management, the absence of large carnivores, and land use changes (Mysterud et al. 2002, Apollonio et al. 2010). Abundant populations of large herbivores can have several undesirable effects on ecosystems, such as diminishing biodiversity, altering nutrient cycling, and suppressing primary production (McShea and Underwood 1997, Côte et al. 2004, McLaren et al. 2004, Ims et al. 2007, Rooney 2008). High ungulate densities can also damage agricultural and timber crops (Takatsuki 2009, Apollonio et al. 2010, Akashi et al. 2011), increase the risk of zoonotic diseases (Wilkins et al. 2003, Trout and Steelman 2010), and escalate the frequency of costly deer-vehicle collisions (Groot Bruinderink and Hazebroek 1996, Mysterud 2004, Dussault et al. 2006, Danks and Porter 2010).

License-based hunting is the most obvious management strategy for controlling abundant game animals, and has indeed been used to lower ungulate densities and thereby limit adverse ecosystem impacts (Riley et al. 2003, Hothorn and Müller 2010, Strand et al. 2012). However, many areas in North America and Europe with dense deer populations have experienced a decline in the number of hunters in recent years (Enck et al. 2000, Heberlein

2007, Gude et al. 2012). The mean age of active hunters is also increasing (Heberlein 2007, Gude et al. 2012). Simply allowing more animals to be harvested per hunter may be an effective strategy, but only to a certain point, because handling time and other social constraints have effects on per capita harvest removal (VerCauteren et al. 2011). Consequently, increasing the harvest per hunter to face declining numbers of hunters may not be sufficient to regulate ungulate numbers in many areas, and new approaches are needed (Brown et al. 2000).

A typical case of rapid population growth in ungulates is the red deer (*Cervus elaphus*) in Norway. The current Norwegian management system is based on a quota system where the number of animals that can be harvested is based at least partly on the number of deer observed by hunters, which is used as a proxy of population size (Mysterud et al. 2007). The number of red deer shot in Norway increased markedly after 1970 and peaked in 2010, with 39,143 individuals shot (Statistics Norway 2012). The red deer density has increased primarily along the west coast (Milner et al. 2006), but red deer have also expanded beyond traditional core areas in all directions in the western parts of the country (Haanes et al. 2010, see also Fig. 1a). The main reasons for the population growth of red deer in Norway has been age-selective harvesting since 1967 (Fig. 1b), positive effects of mild winters, favorable changes in land use related to forestry and agriculture, and a functionally extinct predator population on the west coast (Mysterud 2011).

Effectively managing higher densities of ungulates, such as red deer, when the number of hunters is declining requires more detailed knowledge about who will continue to hunt in the coming years (e.g., the attitudes and preferred hunting approaches of potential hunters), such that they may be motivated to hunt. Hunters form a broadly mixed group with diverse behaviors, and some hunters are less effective than others for meeting quota objectives (Lebel et al. 2012). For example, the most effective way to reduce ungulate populations is to increase the harvest of adult females (e.g., Ueno et al. 2010, Milner et al. 2011, Boulanger et al. 2012), yet some hunters do not pursue females for nonobjective reasons. Such established beliefs make implementing new harvesting regimes difficult (Finch and Baxter 2007, Cornicelli and Grund 2011).

Because hunters form such a heterogeneous group, identifying hunter types can be challenging. One established index for identifying hunter typologies is motivation (Crompton 1979, Manfredo et al. 1996, Vaske 2008). Motivation is a complex sum of many single motives (Beardmore et al. 2011, Tangeland 2011); nevertheless, identifying the motivations of hunters may be key to understanding the hunters' preferences, goals, and behaviors. Satisfaction is another potential index for identifying hunter typologies, e.g., if measured as bag orientation (satisfaction with number of animals harvested) or preferences to hunting regulations, such as the size of the daily bag limit (Faye-Schjøll 2008, Wam et al. 2012). A hunter's typology may be identified through what we may collectively label as their specialization, e.g., their choice of equipment, hunting approach, skills, knowledge, the species they hunt, or choice of hunting grounds. The degree of specialization may therefore explain factors that can affect hunter motivation and satisfaction (Norton 2008) and may lead to more effective management plans for reducing ungulate densities. For example, Ward et al. (2008) identified 2 main typologies among deer hunters in Pennsylvania in relation to high deer abundances. They concluded that the hunters who supported antler restrictions and strongly agreed that deer damage to forests is a problem (damage-control managers) were more likely to be effective for lowering the deer population than were the hunters who expressed markedly less support for antler restrictions and views on deer damage (no-damage traditionalists). Hunters described as damage-control managers appeared to be more committed, put more effort into hunting, purchased more tags, and harvested multiple antlerless deer at higher percentages than the less supportive no-damage traditionalists. In practice, enlisting the most dedicated hunters in large-scale deer reduction efforts may be possible if innovative harvest policies are designed to take advantage of their concern for deer damage.

We used latent class analyses (LCA) on data from hunter surveys to identify typologies among active and non-active red deer hunters in Norway. We divided hunters into active and non-active based on whether they had hunted red deer in the previous hunting season (2010–2011). Our aim was to better understand hunter typologies to aid in ensuring sufficient recruitment of hunters for the future harvest of red deer when targeted reductions are needed. The underlying survey therefore addressed motivation and hunting approach, logistical preferences (where and when to hunt), and, for non-active hunters, whether they intended to start hunting again.

STUDY AREA

We collected data from 209 municipalities in Norway where red deer are present (Fig. 1a). Vegetation and climate reflected a coastal-inland gradient related mainly to precipitation (climatic humidity) and distance from the sea, and a south-north gradient related to temperature and elevation (Bakkestuen et al. 2009). In general, temperature and precipitation declined from south to north and from coastal to inland areas, whereas snow depth increased. The west coast lies mainly in the boreonemoral zone, apart from a small area around the Hardangerfjorden in Hordaland county, which is in the nemoral zone (Abrahamsen et al. 1977). In addition, several areas around the Trondheimsfjorden are in the southern boreal zone. Forests on the west coast were naturally dominated by deciduous and Scots pine (*Pinus sylvestris*); however, there had been extensive commercial planting of Norway spruce (*Picea abies*). The inland (eastern) region is in the southern boreal zone. The typical red deer habitat type of the inland regions was coniferous forest with either Norway spruce or pine as the dominant tree species (Mysterud et al. 2011).

Roe deer (*Capreolus capreolus*) were sympatric to red deer in most regions except much of Sogn and Fjordane county. Moose (*Alces alces*) were abundant in the eastern, southern, and northern regions but of low abundance in the western region. Large predators were absent along the west coast, but lynx (*Lynx lynx*) were mostly common elsewhere. Wolf (*Canis lupus*) and brown bear (*Ursus arctos*) occurred in parts of the eastern, southern, and northern regions.

Harvest management of red deer (and other large ungulates) in Norway was based on an area-based quota system, where landowners obtained quotas in relation to the size of their land. The area behind each license provided varied (adjusted for deer density), e.g., from 100 ha in high-density areas to more than 300 ha in areas with a low abundance of deer. Further, the age structure of the harvested deer followed a harvest plan approved by the game management authorities, typically with a 3–5-year time horizon (e.g., 40% calves, 30% yearlings, and 30% adults for the timespan of the harvest plan). Hunting licenses could be sold in a variety of ways, from single licenses to long-term lease agreements for hunting teams with many hunting licenses. Hunting on the west coast of Norway was traditionally conducted by landowners who included their family and friends (Olaussen and Mysterud 2012). Less focus has been paid to organize landowners into management units offering hunting access to non-local hunters. In the eastern and northern regions, red deer hunting was often associated with moose hunting teams, which often consisted of non-local hunters as well. Only in recent years has red deer hunting been separated from the traditional moose hunting teams, and hunting has been commercialized in both the western and eastern regions.

