Grouse Hunting Regulations and Hunter Typologies in Norway

Hilde K. Wam, Oddgeir Andersen and Hans Chr. Pedersen

Author Note

Hilde K. Wam, Department of Ecology and Natural Resource Management, Norwegian University of Life Sciences.

Oddgeir Andersen, Human Dimension Department, Norwegian Institute for Nature Research.

Hans Chr. Pedersen, Terrestrial Ecology Department, Norwegian Institute for Nature Research; Department of Forestry and Wildlife Management, Hedmark University College.

This research was supported by the Norwegian Research Council, program Nature-based industry, grant 176321.

Correspondence concerning this article should be addressed to Hilde K. Wam, Department of Ecology and Natural Resource Management, Norwegian University of Life Sciences, Box 5003, 1432 Ås, Norway. E-mail: hilde.wam@bioforsk.no

Abstract

Game management relies on satisfied hunters. Satisfaction determinants are, however, seldom uniform across the whole hunter segment and may therefore be difficult to accommodate. Latent class analysis (LCA) is a probabilistic model-based approach to categorizing hunter typologies by, for example, their attitudes and preferences. We applied LCA to large-scale survey data relating to grouse hunting regulations in Norway (3,293 respondents). We identified three typologies with regard to *importance of bag size* (the "Experience Seeker" 43%, "Bag Oriented" 32% and "Northern Traditionalist" 25%) as well as *crowding tolerance* (the "Semi-tolerant Mainstream" 86%, "Altruistic Compatriot" 10% and "Passionate Crowd-avoiding" 4%), but we could not find a set of typologies that conformed uniformly across the two. The potential and limitation of using hunter typologies in game management is discussed in an applied context. Broadly summarized, typologies are valuable for tailoring local hunting regulations, provided their actual distribution is identified at the appropriate scale.

Key-words: bag limit, game, harvest, willingness-to-pay, ptarmigan

Declining grouse populations is a pressing management issue worldwide (Storch, 2007). The underlying causes are complex, and while no study has yet identified one single factor that explains the declines at larger spatial scales, the most prominent threat seems to be habitat loss, degradation and fragmentation (e.g., Webb, Boarman, & Rotenberry, 2004; Marzluff & Neatherlin, 2006): changes that are long-lasting and not easily reversed. Additionally, we see growing evidence that game-bird hunting may be more additive to other causes of mortality than previously thought (Smith & Willebrand, 1999; Pedersen et al., 2004; Pöysä et al., 2004; Sandercock, Nilsen, Brøseth, & Pedersen, 2011; Connelly, Hagen, & Schroeder, 2011; but see also Sedinger, White, Espinosa, Partee, & Braun, 2010).

It thus seems clear that harvest regulations are inevitable for mitigating grouse population declines. Management agencies then face a partly conflicting quest; they must achieve the ecological goal without overly restricting hunting opportunities and thereby jeopardize hunter satisfaction. Grouse hunting has a considerable socioeconomic impact. Norway, for example, has about 55,000 ptarmigan hunters (out of a population of 4.8 million people; Statistics Norway, 2010a), and they annually spend approximately €1,200 each on activities directly related to grouse hunting (Pedersen, & Karlsen, 2007; Storm, 2007; Andersen et al., 2009).

As initiated by Hendee (1974), hunter satisfaction has many components and is therefore best looked at by a "multiple-satisfaction approach" (e.g. Hazel, Langenau, & Levine, 1990; Woods, Guynn, Hammitt, & Patterson, 1996; Frey, Conover, Borgo, & Messmer, 2003; Hayslette, Armstrong, & Mirarchi, 2001, Manfredo, Fix, & Teel, 2004; Schroeder, Fulton & Lawrence, 2006). This extensive literature shows that satisfaction determinants are seldom uniform across the whole hunter segment, and that hunters can typically be more or less clearly grouped into what we call hunter typologies.

The concept of typologies is statistically challenging because it normally consists of unobservable qualitative variables that may only be indirectly identified through related stated manifests (Goodman, 1974). An increasingly popular method for treating this kind of data is latent class analysis (LCA) (Dean, & Raftery, 2010). Compared to traditional clustering methods based on Euclidean distance (such as the prevalent *K*-means method), LCA clustering is based on distributional probability—involving less arbitrarily set cluster criteria and more rigorous statistical testing (Magidson, & Vermunt, 2002). With this model based approach we can, for example, set up formal tests using Bayesian techniques to check the validity of our findings (for a general introduction, see Hagenaars & McCutcheon, 2002).

In this study, we used LCA clustering to identify typologies among Norwegian grouse hunters based on a combination of attitudinal data and willingness-to-pay collected in a nationwide survey. Our aim was to establish hunter typologies specifically to aid in the implementation of harvest regulations. Although the subject of general hunter typologies has been thoroughly covered over a number of decades, few studies have applied the theory to a specific game management problem. One notable example is Ward, Stedman, Luloff, Shortle, and Finley (2008): a study that identified two main typologies among deer hunters in Pennsylvania and determined that "Deer-Damage Managers" would be more useful than the "No-Damage Traditionalists" for counteracting the prevalent deer overabundance in the area.

Game harvesting can only be regulated in two ways: 1) Controlling the number of hunting permits and/or 2) Controlling the yield taken by each hunter. In terms of hunter satisfaction, these strategies relate to the hunters' *crowding tolerance* and how hunters rate the *importance of bag size*, respectively. Consequently, these are the two main themes addressed in this study. While crowding may be considered part of the bag size (more hunters generally means fewer birds available per hunters, given the same total quota), crowding should also be assessed independent of bag size as it includes other aspects that relate to hunter satisfaction

(like experiencing solitude and safety concerns). If hunters comprise distinct typologies with different preferences, game managers may use this knowledge to tailor hunting regulations more precisely.

