Ecological Economics 79 (2012) 89–96

Contents lists available at SciVerse ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Analysis

# Balancing hunting regulations and hunter satisfaction: An integrated biosocioeconomic model to aid in sustainable management

Hilde Karine Wam [a],*, Hans Chr. Pedersen [b,c], Olav Hjeljord [a]

[a] Norwegian University of Life Sciences, Department of Ecology and Natural Resource Management, PO Box 5003, N-1432 Ås, Norway
[b] Hedmark University College, Department of Forestry and Wildlife Management, PO Box 400, N-2418 Elverum, Norway
[c] Norwegian Institute for Nature Research, Department of Terrestrial Ecology, PO Box 5685, N-7485 Trondheim, Norway

ARTICLE INFO

*Article history:*
Received 9 January 2012
Received in revised form 20 April 2012
Accepted 24 April 2012
Available online 6 June 2012

*Keywords:*
Bioeconomic
Game
Grouse
Harvest
Typology
Willingness-to-pay

ABSTRACT

Hunting of game animals needs to be regulated, either through the number of permits or the bag size allowed per hunter. Such regulations may, however, jeopardize hunter satisfaction, on which game managers depend. Consequently, finding the optimal hunting intensity is not straightforward. Using data from Norwegian grouse hunting, we show that an integrated approach combining sociology and bioeconomics can give markedly different priorities than an optimization based exclusively on bioeconomics. Three grouse hunter typologies with contrasting stated preferences regarding bag size and crowding were used to account for varying hunter behavior. Omitting the social constructs from the model pushed the hunter density towards its upper limit, because the gain of selling one more permit generally superseded the loss in hunter satisfaction (expressed as willingness-to-pay). Although this strategy multiplied the overall profit, it produced a daily bag size that would be unacceptable to practically all hunters. We conclude that biosocioeconomic modeling is a valuable tool in the pursuit of sustainable game management.

## 1. Introduction

Around the globe, populations of game species cause concern for being either overabundant (e.g., moose: Serrouya et al., 2011; deer: Warren, 2011) or declining (e.g., grouse: Storch, 2007; caribou: Wittmer et al., 2005). To decide on the right action, managers normally depend on the engagement and goodwill of hunters. While hunting regulations are instrumental in keeping game populations within sustainable frames, we also need satisfied hunters in order to maintain hunting as an activity of the future (Heberlein and Kuentzel, 2002; Schroeder et al., 2006). Additionally, hunting revenues may constitute a substantial part of rural economy (Sharp and Wollscheid, 2009), and as such presents yet another reason for managers to take hunter satisfaction into account.

Historically, hunter satisfaction has been commonly viewed as being linearly related to hunting success, i.e. the number of animals killed (Mechling, 2004). However, already four decades ago it was established that hunter satisfaction is determined by far more complex elements than such a consumptive measure (Hendee, 1974). Since then research on the topic has more or less taken this "multiple-satisfaction" approach to heart (e.g. Decker et al., 1980; Hayslette et al., 2001; Hazel et al., 1990; Vaske et al., 1986). Principally, the factors that determine hunter satisfaction are strongly linked to hunting motivation. What Decker and Connelly (1989) state about deer hunters, "…motivations for hunting deer are rooted in the areas of personal achievement, affiliation with friends and family, and appreciation of the outdoors" (p. 462) seems to hold for hunters in general. A motivation that is quite weak, is to hunt for non-personal gains to benefit other stakeholders or the wider community (e.g., Ward et al., 2008). Often this leads to a disagreement between hunters and managers over what constitutes optimal animal densities (Diefenbach et al., 1997; Finch and Baxter, 2007; Horton and Craven, 1997; Wam and Hofstad, 2007).