METHODS

Surveys

We sent the survey to individuals registered in the National Hunting Registry (NHR) who had hunted red deer at least once during the last decade (2002–2009) and who had purchased a national hunting license for the 2010–2011 hunting season. The latter ensured that the respondent had recently intended to hunt. We randomly selected 1,500 recipients that had 1–4 years of experience with red deer hunting within the last decade and 1,500 recipients with 5–9 years of experience to survey hunters with 2 levels of hunting experience and eagerness. We selected recipients corresponding to the distribution of deer hunters at the county level. We extracted demographic data on the recipient's age, sex, education level, and location of residence (rural or urban) from the National Population Registry by Statistics Norway, who also administered the data collection according to their established standards.

Out of the 3,000 questionnaires sent out, we received 1,820 responses (a response rate of 61%). Because registry data were linked to the respondents, we were able to compare the distributions of demographic variables between non-respondents and respondents (Table 1). Compared with the non-respondents, the 16–25-year-old age group was underrepresented among respondents, whereas hunters older than 67 years of age were overrepresented in the sample of survey respondents. However, these 2 groups represent a small portion of the hunter segment (7% and 5% of the samples, respectively). A higher proportion of respondents than non-respondents had a university level of education, whereas a higher proportion of non-respondents had only an elementary school level of education. The response rate was lower among hunters with 1–4 years of hunting experience compared with hunters with ≥5 years of hunting experience.

The survey questionnaire consisted of 45 questions, arranged in 5 sections: 1) background information about the hunter such as the household's gross annual income, number of years as a hunter, annual average hunting effort, environmental orientation, and the importance of game meat; 2) recent hunter activity (red deer), traveling distance, use of a dog, hunting technique, hunting in a team or not, and season of interest; 3) perception of the current situation (management practice and hunting access), prices for licenses, hunting regulations, and crowding; 4) preferences for red deer hunting in the future such as region of interest, preferred hunting technique, importance of bagging deer, and preferences for possible additional facilitation (guide, standard of accommodation, etc.); and 5) willingness to pay for hunting licenses, per kilogram game meat, age groups of deer, and hunting seasons. We constructed categorical questions that used a balanced 5-point Likert scale. No questions were mandatory. When relevant, the respondent had the option of choosing “I do not know” or “Not relevant.” We used reverse keying to ensure that respondents had interpreted the more complex questions correctly, i.e., repeating the same question with a different phrasing.

We mailed the survey by the postal service on 24 January 2011 and had a response deadline of 14 days later. We sent a reminder to the non-respondents 2 days before the deadline. Fourteen days after the deadline, we sent a copy of the questionnaire to the remaining non-respondents. Data collection closed 22 March 2011.

Data Analyses

We used LCA to identify the deer hunter typologies. Latent class analysis groups survey participants into unique segments with shared identity, based on characterizing variables such as attitudes, motivations, and habits (Lazarsfeld and Henry 1968). Compared with the more traditional clustering approaches applying distance measures, LCA clustering is based on distributional probabilities (Magidson and Vermunt 2002). This allows multiple statistical approaches for choosing the optimal clustering variables (step 1) and the number of segments (step 2). We used the headlong algorithm search based on iterative maximum likelihood estimation (Goodman 1974), as developed by Dean and Raftery (2010). The output of the search is a point estimate for each variable within each segment. For a general introduction to LCA, see Hagenaars and McCutcheon (2002).

Prior to the LCA analyses, we checked for correlations between variables addressing the same subject (i.e., reverse keyed questions). We did not find any negative correlations, which would indicate misinterpretation due to ambiguous question phrasing. In the case of positive correlations, we omitted the variable with the lowest standard deviation. These are less likely to detect distinct typologies (Dean and Raftery 2010) because a lower standard deviation is associated with a higher level of agreement between respondents. This reduced the number of variables from 40 to 25 (Table 2). We also transformed continuous variables into <10 categories (a necessity for classification) without changing the original distribution of data. Because of the complex management issue at hand, we opted to perform the latent class analyses separately for 2 distinct topics: 1) motivation and hunting approach and 2) logistical preferences.

The selection of optimal variables in LCA is typically performed by backward elimination, i.e., beginning with full models and refining these by removing variables that are not useful (Vermunt and Magidson 2004). We determined the latter using likelihood-ratio goodness of fit in relation to the degrees of freedom, where L^2 < df indicates a good model fit (Vermunt and Magidson 2005). However, with a high number of variables, backward elimination becomes unfeasible with regard to time (Wam et al. 2013). We therefore systematically tested blocks of 3–5 thematically related variables against each of the remaining variables. This approach reveals variables that consistently add very little to the model fit, narrowing down which variables are the most influential. We tested all mutual combinations of the most influential variables by alternating between inclusion and exclusion, following Dean and Raftery (2010). The approach may not identify all significant models, but we can safely assume that those missed are not among the models with the best fit.

When we determined the final set of significant models, we used the log-likelihood Bayesian Information Criterion (BIC_{LL}) and classification errors to rank model parsimony and to select the optimal number of latent classes (i.e., the number of typologies). Because our main purpose was identification and not prediction, we chose BIC over Akaike's Information

Criterion (AIC). The BIC has a stronger penalty for additional parameters (Clarke et al. 2009). We also included as inactive covariates (Vermunt and Magidson 2005) remaining variables addressing the topic in question, as well as the demographic variables D1-D3 (ignoring variables that had not shown up as significant in any model set). These may give further insight regarding the segments, even though they do not statistically add to the outcomes.

We ran LCA using the cluster analysis available in Latent GOLD® (version 4.5, Windows XP, Statistical Innovations, Inc., Boston, MA). To minimize the probability of finding local solutions, as opposed to global solutions, we set the number of random starting sets to 100 (the default is 10). We ran descriptive statistics in Minitab® 15 (Minitab, Ltd., Coventry, UK).

RESULTS

Respondent Sample

Study participants included 5% women and 95% men, which is consistent with the 4.5% national proportion of female red deer hunters (Statistics Norway 2012). The average ages (mean ± 1 SE) for women and men were 42 ± 1.2 and 48 ± 0.4 years, respectively. The average age of all hunters participating in the survey (48 ± 0.3 years) was slightly higher than the national average for hunters (46 years).

We designated the respondents (n = 1,185) who had hunted red deer in 2010–2011 as active hunters, and the remaining (n = 635) respondents as non-active hunters. We used the group of active hunters to identify typologies related to the management issue of the overpopulation of deer, and the group of non-active hunters to identify typologies related to hunter recruitment.

Active Hunters

Motivation and hunting approach.— With regard to motivation and hunting approach, the typologies of active deer hunters were distinguished mainly by 5 variables related to their interest in team hunting, their motivation to hunt trophies, and their location of residence (Fig. 2) (Table 3). The 2-class and 3-class models had an equally good fit (L^2 < df, low classification errors). We consider the 3-class model to have more applied value because it identified a distinct group of local hunters. We therefore labeled 3 typologies regarding motivation and hunting approach: mixed visitors (77%), deer enthusiasts (13%), and solitary locals (10%).