Method

Recipient Sample

Invitations to take part in the survey were sent by personalized e-mail letters to all those who had applied electronically for grouse hunting permits through the two large public agencies "Norwegian State-Owned Land and Forest Enterprise" and "The Finnmark Estate" (together managing roughly 50% of all outfields in Norway). The original e-mail invitation was sent 25/05/2010, a reminder was sent 09/09/2010, and the survey was closed 01/10/2010. The majority of the respondents (83%) completed the questionnaire prior to the reminder. We sent 8,129 invitations, of which 256 were negated because of failed delivery. Of the remaining 7,873 hunters who were invited, 3,127 participated (response rate 40%). Prior to the analyses we omitted 20 foreign, blank or irrational questionnaires (e.g., age = 110 years).

In addition to the direct e-mails, open invitations to participate in the survey were posted on various Norwegian web-sites related to hunting. An e-mail filter was used to make sure only new respondents participated. Standard descriptive analyses of the response data did not reveal any deviations between the internet participants (N = 186) and those invited by e-mail, and therefore the two samples are pooled in this study.

Questionnaire

The questionnaire was built with a digital platform provided and administered online by QuestBack Ask&Act^{TM} (Oslo, Norway). It consisted of 26 main questions, arranged in a semi-structured frame of three sections. The first section contained simple questions about demography and hunting habits. A middle section contained the more complex questions addressing attitudes and willingness-to-pay, largely through the use of what-if scenarios. We

set the answering format for numerical and complex attitudinal questions as open-ended to avoid scale bias (Mitchell & Carson, 1989), and simple categorical questions as closed (tick boxes and balanced 4- or 5-point Likert scales). Topics that we deemed particularly difficult were addressed twice in two different questions (reverse-keying).

No questions were made mandatory, and when relevant, the respondent had the option of choosing "unknown" or "other, please specify". The majority of the respondents in our survey completed most of the questionnaire: 59% answered all of the 26 questions, 22% left out 1-2 questions and 8% left out 3-4 questions.

Data Analyses

The survey generated 25 variables of relevance for this study (the survey was not exclusively conducted to do the typology study, and contained for example detailed information about the terrains used by the hunters within the last five years). For those questions that had been addressed twice, we checked for positive correlation and omitted the question with the lowest standard deviation as these are less likely to detect distinct typologies (Dean, & Raftery, 2010). Continuous variables were transformed into <10 categories. To ease the subsequent discussion of results, variables were categorized as either characterizing (addressing demography and hunting habits) (Table 1) or attitudinal (Table 2).

It is normally recommended that LCA are conducted top-down, beginning with full models and refining these by removing variables that are not useful (Vermunt, & Magidson, 2004). However, in our case the number of variables needed to be reduced to make the practical procedure feasible (25 variables comprise millions of possible models). We therefore did preliminary LCA by systematically running blocks of 3-5 attitudinal variables against all possible combinations of characterizing variables. Five characterizing variables were nonsignificant in all such partial models and omitted from the dataset (C2-C5, Table 1). We then looked similarly at the attitudinal variables only: Starting out with those three having the

highest variance and going systematically back-and-forth with inclusion and exclusion of variables (a nonsignificant variable may be significant at a lower of nested models, Dean & Raftery, 2010). Five nonsignificant attitudinal variables were omitted (A1d-e, A6-A8, Table 2). The 15 remaining variables were used in a final LCA starting from the full model, and following the exploratory inclusion-exclusion procedure. Variables that were correlated were not simultaneously included in a model (e.g., 'number of hunting days/year' and 'hunts grouse also in Nov-Jan', $r = 0.425$, df = 3,271, $P \leq 0.001$).

We used the likelihood-ratio goodness of fit in relation to the degrees of freedom ($L^2 >$ df indicates a good model fit, Vermunt & Magidson, 2005) and classification errors to determine if a variable contributed significantly to a model. When the final set of significant models had been determined, we also used these statistics as well as the log-likelihood Bayesian Information Criterion (BIC_{LL}) to rank model parsimony and to select the optimal number of latent classes. Since our purpose was mainly identification and not prediction, we chose BIC over Akaike's Information Criterion (AIC) because of BIC's stronger penalty for additional parameters (Clarke, Fokoué, & Zhang, 2009).

For the LCA we used the cluster analysis available in Latent GOLD® (version 4.5, Windows XP). All remaining statistics were run in Minitab® 15 (Minitab Inc. 2007). Measurements of central tendency are given as mean ± 1 SE unless stated otherwise (the median is given when the data strongly deviated from the normal distribution).

Results

Respondent Characteristics

The 3,293 grouse hunters that participated in the survey were slightly overrepresented by hunters from northern versus central Norway (Figure 1), but the geographical distribution overall followed that of registered ptarmigan hunters in Norway (Statistics Norway, 2010b) ($\chi^2 = 19.4$, df = 4, $P \leq 0.001$). The large majority of our respondents were men (95%), as are

all registered hunters in Norway (94%). Their average gross income was €61,320, which is equal to the general income for Norwegian men (€58,054 Statistics Norway, 2009).

Of the total 18,435 'hunting years' the respondents collectively reported to have had during 2005-09, 82% included buying hunting permits on public land, 6% leasing private terrains and 11% hunting for free. As many as 79% of the hunting days occurred in September and October (the Norwegian season runs from September 10 to March 15).

Hunter Typologies

The characterizing and attitudinal variables used to identify hunter typologies are summarized collectively for all the respondents in Tables 1 and 2. Of the 15 variables used in the final LCA, ten were part of the most parsimonious models (Table 3). A noticeable effect, however, was that the variables addressing *importance of bag size* and *crowding tolerance* were not simultaneously included in any of the best models. We therefore present typologies for the two key attitudes separately:

Importance of Bag Size. Although the BIC values were slightly lower for some of the models with four or five typology classes, the 3-class models all had the lowest classification errors. Since the drop in the BIC was marked when going from two to three typologies, and then leveled out when going from three to four typologies, we consider the 3-class models to be equally parsimonious, and even better in terms of practical interpretation.