As a result, new harvest regulations must be carefully introduced in order not to critically reduce hunter satisfaction. Management agencies then need tools that can only be developed from truly interdisciplinary research, preferentially from all three relevant research fields: ecology, sociology and economics. Although ecological economics has come a long way towards interdisciplinary research (Söderbaum, 2007; Wam, 2010), the simultaneous integration of three such different research fields is still a rather novel approach. As has often been the case with interdisciplinary advances in natural resource management, fishery researchers are leading the way (Bunnefeld et al., 2011a). Pioneer biosocioeconomic models for the harvest of marine resources were presented several decades ago (e.g., Charles, 1989; Krauthamer et al., 1987; Smith, 1968), and in the last 10 years inclusion of stakeholder behavior has frequently been argued to be essential for successful fishery models (e.g., Fulton et al., 2011; Mapstone et al., 2008; Millner-Gulland, 2011). Similar approaches in terrestrial systems seem to be lagging.

In this study we made a socioeconomic survey of habits, attitudes and stated preferences among grouse hunters in Norway, and used

---

* Corresponding author. Tel.: +47 920 10 746.
*E-mail addresses:* hilde.wam@bioforsk.no (H.K. Wam), hans.pedersen@nina.no (H.C. Pedersen), olav.hjeljord@umb.no (O. Hjeljord).

0921-8009/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.ecolecon.2012.04.022

the data in an integrated biosocioeconomic model to evaluate the optimal balancing of harvest regulations and hunter satisfaction. While our overall model objective was to maximize landowner profit, we also contrast this with alternative scenarios that more directly prioritize hunter satisfaction. We kept the model framework fairly simple, but its parameterization is based on extensive empirical data, with the aim of having a model that is "robust in the real world rather than optimal in the ideal world" (Milner-Gulland, 2010, p. 1). While some general recommendations for game managers can be drawn from the study, our main goal is to illustrate how a stronger inclusion of social constructs can be a valuable expansion to the traditional tools used in the pursuit of sustainable game management.

## 2. Materials and Methods

### 2.1. Hunter Satisfaction Survey

An e-mail invitation to participate in a web-based questionnaire was sent to all grouse hunters ($N = 8{,}129$) registered with the two large public agencies "Norwegian State-owned Land and Forest Enterprise" and "The Finnmark Estate" (managing approximately 50% of Norwegian outfields). The questionnaire was available from 25/05/2010 to 01/10/2010, with a reminder e-mail sent 09/09/2010. Of the invitations sent, 256 bounced due to failed delivery and after eliminating 20 responses that were either blank, irrational or foreign, we were left with 3,107 respondents (response rate 40%). We also posted open survey invitations on various Norwegian hunting-related web-sites, and got an additional 186 respondents (an e-mail filter was used to avoid double participation). Because of the low sample size, and because descriptive statistics indicated that the responses did not deviate from those in the e-mail survey, all respondents have been pooled in this study.

The questionnaire contained 26 main questions, of which 14 were attitudinal and 12 were purely descriptive asking for hunter habits and demographic data. The questions ranged from simple closed-option tick boxes and balanced 5-point Likert scales to a majority of complex open-ended what-if-scenarios. The latter was preferred for questions addressing willingness-to-pay as it has been extensively shown that the open-ended answering format may reduce response bias (e.g. Boyle et al., 1985; Mitchell and Carson, 1989; Pollicino and Maddison, 2001). However, in some cases we were mainly interested in relative changes (e.g., when parameterizing the shape of the $c_{tkl}$ function in Eq. (5)), and we then gave a starting value (outlining, e.g., a normal situation worth 1,000 NOK for a week's hunting, and thereafter asking for willingness-to-pay for increased bag sizes). While this may have given some slight bias, we believe it is less of a negative influence than what could have occurred from a potentially very large spreading of data. Questions that we deemed particularly difficult were addressed twice in two different formats (reverse-keying). The survey questions are described in more detail in Wam et al. 2012.

### 2.2. Hunter Typology Classification

We classified the respondents into hunter typologies using latent class analyses (LCA), specifically the cluster analysis package available in Latent GOLD® (version 4.5, Windows XP) (Vermunt and Magidson, 2005). Typologies were determined with regard to "importance of bag size", which basically reflects their acceptance for a regulated game hunting (i.e. limiting the yield allowed per hunter, or controlling it indirectly through the number of hunters). To determine which LCA models that best (in terms of parsimony) captured the heterogeneity in the stated preferences of our respondents, we used likelihood-ratio goodness of fit in relation to the degrees of freedom, classification errors as well as $\mathrm{BIC}_{\mathrm{LL}}$ values. The typology classification is described in more detail in Wam et al. (2012).