Both of the more yield-oriented typologies (deer enthusiasts and solitary locals) were more likely to live in rural areas and were clearly distinguished by their interest in trophy and team hunting. In contrast to the deer enthusiasts, the solitary locals preferred to hunt alone and were not interested in trophies, but meat. The solitary hunters also spent fewer days hunting deer than did the enthusiasts.

Urban hunters were mostly part of the large group of mixed visitors who were willing to travel and pay to hunt, but who varied in their view on the importance of having large quotas. When going from a 3-class to a 4-class model, all rural hunters were split off from the mixed visitor typology. A fourth class emerged that consisted of team hunters living in rural areas outside the core deer areas (16% of the hunters). However, with 4 classes, the classification error (21.7%) increased (Table 3).

Logistical preferences.— With regard to logistical preferences, the typologies of active deer hunters were distinguished mainly by 4 variables (Table 3). A major distinction between hunter typologies was their interest in long-term leasing of land for hunting (Fig. 3). Naturally, the interest in leasing was in part linked to landowner relations and willingness to pay. The largest subgroup not interested in long-term lease agreements were hunters who had close landowner relations and were less willing to pay for hunting. We labeled 3 typologies: landowner acquaintances (47%), less involved locals (40%), and long-term visitors (13%).

We opted for the 3-scheme typology because of its low classification error (9%) and because a fourth class mainly distinguished the actual landowners (who otherwise behaved largely similar to landowner acquaintances). Nevertheless, recognizing this division may be useful because landowners indicated they hunted fewer days than their acquaintances.

Non-Active Hunters

All the best models for non-active hunters consisted of a full or partial set of the same 5 variables related to whether the hunters anticipated to start hunting deer again, which factors would contribute to such a reconsideration, and their location of residence. We opted for the full model (Table 3) because it had the best fit and more parameters give more characterizing information about the typologies. Because much of the applied value (i.e., identifying which hunters should be targeted for recruitment) is covered by a 2-class scheme, we labeled only 2 typologies: likely recruits (79%) and permanently gone (21%). Notably, likely recruits could be found both inside and outside the typical deer counties with high deer densities (the 3-class scheme; Fig. 4).

Lack of time was a frequent reason for not hunting, which was reported by 70% of the respondents, but showed no consistent pattern regarding whether the hunter intended to start hunting again in the future. Hunters who were the least likely to start hunting again generally lived in rural areas and had a low willingness to travel (Fig. 4). Among these individuals, some lived in counties with high deer densities, which indicated a short travel distance. The inactive covariates indicated a fading interest due to age of the hunter, which may particularly apply to these individuals. However, there were also hunters who lived outside the core deer areas, and hunters who largely felt that deer hunting was too expensive (possibly comprising the same individuals). Non-active hunters who intended to start hunting again were largely from urban areas, moderately to highly motivated to travel, and currently considering deer hunting to be too expensive.

DISCUSSION

This study shows that despite hunter diversity, consistent patterns emerge that may be useful for securing hunter recruitment and realizing the full potential of the hunter resources that are indeed available. Cultural traditions held by stakeholders may hamper such achievements, but with sufficient information of the potential benefits gained, these are likely receptive to change. In Norway, for example, red deer hunting has traditionally been conducted by the landowner with family and friends, and only a few landowners have allowed increased numbers of non-local hunters on their hunting grounds (Olaussen and Mysterud 2012).

The core area for red deer hunting lies in the rural western parts of Norway, whereas the major share of the human population lives in the more urban southeastern part of Norway. The southeast region comprises 50% of the human population (26.4 citizens/km^2), compared with 26% in the western parts (22.6 citizens/km^2). The currently most eager red deer hunters in Norway are rural citizens (deer enthusiasts). Simultaneously, hunters living in the western region (the core deer area) are unwilling to travel east to hunt in the low deer counties. Therefore, efforts to increase hunter participation are more likely to be cost-effective if targeted according to these geographic differences (e.g., activating urban hunters who live outside the core areas of the deer distribution range). Seemingly, reducing costs is the most important factor determining the participation of these hunters. Travel costs are outside the control of deer management; however, adjusting hunting fees and providing affordable accommodation may be strategies worth pursuing. In general, deer hunting in Norway is not considered particularly expensive compared with moose hunting (Andersen et al. 2011, Olaussen and Mysterud 2012). As indicated by inactive covariates in our analyses, easier access to information may also be a key to success (Fig. 4). However, if red deer expansion to the east and north accelerates, motivating the western hunters to travel could be a priority.

Based on previous research, hunting motivation varies largely among those aiming for meat, recreation, and/or trophies (Jenks et al. 2002, Martínez et al. 2005, Mysterud et al. 2006). The hunting culture in Norway, for example, is typically closer to meat and recreation rather than trophies, although the latter has been suggested to have increased in recent years (Naevdal et al. 2012). In our study, the trophy hunter was mainly represented by the deer enthusiasts, comprising only 13% of the hunters surveyed. Because the availability of trophies is biologically limited to the available age and sex structure produced by selective harvesting, these hunters are likely to be more difficult to satisfy if increased harvest of adult females is needed. The mixed visitors, on the other hand, consisted of hunters who do not have very strong preferences and therefore should be easier to motivate. These hunters are partly interested in team hunting, partly interested in trophy hunting, and unlike the rural-dominated deer enthusiasts, more likely to live in urban areas, where we found the best potential for recruiting new hunters. By contrast, trophy hunters in Poland (Mysterud et al. 2006) and Hungary (Rivrud et al. 2013) are typically foreign hunters with a high willingness to pay, whereas the local people more often target younger animals and females, which are more accessible at a lower price per license. Thus, in these countries, motivating the locals rather than the visitors would be more in accordance with a management goal of reduced deer populations. Because Norwegian citizens generally have a higher income compared with eastern Europe (worldsalaries.org, accessed 19 May 2014), using flexible hunting fees to adjust hunting intensity is less likely to be effective in this country. Nevertheless, the potential should be investigated.

Hunters in general can be classified along a need for meat axis and along a willingness to pay axis and a tradeoff may occur between willingness to pay and how much effort deer hunters are willing to put into harvesting their entire quota. For example, trophy hunters may be willing to pay large sums to target large males but may have no interest in paying for shooting females for population control purposes. In Scotland, the income from male deer is high, whereas the female harvest is actually a net cost for management (Clutton-Brock et al. 2002, Milner-Gulland et al. 2004). Although our results indicate that willingness to pay is positively related to interest in trophy hunting (an inactive covariate in the 3-class model; Fig. 3), it also confirms that those willing to pay the most (landowners acquaintance and the long-term visitors in this case) want yield dependent prices (i.e., they want value for their money).

To help increase hunter satisfaction, landowners may offer hunting access on a more discriminating basis. By aiming for a mixture of strategies within management units that complement each other, one may be able to absorb some of the impact of failing hunter recruitment. For example, one can separate areas within a management unit or a time period for single licenses (the solitary hunters) or shared quotas for team hunters, thus enabling maximization of hunter effort and offtake for a given management unit. One can also differentiate hunting fees over the season. One important point in this regard, is the finding that the solitary hunters in our study were almost exclusively living in rural areas within the main deer counties. Local hunters likely need less facilitation from the landowner, and therefore single licenses may be sold for a lower price. This would also be sensible based on our finding that local hunters had a lower willingness to pay. Furthermore, solitary hunters preferred to hunt fewer days, and therefore would occupy less of the season. One could possibly even accommodate a greater proportion of solitary hunters later in the season, particularly because the solitary hunters are less interested in trophies, thus the dilemma of pre-emptive use is less prevalent.