We therefore labeled three hunter typologies with regard to *importance of bag size* (Figure 2A): "The Bag Oriented" (class 1), "The Northern Traditionalist" (class 2) and "The Experience Seeker" (class 3), and these made up 32%, 25% and 43% of the respondents, respectively. Broadly summarized, "The Bag Oriented" was the most eager in terms of hunting days and willingness-to-pay for larger bags, while "The Experience Seeker" was satisfied with lower bags and fewer hunting days. "The Northern Traditionalist" resembled "The Bag Oriented" in terms of hunting days, but with a much lower willingness-to-pay.

Crowding Tolerance. The selection of number of hunter typology classes was less clear-cut for *crowding tolerance*. Generally, both the BIC values and the classification errors differed only slightly between the 3- and 4-class models. We prefer the 3-class models for its relative simplicity, and therefore labeled three hunter typologies with regard to *crowding tolerance*: "The Semi-tolerant Mainstream" (class 1), "The Passionate Crowd-avoiding" (class 2) and "The Altruistic Compatriot" (class 3), making up approximately 86%, 4% and 10% of the respondents (Figure 2B).

Discussion

The interpretation of attitudinal latent segments should not be too stringent, as groups of people behave differently depending on the problem at hand (Goodman, 2002). This was aptly illustrated by the only partial overlap in variables included in the best models for our two key groups of attitudes. Consequently, the respective typologies we identified regarding *importance of bag size* and *crowding tolerance* did not consistently contain the same individual hunters. Thus, studies identifying latent segments within such a varied group as grouse hunters are likely to be more successful if they are target-specific rather than general.

Of the three typologies identified in our study with regard to *importance of bag size*, "The Bag Oriented" conforms to the most conventional hunter type whose motivation for being a hunter is mainly consumptive. "The Experience Seeker" represents a culturally newer generation, and is hunting mainly for appreciative reasons. These two are the furthest apart on the functional – hedonistic gradient of nature views, where the latter seems to steadily replace the former throughout Europe because of increased urbanization (Buijs, Pedroli, & Luginbühl, 2006). Conformingly, there were more experience seekers than bag oriented hunters even among our respondents.

For *crowding tolerance*, inclusion of any willingness-to-pay or bag related variables had negligible effects on the LCA models. This may indicate that crowding did not significantly

affect the respondents' valuation of bag size, which is further supported by the finding that 85% of them were "Semi-tolerant mainstream". If so, this is good news, as a strong limitation of hunting permits may not always be socioeconomic viable in game management. On public land in Norway, game managers have an obligation to offer people access to small game hunting. It should be noted, however, that while the hunters were quite tolerant, their tolerance clearly decreased with encounter rate and is therefore not inexhaustible.

Another interesting finding regarding *crowding tolerance* was that mainly northern hunters were identified as "The Altruistic compatriot". Allegedly altruism is easier when resources are plentiful (Hamilton, 1964), as is the case in the rural northern parts of Norway versus the more developed south. However, the northern region has more visiting hunters (approximately two thirds of the hunters), and the local hunters may not be equally tolerant to all hunter segments. Comments such as "*nonlocal hunters are coming in with dogs to vacuum-clean the terrain at the start of the season*" were frequently given by northern hunters in the open commentary fields in the questionnaire. Their tolerance may not be founded in altruism at all, but rather originate from a wish to generate local income (Willebrand, 2009).

At what scale will our hunter typologies be representative of the hunting population in a given area? Since the respondents were drawn from a nationwide sample, their typologies should apply to the general grouse hunters in Norway. One potential source of bias is that survey invitations were only sent to hunters who had bought a hunting permit electronically. While the internet coverage in Norway currently runs as high as 92% of all households (Statistics Norway 2011), there likely are socioeconomic discrepancies between those who buy their hunting permits on the internet and those still buying it on paper only (Solomon, 2001). By all likelihood, however, the latter hunters conform to either one of the identified typologies, and so the eventual bias would only affect the distribution of hunters among typologies. Local distribution of typologies may also differ from our nationwide sample.

Ideally, managers who wish to use the typologies for applied purposes at smaller scales should first identify the distribution locally.

For a study of latent segments to be deemed successful, the expressed attitudes must also be adequate depictions of the true attitudes. According to Baumgartner and Steenkamp (2001), the most common biases are: (dis)acquiescence (automatically (dis)agreeing with statement as presented), carelessness (for example due to lack of motivation), central tendency (systematically avoiding extremes), extreme tendency (for example to gain stronger influence) and desirability (pretending to be better than one are). Our majority of open-ended questions and lack of mandatory questions should largely have eliminated the first three. The last two, on the other hand, may have applied to our respondents. Their influence on categorical clustering should be weak, though, since both are amplifications of—rather than directional deviations from—the respondent's true attitude. Either way, the high number of respondents is likely to counterbalance the effects of a few cases of deliberate response styling.

Both 3- and 4-class models were statistically defensible in our study, and it is arguable which number of classes is preferential in an applied context. The main change when going from three to four classes was a further splitting of already small groups. We doubt a management regime can be sufficiently fine-tuned to specifically tailor for 3% of the hunter segment. Small typology classes still have theoretical value, though. Groups that are small today may be large tomorrow, and LCA clustering can be used to identify changes in typology distributions over time (Magidson, & Vermunt, 2004).