### 2.3. Model Framework

Our biosocioeconomic model was developed for the planning of grouse hunting over a fixed period of time on a property with only one decision-maker. We thus assume that the property is large enough for cross-border migration of grouse to be negligible. Consequently, we do not address property right issues related to such movement, which is generally not a prevalent issue for grouse in Scandinavia (dispersal of willow ptarmigan *Lagopus lagopus*, e.g., is approximately 400 m for adults and 4,200 m for juveniles, Brøseth et al., 2005). The basic management issue we are addressing is how to best allocate a given hunting quota between varying numbers of hunters, considering both landowner profit and hunter satisfaction.

The model was built on a matrix framework reflecting different hunting zones, with added functions of density-dependency operating on the hunter satisfaction parameters (i.e. willingness-to-pay indices). The grouse population projection was kept simple with set recruitment rates and the notion that hunting should not reduce next year's density of adult birds (1 year and older). While this simple strategy omits essential biological dynamics, we believe a more complex model (including e.g., weather stochasticity, migration or innate population fluctuations) will mask the socioeconomic aspects that are of main interest here (see also discussion).

In the model, the grouse population is projected at one-year intervals in a modified zone-version of the basic Leslie matrix (Leslie, 1945), assuming discrete reproduction and mortality (natural and hunting). The number of individuals is counted after reproduction, immediately before the hunting season commence. No differentiation is made of sex and age of birds, as this to very little extent can be intentionally selected for by grouse hunters in a shooting situation (Bunnefeld et al., 2009, 2011b; Hörnell-Willebrand et al., 2006). The various hunting zones correspond to distinguishable bioeconomic units. They may be set to reflect basic differences in, for example, grouse productivity, infrastructure (roads and cabins), or terrain type (steepness and ruggedness). If $G_{tk}$ is the number of grouse present in zone $k$ at time $t$, then:

$$\vec{\mathbf{G}}_{t+1,k} = \vec{\mathbf{G}}_{tk} - \vec{\mathbf{S}}_{tk} - \vec{\mathbf{M}}_{tk} + \mathbf{G}\cdot\vec{\mathbf{G}}_{tk} \tag{1}$$

where $\vec{\mathbf{G}}_{tk}$ is the vector of population zone structure (number of birds per zone $k$) at time $t$, $\vec{\mathbf{S}}_{tk}$ is the number of birds shot by the hunters, $\vec{\mathbf{M}}_{tk}$ is the natural mortality and $\mathbf{G}$ is the population projection matrix. The latter is given by:

$$\mathbf{G} = \begin{bmatrix} r_{11} & 0 & \cdots & 0 \\ 0 & r_{21} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & r_{ij} \end{bmatrix} \tag{2}$$

where $r_{ij}$ is the discrete recruitment rate (number of juveniles observed per adult). Although not included here, $\mathbf{G}$ can easily be expanded to include movement of birds across zones, which may be relevant to other hunting regulations such as the use of refugee areas. Basically, what is available as hunting quotas ($q_{tk}$) are $r_k \cdot G_{tk}$. Naturally, the number of shot birds can never exceed the hunting quotas, and because we were not interested in temporal population effects in this study, we assume that the quotas are fully utilized ($s_{tk} = q_{tk}$). However, as grouse hunting is more or less additive to other causes of death (Pedersen et al., 2004; Pöysä et al., 2004; Sandercock et al., 2011), the available quotas are delimited with a compensation factor:

$$q_{tk} = c\cdot(r_{tk}\cdot G_{tk}), \quad c = [0,\ 1] \tag{3}$$

Sale of hunting permits (including accommodation) is the only source of income in the model. The price obtained per permit can,