Hunters in our study who were not landowners or landowner acquaintances were more interested in long-term leasing hunting agreements. We may interpret this as a desire to secure hunting access. Long-term leasing, however, is not necessarily the best management solution to control dense populations because it provides less flexibility. Furthermore, with long-term leasing, the harvest rates depend on the same hunters year after year, and the efficiency range for a given hunter is limited (Foster et al. 1997, Boulanger et al. 2012).

Recent studies of hunter recruitment suggest a need to shift the focus toward older male hunters (Gude et al. 2012) rather than more traditional programs targeting young adults. However, our study indicates that older hunters who have left hunting are less likely to start again compared with younger hunters (inactive covariate D1; Fig. 4).Furthermore, emerging hunter groups may not be represented in our study, such as young small game hunters with growing interest in red deer hunting (Andersen et al. 2010).

MANAGEMENT IMPLICATIONS

In Norway, only 63% of the quotas for red deer harvest are actually filled (Statistics Norway 2012). Clearly, deer harvest is not solely limited by quotas but also by hunter effort. Therefore, ways to increase effort might lead to increased offtake of deer, enabling better regulation of growing deer populations. We urge landowners and managers in areas with undesirably dense deer populations to rethink the way hunting is organized and promoted. Generally, there is a need to be more flexible and accommodate a diverse group of hunters. An apparent strategy therefore is zone-based management, differentiating areas and time of season by the key factors determining hunter participation (in our study: location of residence, interest in trophies, willingness to pay, willingness to travel, sociality, landowner relations, and leasing agreements). By using the model variables in our study as indicators, local managers should be able to conduct simplified surveys to identify the prevalence of typologies in their area. By tailoring the local hunting opportunities accordingly, this information can be used pro-actively to increase hunter satisfaction.

Harvest policies need to give hunters incentives (e.g., reduced prices for licenses) to shoot antlerless deer and calves voluntarily, or simply require them to do so by implementing harvest regulations (Brown et al. 2000). The likely recruits typology in our study comprised 4 out of 5 non-active red deer hunters, and thus, there is a large potential to re-activate hunters not currently participating. Understanding the reasons why hunters become passive is of crucial importance (Enck et al. 2000). Factors that recruit new hunters are also an important part of the equation. Our study did not address these matters in much detail and a follow-up survey should be conducted.

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FIGURE CAPTIONS

Figure 1. (a) Number of red deer shot at the municipality level during the 2011–2012 hunting season and (b) national bag records for red deer from 1952–2012. Arrow indicates the year (1967) selective harvesting was implemented (Source: Statistics Norway 2013).

Figure 2. Variables segmenting active Norwegian deer hunters regarding motivation and hunting approach in 2011 (latent class analysis, *n* = 1,200 respondents). * denotes explanatory variables (i.e. significant part of model estimation), inactive covariates listed in light font (supportive information, not part of model estimation). Numbers in brackets are group means (see Table 2 for scales of variables). The 3-class scheme was the most supported model.

Figure 3. Variables segmenting active Norwegian deer hunters regarding logistical preferences in 2011 (latent class analysis, *n* = 1,200 respondents). * denotes explanatory variables (i.e. significant part of model estimation), inactive covariates listed in light font (supportive information, not part of model estimation). Numbers in brackets are group means (see Table 2 for scales of variables). The 3-class scheme was the most supported model.

Figure 4. Variables segmenting non-active Norwegian deer hunters in 2011 regarding future hunting participation (latent class analysis, *n* = 620 respondents). * denotes explanatory variables (i.e. significant part of model estimation), inactive covariates listed in light font (supportive information, not part of model estimation). Numbers in brackets are group means (see Table 2 for scales of variables). The 2-class scheme was the most supported model.

Tables

Table 1. Percent of Norwegian survey recipients surveyed in 2011 that responded and had no-response, and active versus non-active hunters among the respondents, by sex, age, education level, rural vs. urban residences, and hunting experience.

Variables	**% Response**	**% No-response**	**Total for response type (%)**	**% Active**	**% Non-active**	**Total for activity status (%)**
Females	4.9	5.2	151 (5)	3.7	7.2	90 (5)
16–25 yr	7.4	14.2	302 (10)	8.8	4.7	134 (7)
26–44 yr	35.1	43.2	1,148 (38)	35.4	34.3	638 (35)
45–66 yr	46.6	37.3	1,289 (43)	47.1	45.8	849 (47)
≥67 yr	10.9	5.3	261 (9)	8.7	15.1	199 (11)
Primary school	17.3	22.3	578 (19)	17.5	17.2	315 (17)
High school	57.1	59.2	1,738 (58)	58.9	55.0	1,040 (57)
College or University	24.8	18.0	664 (22)	23.5	27.8	452 (25)
Rural living	55.8	57.5	1,693 (56)	59.8	48.6	1,015 (56)
1–4 yr hunting experience	43.6	59.8	1,500 (50)	36.4	57.2	794 (44)
Total	1,820	1,180	3,000	1,200	620	1,820

Table 2. Latent variables used to identify deer hunter typologies in Norway in 2011 (categorical survey data, *n* = 1,820). Population estimates are presented as mean ± 1 standard error or proportions where applicable.