How can our typology study be useful for determining optimal implementation of harvest regulations? This is best illustrated by turning the question around: if harvest regulations are set based on an average type of hunter, they may end up reducing too much of the hunting opportunities (and hence, hunter satisfaction) to no avail. In an area with mainly

“Experience seekers”, for example, it may be wiser to keep a low bag limit than to reduce the number of permits. Large properties that can offer a wider range of hunting options may also use the typologies to channel different people to specific areas, such as “The Bag Oriented” to where there are the most shooting opportunities. The socioeconomic benefit of such a diversified management regime should be investigated further using, for example, bioeconomic models focusing on how to optimize the number of hunters given various harvest quotas.

References

Andersen, O., Kaltenborn, B. P., Pedersen, H. C., Storaas, T., Faye-Schjøll, E., & Solvang, H. (2009). Survey among willow ptarmigan hunters after hunting season 2006/07. Data and key findings from The Grouse Management Project 2006-2011. *NINA Report,* 379, 1-44. (English abstract)

Baumgartner, H., & Steenkamp, J.-B. (2001). Response styles in marketing research: a cross-national investigation. *Journal of Marketing Research,* 38, 143-156.

Bujis, A. E., Pedroli, B., & Luginbühl, Y. (2006). From hiking through farmland to farming in a leisure landscape: changing social perceptions of the European landscape. *Landscape Ecology,* 21, 375-389.

Clarke, B., Fokoué, E., & Zhang, H. H. (2009). *Principles and theory for data mining and machine learning*. New York: Springer Press.

Dean, N., & Raftery, A. E. (2010). Latent class anaysis variable selection. *Annals of the Institute of Statistical Mathematics*, 62, 11-35.

Frey, S. N., Conover, M. R., Borgo, J. S., & Messmer, T. A. (2003). Factors influencing pheasant hunter harvest and satisfaction. *Human Dimensions of Wildlife,* 8, 277-286.

Goodman, L. A. (1974). The analysis of systems of qualitative variables when some of the variables are unobservable. Part I-A Modified latent structure approach. *American Journal of Sociology,* 79, 1179-1259.

Goodman, L. A. (2002). Latent class analysis: the empirical study of latent types, latent variables and latent structures. In Hagenaars, J. A., & A. L. McCutcheon (Eds.), *Applied latent class analysis* (pp. 3-55). Cambridge: Cambridge University Press.

Hagenaars, J., & McCutcheon, A. (2002). *Applied latent class analysis models*. New York: Cambridge University Press.

Hamilton ,W. D. (1964). The genetical evolution of social behaviour I and II. *Journal of Theoretical Biology,* 7, 1-16 and 17-52.

Hayslette, S. E., Armstrong, J. B., & Mirarchi, R. E. (2001). Mourning dove hunting in Alabama: motivations, satisfactions, and sociocultural influences. *Human Dimensions of Wildlife,* 6, 81-95.

Hazel, K. L., Langenau, E. E., & Levine, R. L. (1990). Dimensions of hunting satisfaction: multiple-satisfactions of wild turkey hunting. *Leisure Sciences,* 12, 383-393.

Hendee, J. C. (1974). A multiple-satisfaction approach to game management. *Wildlife Society Bulletin,* 2, 104-113.

Magidson, J., & Vermunt, J. K. (2002). Latent class models for clustering: A comparison with K-means. *Canadian Journal of Marketing Research,* 20, 37-44.

Magidson, J., & Vermunt, J. K. (2004). Latent class models. In D. Kaplan (ed.), The Sage Handbook of Quantitative Methodology for the Social Sciences. 175-198. Thousand Oaks, Sage Publications.

Manfredo, M. J., Fix, P. J., & Teel, T. L. (2004). Assessing demand for big-game bunting opportunities: applying the multiple-satisfaction concept. *Wildlife Society Bulletin,* 32, 1147-1155.

Marzluff, J. M., & Neatherlin, E. (2006). Corvid response to human settlements and campgrounds: causes, consequences, and challenges for conservation. *Biological Conservation,* 130, 301-314.

Mitchell, R., & Carson, R. (1989). Using surveys to value public goods: The contingent valuation method. Washington: Resources for the Future.

Pedersen, H. C., Steen, H., Kastdalen, L., Brøseth, H., Ims, R. A., Svendsen, W., & Yoccoz, N. G. (2004). Weak compensation of harvest despite strong density-dependent growth in willow ptarmigan. *Proceedings Royal Society London Series B,* 271, 381-385.

Pedersen, H. C., & Karlsen, D. H. (2007). *Alt om rypa: biologi, jakt og forvaltning*. Oslo: Tun forlag AS. (in Norwegian)

Pöysä, H., Elmberg, J., Gunnarsson, G., Nummi, P., Sjöberg, G. G., & Sjöberg, K. (2004). Ecological basis of sustainable harvesting: is the prevailing paradigm of compensatory mortality still valid? *Oikos,* 104, 612-615.

Connelly, J. W., Hagen, C. A., & Schroeder, A. (2011). Characteristics and dynamics of Greater Sage-Grouse populations. In S. T. Knick & J. W. Connelly (Eds.), *Greater Sage-Grouse: Ecology and conservation of a landscape species and its habitats* (pp. 53-67). Berkeley: Studies in Avian Biology Series (vol. 38), University of California Press.

Sandercock, B. K., Nilsen, E. B., Brøseth, H., & Pedersen, H. C. (2011). Is hunting mortality additive or compensatory to natural mortality? Effects of experimental harvest on the survival and cause-specific mortality of willow ptarmigan. *Journal of Animal Ecology,* 80, 244-258.

Schroeder, S. A., Fulton, D. C., & Lawrence, J. S. (2006). Managing for preferred hunting experiences: A typology of Minnesota waterfowl hunters. *Wildlife Society Bulletin,* 34, 380-387.

Sedinger, J. S., White, G. C., Espinosa, S., Partee, E. T., & Braun, C. E. (2010). Assessing Compensatory Versus Additive Harvest Mortality: An Example Using Greater Sage-Grouse. *Journal of Wildlife Management,* 74, 326-332.

Smith, A., & Willebrand, T. (1999). Mortality causes and survival rates of hunted and unhunted willow grouse. *Journal of Wildlife Management,* 63, 722-730.

Solomon, David J. (2001). Conducting web-based surveys. Practical Assessment, Research & Evaluation, 7, 19.

Statistics Norway (2009). Statistikkbanken: subject 05, table 05039. (in Norwegian) *http://statbank.ssb.no/statistikkbanken/* (accessed 15/06/2011).

Statistics Norway (2010a). Statistikkbanken: subject 10, table 05634. (in Norwegian) *http://statbank.ssb.no/statistikkbanken/* (accessed 15/06/2011)

Statistics Norway (2010b). Statistikkbanken: subject 10, table 03951. (in Norwegian) *http://statbank.ssb.no/statistikkbanken/* (accessed 15/06/2011)

Statistics Norway (2011). Statistikkbanken: subject 10, table 06215. (in Norwegian) *http://statbank.ssb.no/statistikkbanken/* (accessed 15/02/2012)

Storch, I. (2007). Conservation status of grouse worldwide: an update. *Wildlife Biology,* 13, 5-12.

Storm, H. N. (2007). *Product development and value creation of grouse hunting. Demand, opinions and the experience of a hunting product*. Ms thesis, University of Life Sciences, Ås, Norway.

Vermunt, J. K., & Magidson, J. (2004). Latent class models. In D. Kaplan (Ed.)*, The Sage Handbook of Quantitative Methodology for the Social Sciences* (chapter 10).Thousand Oaks: Sage Publications.

Vermunt, J. K., & Magidson, J. (2005). *Latent Gold 4.0 user's guide*. Belmont: Statistical Innovations, Inc..

Ward, K. J., Stedman, R. C., Luloff, A. E., Shortle, J. S. & Finley, J. C. (2008). Categorizing deer hunters by typologies useful to game managers: a latent-class model. *Society & Natural Resources,* 21, 215-229.

Webb, W. C., Boarman, W. I., & Rotenberry, J. T. (2004). Common Raven juvenile survival in a human-augmented landscape. *Condor,* 106, 517-528.

Willebrand, T. (2009). Promoting hunting tourism in north Sweden: opinions of local hunters. *European Journal of Wildlife Research,* 55, 209-216.

Woods, G. R., Guynn, D. C., Hammitt, W. E., & Patterson, M. E. (1996). Determinants of participant satisfaction with quality deer management. *Wildlife Society Bulletin,* 24, 318-324.

Table 1

Latent class characterizing variables.

Variable	Proportion or mean ± SD
C1. Region (place of living)[a]	see text
C2. Sex	
Male	95%
Female	5%
C3. Gross annual personal income	€61,320 ± 24,858
C4. Annual spending related to grouse hunting[b]	€1,371 ± 1,593
C5. Distance traveled from home to current hunting area (km)	342 ± 487
C6. Number of grouse hunting days/year	15 ± 12.0
C7. Hunts grouse also in late season (Nov-Jan)	59%
C8. Hunts on own property (landowner)	8%
C9. Number of years hunted grouse throughout life	18 ± 12.0
C10. Number of grouse terrains used throughout life	median 8
C11. How often hunts with dogs	
Always	43%
Sometimes	16%
Never	41%

Note: Variables that were part of one or more significant models are shown in bold.

[a] Regions comprise the following counties: east = Oslo/Akershus/Østfold/Vestfold/Buskerud/Telemark, south = Aust-Agder/Vest-Agder, west = Rogaland/Hordaland/Sogn&Fjordane, middle = Oppland/Hedmark/Møre&Romsdal/Sør-Trøndelag/Nord-Trøndelag, north = Nordland/Troms/Finnmark.

[b] including hunting fees, equipment, travel costs, accommodation and food during the hunt.

Table 2

Latent class attitudinal variables.

Variable	Proportion or mean ± SD
A1. Hunting satisfaction factors (1 = *most*, 5 = *least important*)	
a. To bag a lot of grouse	3.2 ± 0.76
b. To see a lot of grouse	1.7 ± 0.77
c. Not seeing other hunters	2.6 ± 0.99
d. Being social	1.8 ± 0.95
e. Being in intact nature	2.3 ± 1.06
A2+A3. Willingness-to-pay per bagged bird (WP)	€13 ± 6.9
Increasing with bag size	36%
Decreasing with bag size	42%
Bell-shaped	1%
Not affected by bag size	21%
A4. Bag size with maximum WP (number of birds bagged per day)	5.7 ± 2.30
A5. Wants to pay for bagged yield rather than with a fixed fee	
Interested	38%
Not interested	62%
A6. View on current levels of hunting fees (1 = *inexpensive*, 5 = *expensive*)	
Leasing private land	4.6 ± 0.79
Buying hunting permits on public land	3.2 ± 0.90
A7. Density at which temporary hunting ban accepted (bird encounters/day)[a]	6.5 ± 2.27
<10 bird encounters/day	92%
≥10 bird encounters/day	2%
Never	6%
A8. Prefer a daily or weekly bag limit	
Daily	1%
Weekly	54%
No preference	45%
A9+A10. Crowding tolerance (1 = *acceptable*, 5 = *unacceptable*)	
If seeing 1-2 hunter groups/day in a large, open terrain	1.9 ± 1.30
If seeing 5-6 hunter groups/day in a large, open terrain	2.7 ± 1.44
If seeing 10+ hunter groups/day in a large, open terrain	3.4 ± 1.79
If seeing 1-2 hunter groups/day in a more secluded terrain	2.4 ± 1.57
If seeing 5-6 hunter groups/day in a more secluded terrain	3.3 ± 1.75
If seeing 10+ hunter groups/day in a more secluded terrain	3.6 ± 1.97

Note: Variables that were part of one or more significant models are shown in bold.

[a] Normally encounter rate was stipulated in the question to be 20 birds/day.