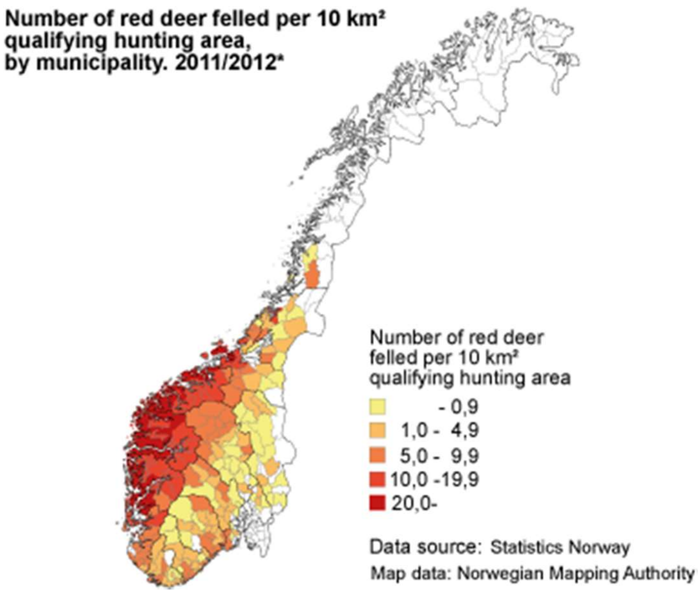
Variables	Scale	Population estimate
2. Hunting days per year	1–5 (1–5, 6–10, 11–15,16–20, 21+ days)	3.4 ± 0.03 (17 days/year)
5b. Hunting is important for keeping traditions	1–5 (1=disagree, 5=agree)	3.3 ± 0.03
5e. It is a moral duty to harvest	1–5 (1=disagree, 5=agree)	4.0 ± 0.02
9c. Not hunting because of lack of time	1–5 (1=disagree, 5=agree)	3.3 ± 0.07
10. Will hunt deer in future	1–2 (yes, no) (only non-active hunters)	1.3 ± 0.02 (64% yes)
11a. Guest hunting may facilitate participation	1–5 (1=disagree, 5=agree)	2.5 ± 0.07
11c. Will hunt if hunting gets less expensive	1–5 (1=disagree, 5=agree)	3.0 ± 0.06
11d. Needs more easily accessible information	1–5 (1=disagree, 5=agree)	3.0 ± 0.07
12. Willingness to travel (to hunting area)	1–7 (0, 1–2, 3–4, 5–6, 7–8, 9–10, 10+ hours)	2.6 ± 0.04 (4.7 hours)
15. Interest in winter hunting	0–3 (none, some, intermediate, high)	1.3 ± 0.03 (38% none)
24. Number of team members when deer hunting	0–4 (0, 1–3, 4–6, 7–9, 10+)	1.9 ± 0.04 (5 members)
26a. Obtains hunting through landowner relations	0–2 (none, is a landowner, landowner friend/relative)	1.2 ± 0.02 (55% is/knows landowners)
33. Yield (kg meat) needed to be satisfied	1–6 (<10, 11–20, 21–30, 31–40, 41–50, 50+ kg)	4.0 ± 0.05 (36 kg)
36b. Interest for hunting in county with few deer	0–11 (number of counties)	0.4 ± 0.03 (77% no interest)
37a. Wants long-term lease agreement	1–5 (1=disagree, 5=agree)	2.8 ± 0.04
37b. Wants short-term lease agreement	1–5 (1=disagree, 5=agree)	2.2 ± 0.04
37f. Wants trophy hunting	1–5 (1=disagree, 5=agree)	2.8 ± 0.04
37h. Wants large hunting quotas	1–5 (1=disagree, 5=agree)	4.0 ± 0.04
41. Want yield-dependent payment options	0–4 (0=do not know, 1=least and 4=most interested)	2.1 ± 0.04
42. Willingness to pay for deer hunting	1–7 (≤60, 70, 80, 90, 100, 110, ≥120 NOK[1]/kg meat)	2.4 ± 0.05 (84 NOK/kg)
45. Seeing versus shooting deer	−4–4 (<0=less, 0=equally, >0 more important)	0.6 ± 0.03 (11% less important)
D1. Age	1–5 (18–24, 25–34, 35–49, 50–64, 65+ years)	3.2 ± 0.04 (48 years)
D2. Urban or rural location of residence	1–2 (1=urban, 2=rural)	1.6 ± 0.01 (56% rural)
D3. Living in county with abundant deer	0–1 (no, yes)	0.8 ± 0.01 (79% in deer counties)
D4. Level of education	1–3 (1= primary school, 2=high school, 3=upper level)	2.1 ± 0.02 (25% upper level)

[1] 1 NOK =0.163 US$ or 0.12 €

Table 3. Latent class models for typologies among red deer hunters in Norway, based on 2011 survey data.. Shown is the most parsimonious variable set distinguishing types of active hunters by 1) motivation and hunting approach and 2) logistical preferences (active hunters, *n* = 1,200), and types of non-active hunters by 3) future hunting participation (non-active hunters, *n* = 620). Model significance can be assessed by likelihood-ratio goodness of fit in relation to the degrees of freedom (where L^2/df <1 indicates a significant model fit). A low Bayesian Information Criterion (BIC_{LL}) and classification error (class. error) indicate the optimal number of typology classes.

Variables in model	No. of classes	BIC_{LL}	L^2/df	df	Class. error
Motivation and hunting approach (active hunters)					
24. Number of team members when hunting	2	5.353	0.790	453	0.074
37f. Wants trophy hunting	3	5.369	0.756	447	0.153
2. Hunting days per day	4	5.401	0.753	441	0.217
D2. Urban or rural location of residence	5	5.431	0.749	435	0.203
D3. Living in county with abundant deer					
Logistical preferences (active hunters)					
37a. Wants long-term lease agreement	2	5.080	0.923	453	0.072
26a. Landowner relations	3	5.076	0.857	448	0.090
42. Willingness to pay for deer hunting	4	5.089	0.826	443	0.165
2. Hunting days per day	5	5.104	0.799	438	0.235
Future participation (non-active hunters)					
10. Will hunt deer in future	2	1.620	0.851	154	0.079
11c. If deer hunting gets less expensive	3	1.633	0.764	148	0.145
12. Travel willingness (to hunting area)	4	1.656	0.739	142	0.171
D2. Urban or rural location of residence	5	1.684	0.757	136	0.206
D3. Living in county with high-density deer					

a)


Number of red deer felled per 10 km²
qualifying hunting area,
by municipality. 2011/2012*
Number of red deer
felled per 10 km²
qualifying hunting area
- 0,9
1,0 - 4,9
5,0 - 9,9
10,0 -19,9
20,0-
Data source: Statistics Norway
Map data: Norwegian Mapping Authority

b)

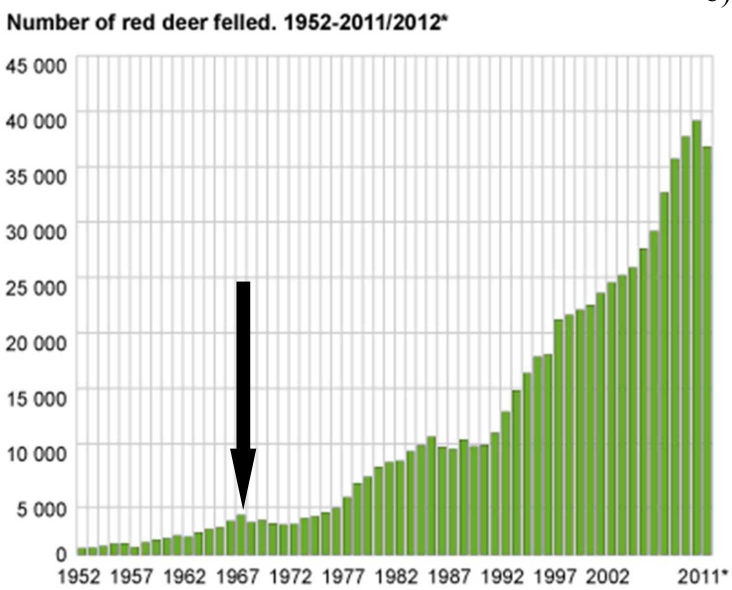

Number of red deer felled. 1952-2011/2012*
45 000
40 000
35 000
30 000
25 000
20 000
15 000
10 000
5 000
0
1952 1957 1962 1967 1972 1977 1982 1987 1992 1997 2002 2011*