Table 3

Latent class models.

	Variables in model	No of classes	BIC_{LL}	L^2	df	*P*-value	Class. error
importance of bag size	A2**.** Willingness-to-pay per bagged bird (WP)[a]	2*	14,628	2,156	1,543	≤ 0.05	0.001
	A3. WP in relation to increased bag size	**3***	**13,874**	1,363	1,538	1.00	**0.036**
	C1. Region (place of living)	4*	13,846	1,296	1,533	1.00	0.082
	C6. Number of grouse hunting days per year	5	13,795	1,207	1,528	1.00	0.115
	A2**.** Willingness-to-pay per bagged bird (WP)[a]	2	18,788	2,033	1,770	≤ 0.05	0.016
	A3. WP in relation to increased bag size	**3**	**18,202**	1,410	1,765	1.00	**0.051**
	A4. Bag size with maximum WP	4	18,172	1,343	1,760	1.00	0.080
	C1. Region (place of living)	5	18,151	1,284	1,755	1.00	0.140
	A1. Bagging vs. seeing birds[b]	2	20,504	2,065	1,890	≤ 0.05	0.013
	A2**.** Willingness-to-pay per bagged bird (WP)[a]	**3**	**19,780**	1,302	1,885	1.00	**0.038**
	A3. WP in relation to increased bag size	4	19,802	1,286	1,880	1.00	0.122
	C6. Number of grouse hunting days per year	5	19,801	1,246	1,875	1.00	0.177
crowding tolerance	A9. Crowding tolerance (CT)[c]	2*	9,670	1,461	2,326	1.00	0.029
	A10. CT in relation to encounter rate	**3***	**9,573**	1,317	2,320	1.00	**0.067**
	C1. Region (place of living)	4*	9,567	1,264	2,314	1.00	0.058
	C6. Number of grouse hunting days per year	5	9,643	1,293	2,308	1.00	0.198
	C11. How often hunts with dog						
	A9. Crowding tolerance (CT)[c]	2	9,675	2,010	2,637	1.00	0.030
	A10. CT in relation to encounter rate	**3**	**9,583**	1,863	2,630	1.00	**0.067**
	C1. Region (place of living)	4	9,582	1,807	2,623	1.00	0.056
	C7. Hunts grouse also in Nov-Jan	5	9,620	1,789	2,616	1.00	0.198
	C11. How often hunts with dog						
	A9. Crowding tolerance (CT)[c]	2	9,726	920	1,080	1.00	0.024
	A10. CT in relation to encounter rate	**3**	**9,627**	773	1,074	1.00	**0.067**
	C1. Region (place of living)	4	9,619	718	1,068	1.00	0.053
	C6. Number of grouse hunting days per year	5	9,661	712	1,062	1.00	0.279

Note: *P*-values >0.05 indicate significant models. The three most parsimonious variable sets (separated by dashed lines) for each of two key attitudes are shown. In each model, three typology classes were deemed to be the best alternative (having low BIC_{LL} and classification error). Models marked with (*) are illustrated in detail in Figure 1. For explanation of variables, see Table 1 and 2.

[a] Average for the three different bag sizes (1-3, 8-10 and 15-20 ptarmigan/day).

[b] Difference in score between 'To bag a lot of grouse' and 'To see a lot of grouse'.

[c] Average for the six various encounter rates and terrain types.

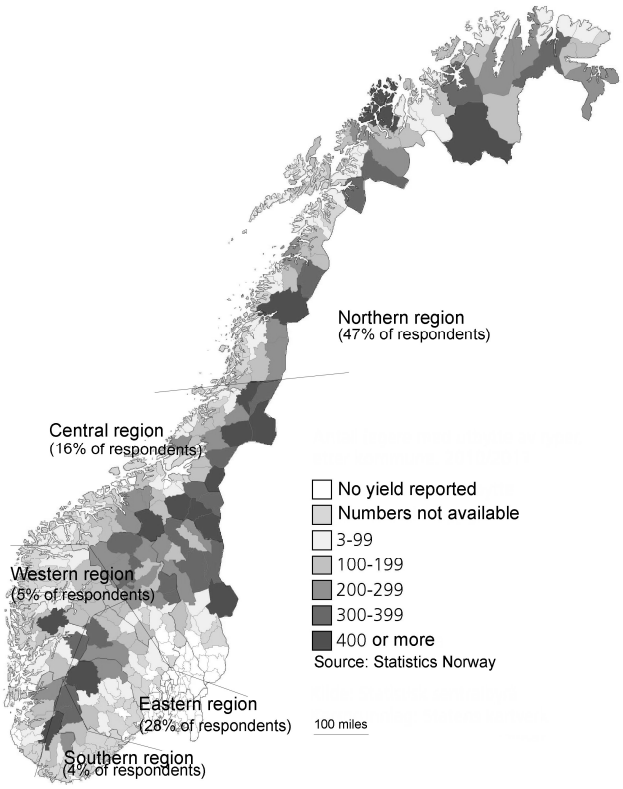


Figure 1. Geographical distribution of Norwegian grouse hunters who participated in a survey on harvest regulations in 2010, and the reported number of harvested grouse per hunter at the municipality level for the 2010/11 season.