Fig. 1

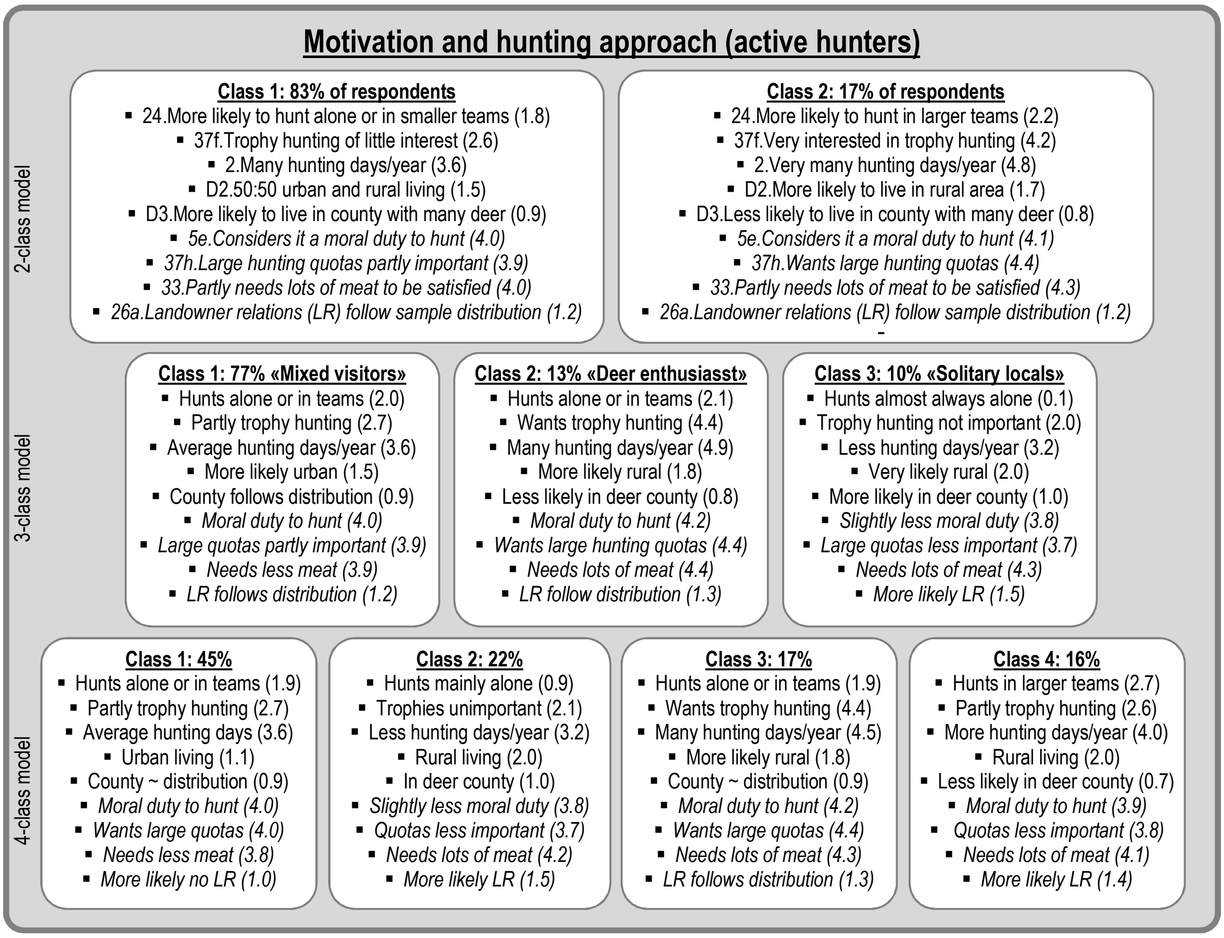

Motivation and hunting approach (active hunters)
2-class model
Class 1: 83% of respondents
▪ 24.More likely to hunt alone or in smaller teams (1.8)
▪ 37f.Trophy hunting of little interest (2.6)
▪ 2.Many hunting days/year (3.6)
▪ D2.50:50 urban and rural living (1.5)
▪ D3.More likely to live in county with many deer (0.9)
▪ 5e.Considers it a moral duty to hunt (4.0)
▪ 37h.Large hunting quotas partly important (3.9)
▪ 33.Partly needs lots of meat to be satisfied (4.0)
▪ 26a.Landowner relations (LR) follow sample distribution (1.2)
Class 2: 17% of respondents
▪ 24.More likely to hunt in larger teams (2.2)
▪ 37f.Very interested in trophy hunting (4.2)
▪ 2.Very many hunting days/year (4.8)
▪ D2.More likely to live in rural area (1.7)
▪ D3.Less likely to live in county with many deer (0.8)
▪ 5e.Considers it a moral duty to hunt (4.1)
▪ 37h.Wants large hunting quotas (4.4)
▪ 33.Partly needs lots of meat to be satisfied (4.3)
▪ 26a.Landowner relations (LR) follow sample distribution (1.2)
3-class model
Class 1: 77% «Mixed visitors»
▪ Hunts alone or in teams (2.0)
▪ Partly trophy hunting (2.7)
▪ Average hunting days/year (3.6)
▪ More likely urban (1.5)
▪ County follows distribution (0.9)
▪ Moral duty to hunt (4.0)
▪ Large quotas partly important (3.9)
▪ Needs less meat (3.9)
▪ LR follows distribution (1.2)
Class 2: 13% «Deer enthusiasst»
▪ Hunts alone or in teams (2.1)
▪ Wants trophy hunting (4.4)
▪ Many hunting days/year (4.9)
▪ More likely rural (1.8)
▪ Less likely in deer county (0.8)
▪ Moral duty to hunt (4.2)
▪ Wants large hunting quotas (4.4)
▪ Needs lots of meat (4.4)
▪ LR follow distribution (1.3)
Class 3: 10% «Solitary locals»
▪ Hunts almost always alone (0.1)
▪ Trophy hunting not important (2.0)
▪ Less hunting days/year (3.2)
▪ Very likely rural (2.0)
▪ More likely in deer county (1.0)
▪ Slightly less moral duty (3.8)
▪ Large quotas less important (3.7)
▪ Needs lots of meat (4.3)
▪ More likely LR (1.5)
4-class model
Class 1: 45%
▪ Hunts alone or in teams (1.9)
▪ Partly trophy hunting (2.7)
▪ Average hunting days (3.6)
▪ Urban living (1.1)
▪ County ~ distribution (0.9)
▪ Moral duty to hunt (4.0)
▪ Wants large quotas (4.0)
▪ Needs less meat (3.8)
▪ More likely no LR (1.0)
Class 2: 22%
▪ Hunts mainly alone (0.9)
▪ Trophies unimportant (2.1)
▪ Less hunting days/year (3.2)
▪ Rural living (2.0)
▪ In deer county (1.0)
▪ Slightly less moral duty (3.8)
▪ Quotas less important (3.7)
▪ Needs lots of meat (4.2)
▪ More likely LR (1.5)
Class 3: 17%
▪ Hunts alone or in teams (1.9)
▪ Wants trophy hunting (4.4)
▪ Many hunting days/year (4.5)
▪ More likely rural (1.8)
▪ County ~ distribution (0.9)
▪ Moral duty to hunt (4.2)
▪ Wants large quotas (4.4)
▪ Needs lots of meat (4.3)
▪ LR follows distribution (1.3)
Class 4: 16%
▪ Hunts in larger teams (2.7)
▪ Partly trophy hunting (2.6)
▪ More hunting days/year (4.0)
▪ Rural living (2.0)
▪ Less likely in deer county (0.7)
▪ Moral duty to hunt (3.9)
▪ Quotas less important (3.8)
▪ Needs lots of meat (4.1)
▪ More likely LR (1.4)