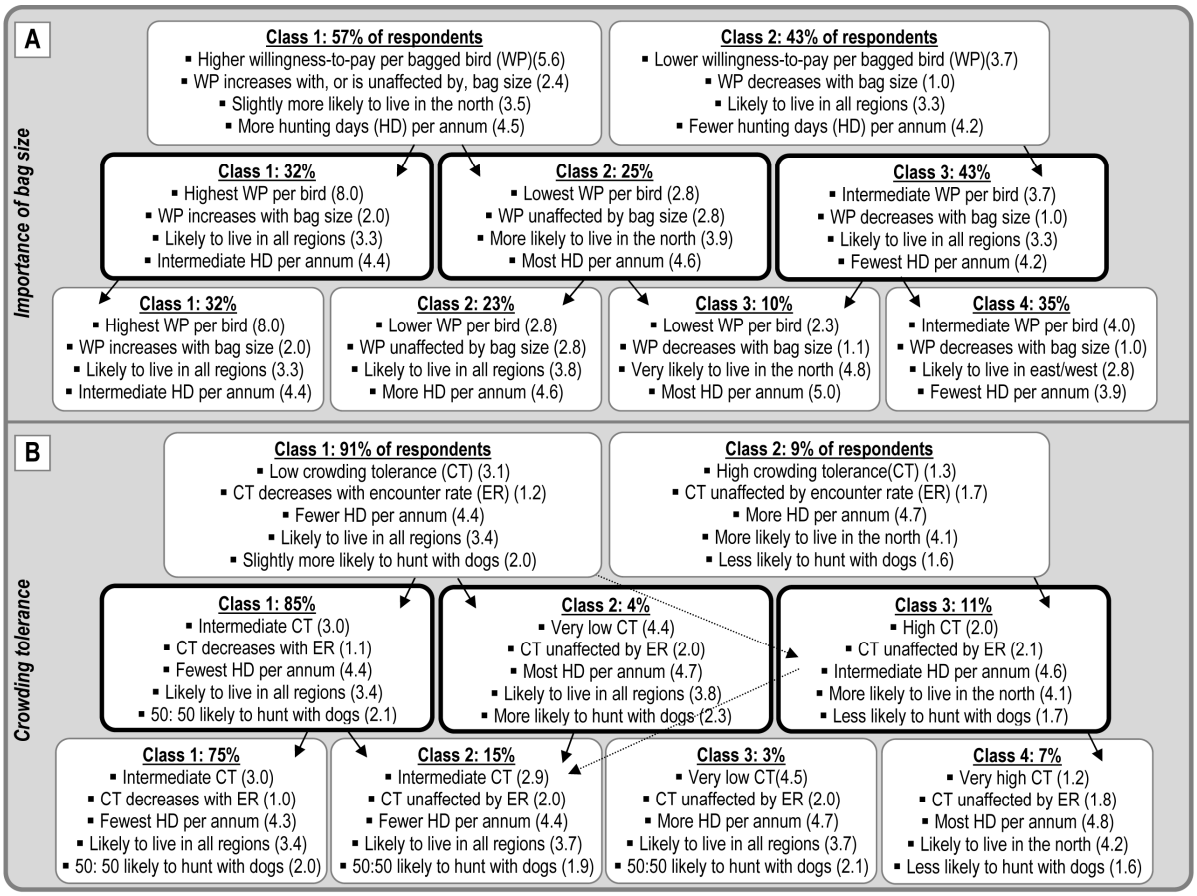
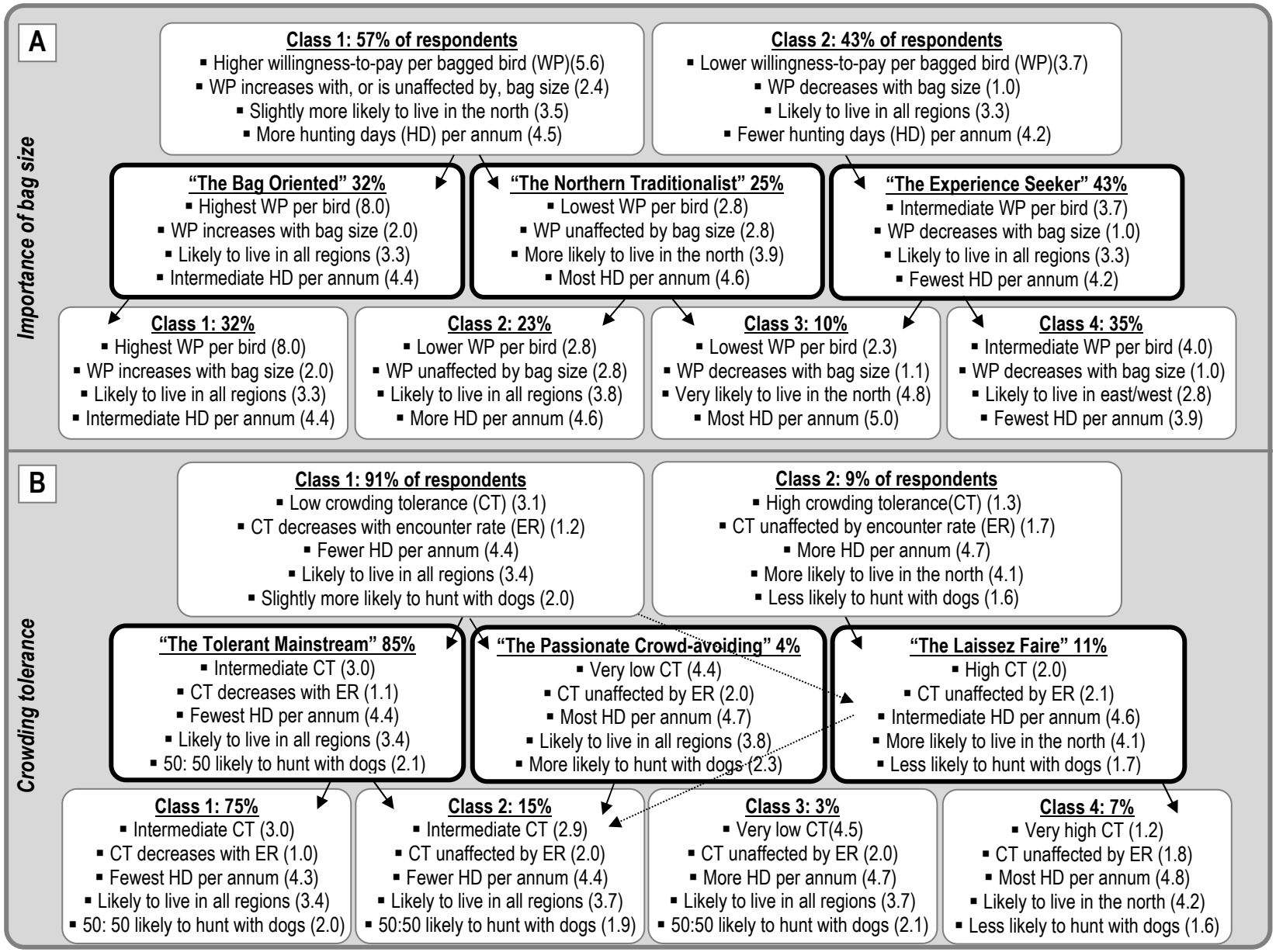