Fig. 2

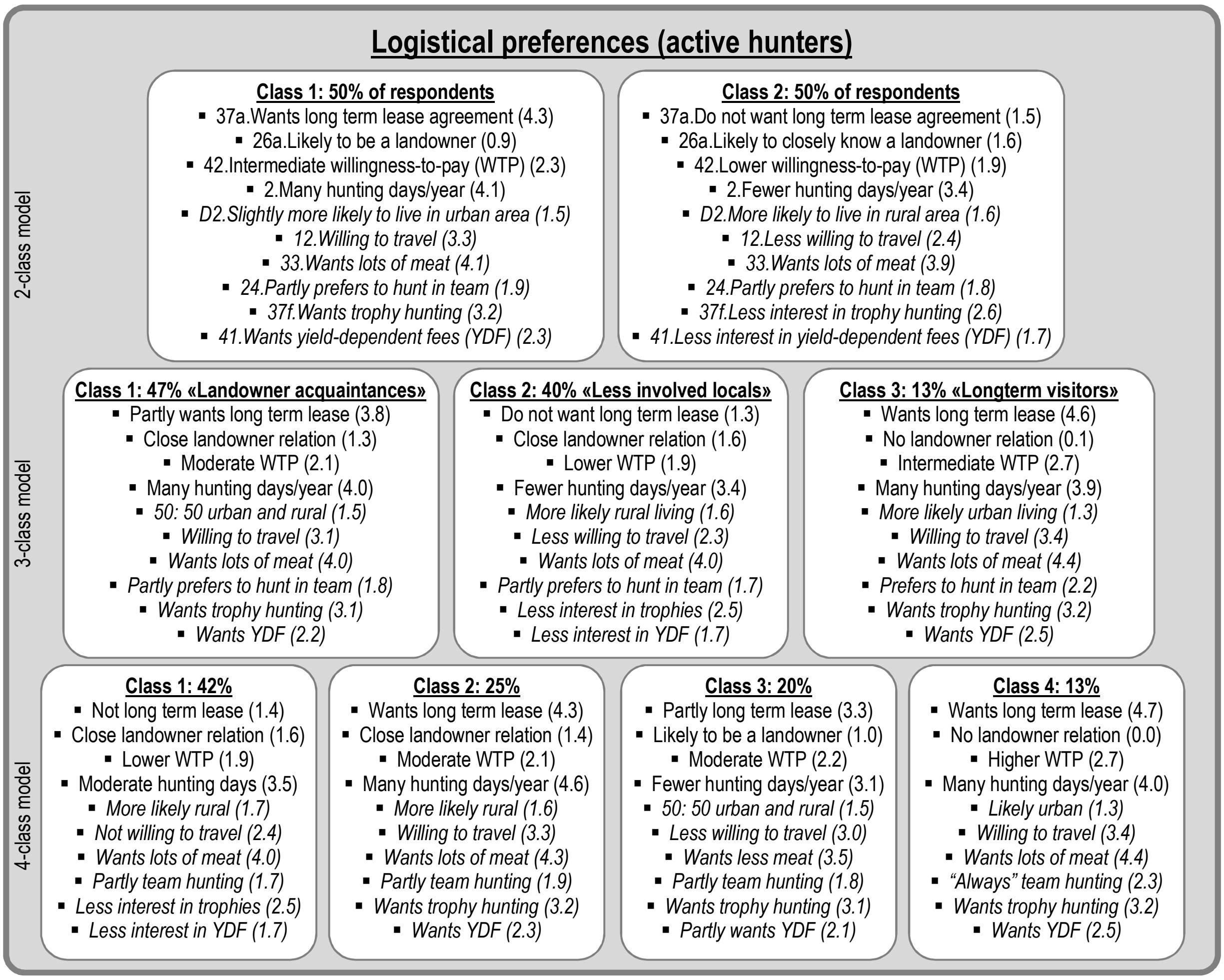

Logistical preferences (active hunters)
2-class model
Class 1: 50% of respondents
37a.Wants long term lease agreement (4.3)
26a.Likely to be a landowner (0.9)
42.Intermediate willingness-to-pay (WTP) (2.3)
2.Many hunting days/year (4.1)
D2.Slightly more likely to live in urban area (1.5)
12.Willing to travel (3.3)
33.Wants lots of meat (4.1)
24.Partly prefers to hunt in team (1.9)
37f.Wants trophy hunting (3.2)
41.Wants yield-dependent fees (YDF) (2.3)
Class 2: 50% of respondents
37a.Do not want long term lease agreement (1.5)
26a.Likely to closely know a landowner (1.6)
42.Lower willingness-to-pay (WTP) (1.9)
2.Fewer hunting days/year (3.4)
D2.More likely to live in rural area (1.6)
12.Less willing to travel (2.4)
33.Wants lots of meat (3.9)
24.Partly prefers to hunt in team (1.8)
37f.Less interest in trophy hunting (2.6)
41.Less interest in yield-dependent fees (YDF) (1.7)
3-class model
Class 1: 47% «Landowner acquaintances»
Partly wants long term lease (3.8)
Close landowner relation (1.3)
Moderate WTP (2.1)
Many hunting days/year (4.0)
50: 50 urban and rural (1.5)
Willing to travel (3.1)
Wants lots of meat (4.0)
Partly prefers to hunt in team (1.8)
Wants trophy hunting (3.1)
Wants YDF (2.2)
Class 2: 40% «Less involved locals»
Do not want long term lease (1.3)
Close landowner relation (1.6)
Lower WTP (1.9)
Fewer hunting days/year (3.4)
More likely rural living (1.6)
Less willing to travel (2.3)
Wants lots of meat (4.0)
Partly prefers to hunt in team (1.7)
Less interest in trophies (2.5)
Less interest in YDF (1.7)
Class 3: 13% «Longterm visitors»
Wants long term lease (4.6)
No landowner relation (0.1)
Intermediate WTP (2.7)
Many hunting days/year (3.9)
More likely urban living (1.3)
Willing to travel (3.4)
Wants lots of meat (4.4)
Prefers to hunt in team (2.2)
Wants trophy hunting (3.2)
Wants YDF (2.5)
4-class model
Class 1: 42%
Not long term lease (1.4)
Close landowner relation (1.6)
Lower WTP (1.9)
Moderate hunting days (3.5)
More likely rural (1.7)
Not willing to travel (2.4)
Wants lots of meat (4.0)
Partly team hunting (1.7)
Less interest in trophies (2.5)
Less interest in YDF (1.7)
Class 2: 25%
Wants long term lease (4.3)
Close landowner relation (1.4)
Moderate WTP (2.1)
Many hunting days/year (4.6)
More likely rural (1.6)
Willing to travel (3.3)
Wants lots of meat (4.3)
Partly team hunting (1.9)
Wants trophy hunting (3.2)
Wants YDF (2.3)
Class 3: 20%
Partly long term lease (3.3)
Likely to be a landowner (1.0)
Moderate WTP (2.2)
Fewer hunting days/year (3.1)
50: 50 urban and rural (1.5)
Less willing to travel (3.0)
Wants less meat (3.5)
Partly team hunting (1.8)
Wants trophy hunting (3.1)
Partly wants YDF (2.1)
Class 4: 13%
Wants long term lease (4.7)
No landowner relation (0.0)
Higher WTP (2.7)
Many hunting days/year (4.0)
Likely urban (1.3)
Willing to travel (3.4)
Wants lots of meat (4.4)
"Always" team hunting (2.3)
Wants trophy hunting (3.2)
Wants YDF (2.5)