Figure 2A-B. Latent class modeling of grouse hunter typologies in Norway, based on a nationwide survey from 2010 (*N* = 3,293). For both *importance of bag size* and *crowding tolerance* the 3-class models were deemed to be the most parsimonious. Numbers in parentheses are average class scores, e.g., in the 2-class model for *crowding tolerance*, the hunters in the second class had more than twice as high tolerance than the hunters in the first class.

NOTE: Figure 2 is optimized for horizontal page lay-out with text at the bottom short side.


A
Importance of bag size
Class 1: 57% of respondents
▪ Higher willingness-to-pay per bagged bird (WP)(5.6)
▪ WP increases with, or is unaffected by, bag size (2.4)
▪ Slightly more likely to live in the north (3.5)
▪ More hunting days (HD) per annum (4.5)
Class 2: 43% of respondents
▪ Lower willingness-to-pay per bagged bird (WP)(3.7)
▪ WP decreases with bag size (1.0)
▪ Likely to live in all regions (3.3)
▪ Fewer hunting days (HD) per annum (4.2)
"The Bag Oriented" 32%
▪ Highest WP per bird (8.0)
▪ WP increases with bag size (2.0)
▪ Likely to live in all regions (3.3)
▪ Intermediate HD per annum (4.4)
"The Northern Traditionalist" 25%
▪ Lowest WP per bird (2.8)
▪ WP unaffected by bag size (2.8)
▪ More likely to live in the north (3.9)
▪ Most HD per annum (4.6)
"The Experience Seeker" 43%
▪ Intermediate WP per bird (3.7)
▪ WP decreases with bag size (1.0)
▪ Likely to live in all regions (3.3)
▪ Fewest HD per annum (4.2)
Class 1: 32%
▪ Highest WP per bird (8.0)
▪ WP increases with bag size (2.0)
▪ Likely to live in all regions (3.3)
▪ Intermediate HD per annum (4.4)
Class 2: 23%
▪ Lower WP per bird (2.8)
▪ WP unaffected by bag size (2.8)
▪ Likely to live in all regions (3.8)
▪ More HD per annum (4.6)
Class 3: 10%
▪ Lowest WP per bird (2.3)
▪ WP decreases with bag size (1.1)
▪ Very likely to live in the north (4.8)
▪ Most HD per annum (5.0)
Class 4: 35%
▪ Intermediate WP per bird (4.0)
▪ WP decreases with bag size (1.0)
▪ Likely to live in east/west (2.8)
▪ Fewest HD per annum (3.9)
B
Crowding tolerance
Class 1: 91% of respondents
▪ Low crowding tolerance (CT) (3.1)
▪ CT decreases with encounter rate (ER) (1.2)
▪ Fewer HD per annum (4.4)
▪ Likely to live in all regions (3.4)
▪ Slightly more likely to hunt with dogs (2.0)
Class 2: 9% of respondents
▪ High crowding tolerance(CT) (1.3)
▪ CT unaffected by encounter rate (ER) (1.7)
▪ More HD per annum (4.7)
▪ More likely to live in the north (4.1)
▪ Less likely to hunt with dogs (1.6)
"The Tolerant Mainstream" 85%
▪ Intermediate CT (3.0)
▪ CT decreases with ER (1.1)
▪ Fewest HD per annum (4.4)
▪ Likely to live in all regions (3.4)
▪ 50: 50 likely to hunt with dogs (2.1)
"The Passionate Crowd-avoiding" 4%
▪ Very low CT (4.4)
▪ CT unaffected by ER (2.0)
▪ Most HD per annum (4.7)
▪ Likely to live in all regions (3.8)
▪ More likely to hunt with dogs (2.3)
"The Laissez Faire" 11%
▪ High CT (2.0)
▪ CT unaffected by ER (2.1)
▪ Intermediate HD per annum (4.6)
▪ More likely to live in the north (4.1)
▪ Less likely to hunt with dogs (1.7)
Class 1: 75%
▪ Intermediate CT (3.0)
▪ CT decreases with ER (1.0)
▪ Fewest HD per annum (4.3)
▪ Likely to live in all regions (3.4)
▪ 50: 50 likely to hunt with dogs (2.0)
Class 2: 15%
▪ Intermediate CT (2.9)
▪ CT unaffected by ER (2.0)
▪ Fewer HD per annum (4.4)
▪ Likely to live in all regions (3.7)
▪ 50:50 likely to hunt with dogs (1.9)
Class 3: 3%
▪ Very low CT(4.5)
▪ CT unaffected by ER (2.0)
▪ More HD per annum (4.7)
▪ Likely to live in all regions (3.7)
▪ 50:50 likely to hunt with dogs (2.1)
Class 4: 7%
▪ Very high CT (1.2)
▪ CT unaffected by ER (1.8)
▪ Most HD per annum (4.8)
▪ Likely to live in the north (4.2)
▪ Less likely to hunt with dogs (1.6)