Fig. 3

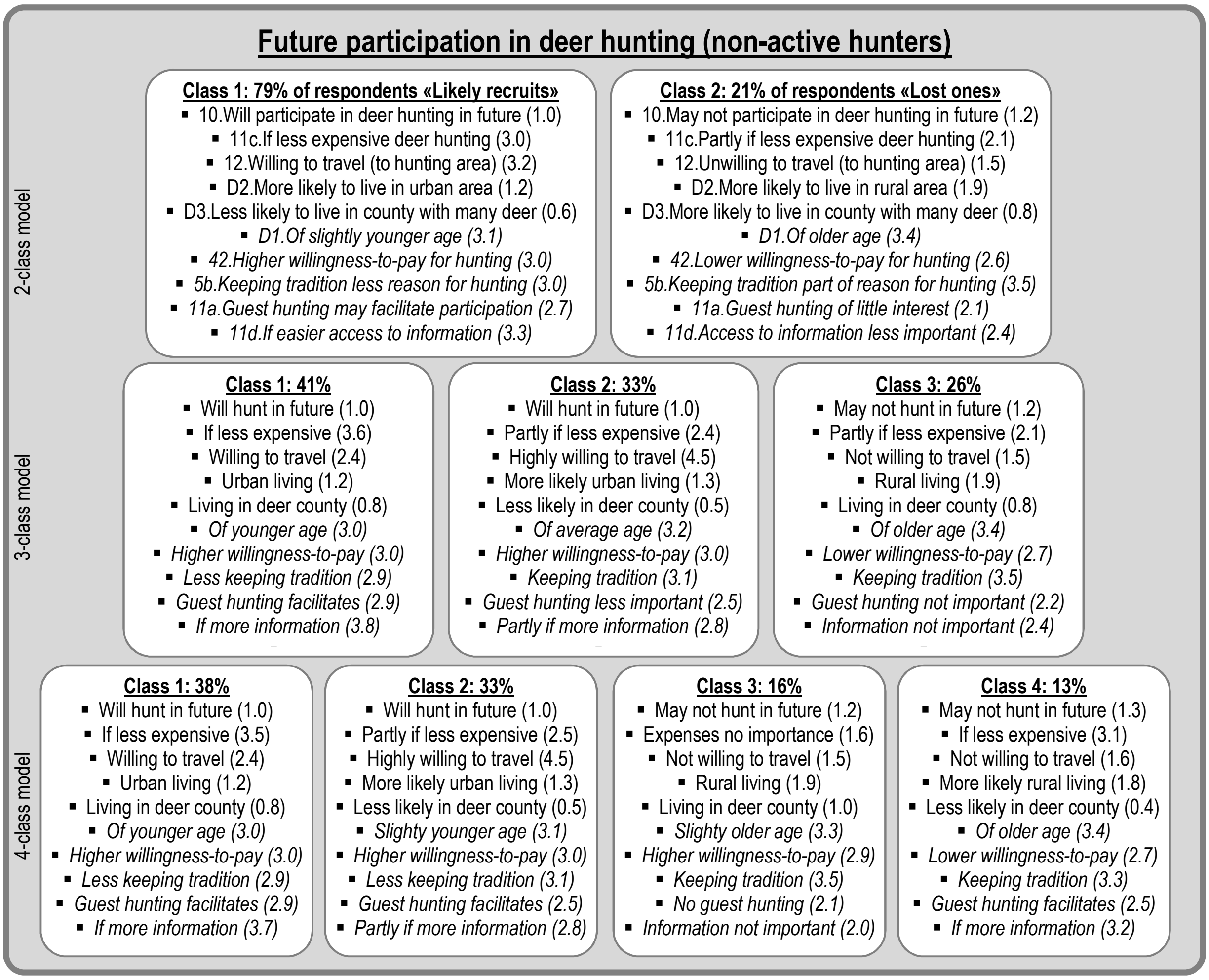

Future participation in deer hunting (non-active hunters)
2-class model
Class 1: 79% of respondents «Likely recruits»
10.Will participate in deer hunting in future (1.0)
11c.If less expensive deer hunting (3.0)
12.Willing to travel (to hunting area) (3.2)
D2.More likely to live in urban area (1.2)
D3.Less likely to live in county with many deer (0.6)
D1.Of slightly younger age (3.1)
42.Higher willingness-to-pay for hunting (3.0)
5b.Keeping tradition less reason for hunting (3.0)
11a.Guest hunting may facilitate participation (2.7)
11d.If easier access to information (3.3)
Class 2: 21% of respondents «Lost ones»
10.May not participate in deer hunting in future (1.2)
11c.Partly if less expensive deer hunting (2.1)
12.Unwilling to travel (to hunting area) (1.5)
D2.More likely to live in rural area (1.9)
D3.More likely to live in county with many deer (0.8)
D1.Of older age (3.4)
42.Lower willingness-to-pay for hunting (2.6)
5b.Keeping tradition part of reason for hunting (3.5)
11a.Guest hunting of little interest (2.1)
11d.Access to information less important (2.4)
3-class model
Class 1: 41%
Will hunt in future (1.0)
If less expensive (3.6)
Willing to travel (2.4)
Urban living (1.2)
Living in deer county (0.8)
Of younger age (3.0)
Higher willingness-to-pay (3.0)
Less keeping tradition (2.9)
Guest hunting facilitates (2.9)
If more information (3.8)
Class 2: 33%
Will hunt in future (1.0)
Partly if less expensive (2.4)
Highly willing to travel (4.5)
More likely urban living (1.3)
Less likely in deer county (0.5)
Of average age (3.2)
Higher willingness-to-pay (3.0)
Keeping tradition (3.1)
Guest hunting less important (2.5)
Partly if more information (2.8)
Class 3: 26%
May not hunt in future (1.2)
Partly if less expensive (2.1)
Not willing to travel (1.5)
Rural living (1.9)
Living in deer county (0.8)
Of older age (3.4)
Lower willingness-to-pay (2.7)
Keeping tradition (3.5)
Guest hunting not important (2.2)
Information not important (2.4)
4-class model
Class 1: 38%
Will hunt in future (1.0)
If less expensive (3.5)
Willing to travel (2.4)
Urban living (1.2)
Living in deer county (0.8)
Of younger age (3.0)
Higher willingness-to-pay (3.0)
Less keeping tradition (2.9)
Guest hunting facilitates (2.9)
If more information (3.7)
Class 2: 33%
Will hunt in future (1.0)
Partly if less expensive (2.5)
Highly willing to travel (4.5)
More likely urban living (1.3)
Less likely in deer county (0.5)
Slighty younger age (3.1)
Higher willingness-to-pay (3.0)
Less keeping tradition (3.1)
Guest hunting facilitates (2.5)
Partly if more information (2.8)
Class 3: 16%
May not hunt in future (1.2)
Expenses no importance (1.6)
Not willing to travel (1.5)
Rural living (1.9)
Living in deer county (1.0)
Slighty older age (3.3)
Higher willingness-to-pay (2.9)
Keeping tradition (3.5)
No guest hunting (2.1)
Information not important (2.0)
Class 4: 13%
May not hunt in future (1.3)
If less expensive (3.1)
Not willing to travel (1.6)
More likely rural living (1.8)
Less likely in deer county (0.4)
Of older age (3.4)
Lower willingness-to-pay (2.7)
Keeping tradition (3.3)
Guest hunting facilitates (2.5)
If more information (3.2)

Fig. 4