Regulation of Hunting: A Population Tax

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Abstract: Within hunting wildlife populations are estimated to be too high in many countries. It is assumed that this is due to the market failure that each hunter harvests too little compared to what the regulator wants. This may be due to the existing regulation which, among other things, requires knowledge of individual harvest. However, information about individual harvest may be costly to obtain. Thus, we may look for alternatives to the existing system. In this paper a population tax/subsidy is proposed as an alternative. The population tax/subsidy is the difference between actual and optimal population times an individual, variable tax rate. The variable tax rate is based on the difference in marginal value of the population between the hunter and the regulator. It is shown that the population tax/subsidy secures an expected first-best optimum. Thus, the population tax is a good alternative to the existing regulation.

1. Introduction

In France, as well as in many other European countries, big game (e.g. roe deer, red deer, wild boar) cause damage on forests and therefore causing conflicts between hunters and forest owners (Alphandéry and Fortier 2007, Poinsot 2008, Rakotoarison et al. 2009). Hunters prefer large populations of game while forest owners experiences economic losses from damages on forest stands (reduced timber quality or replanting costs) or costs of averting measures (e.g. fencing and use of repellents) in areas with large populations. Furthermore, the wildlife manager (regulator) will have to consider potential positive and negative impact of game populations on ecosystem services which are not directly related to hunting values or forest production. This may include positive impacts of game populations on the recreation value of forest for non-hunters as well as negative impacts of game populations on biodiversity and sustainable forest management. For example, large game populations may impede natural regeneration of forest stand and reduce species diversity due to selective browsing of tree species. In addition, large big game may cause crop damages on adjacent agricultural land, damages by vehicle collisions, and large wild boar populations impose sanitary risks (Ropars-Collet LeGoffe 2009b). During the past three decades most big game populations have probably increased significantly (Poinsot 2008). In France, 1985 to 2008 the harvest of roe deer increased from 70,000 to 470,000 and the harvest of wild boar increased from 65,000 to 568,000 (INSEE 2011). This may indicate increasing game populations. Simultaneously, the number of hunters validating their hunting license in France is reduced from 2.0 to 1.3 million in the period 1982 – 2006 (Bédarida and François 2008). Today, the harvest of game is considered to be too low from the point of view of optimal resource exploitation. This is basically due to presence of externalities, i.e. hunters do not bear all damage costs associated with large game populations.

The hunting right belongs to the property owner. However, the *département*[1] government can decide that the hunting right is transferred from small properties to an approved municipality hunting association (ACCA=l'Association Communales de Chasse Agréée). This is the case in one third of the *départements*. Small properties are defined as properties with an area less than a certain threshold (30-60 hectares) determined by the *département* government. In the *département* where transfer of hunting rights is not compulsory for the small properties, the creation of an ACCA is optional. The creation of an ACCA requires participation of at least 60 per cent of the hunting right owners in a municipality and that at least 60 per cent of the land is included in the ACCA agree[2]. In municipalities where hunting right owners decide to establish an ACCA a property owner can reject that hunting take place on her land based on philosophical

[1] *Départements* are administrative divisions between regions and municipalities. There are 96 *départements* in France (exluding the overseas *départements*)
[2] In Moselle and Alsace the hunting is managed by the communes (municipalities).

reasons. In such cases the property owners are not allowed to hunt on their own land. Out of the 36,571 municipalities in metropolitan (i.e. excluding overseas municipalities) France 10,100 municipalities have an ACCA (Fédération Nationale des Chasseurs 2011)

When the hunting rights are transferred to communal associations game management decisions are not made by the forest owner bearing the costs of large game populations.[3] Where the forest owner is keeping the hunting right she can balance the cost and benefit from large game populations by hunting herself or by contracting with hunters. However, as mentioned above there are also externalities of big game populations which have public good characteristics (vehicle collisions with big game, and negative impact on species diversity in natural-managed forest). This is one of the explanations why the game populations in France are currently considered higher than the social optimal level (Ropars-Collet and LeGoffe 2009a).

The current legislation with respect to regulation and management of hunting in France is to some degree reflecting the situation in the 1960-70s where the amount of hunters was increasing and there were concerns about declining game species populations (Alphandéry and Fortier 2007, LeGoffe and Vollet 2008). Hunting plans were introduced by law in 1963 and was implemented in all French regions during the 1970s. The hunting plans introduced a quota system restricting harvest of the big game such as stags, roe deer, fallow deer, mouflon and chamois. Hunting plans was accompanied by other measures designed to enhance reproductive conditions for the hunted wildlife (setting aside reserves where hunting is not allowed)[4] and rules for compensation for damages caused by game was also implemented during the same period (Alphandéry and Fortier 2007,p.45). The hunting plans have since 1970s been a major element in the French regulation of hunting of big game (LeGoffe and Vollet 2008, p7). Later revisions of the regulations has emphasized that the hunting plan should contribute to balance the interest (agricultural and forestry interest) including specification of minimum harvest levels (Charlez 2008).

If the owner of a hunting right (landowner, contractor, or ACCA) want to execute the property right the right owner is required to have a hunting plan for the area corresponding to the right at the *département* administration. The hunting plan is defined based on potential information about the game population in the area and previous incidences of damages caused by the game. Furthermore, the plan is coordinated with a *département* level hunting plan, in which the minimum and maximum harvest for the *département* is determined for the coming hunting season. For the big game the duration of the plan is three years. The plan states who is allowed to hunt on the territory specified in the plan and the maximum and minimum

[3] However, the landowner can also be member of communal hunting organization and thereby influence the decisions made on management of the game.
[4] 10 per cent of land managed by an ACCA has to be set aside as reserves where hunting is not allowed.

harvest of each relevant species. The plan may also include restrictions on the sex and age of the eligible game. The hunting plan is the basis for an initial allocation of bracelets to hunters in the beginning of the hunting season. A bracelet is a strap which has to be attached to the game immediately after killing. Transportation of the game without a bracelet is subject to penalty. The hunters pay for the bracelets and sale of the bracelets contributes to funding the compensation of landowners (forest or agricultural land) who have experienced damages caused by game. This fund is managed by the *département* association of hunters (Fédérations Départementales des Chasseurs). The price of the bracelet depends on the damage caused by the big game and this is set by the *département* administration within a national upper limit of this tax. Since all big game killed should be attached a bracelet sold by the *département* the individual harvests are directly observable.

Farmers are eligible for compensation for wildlife damages on crops while forest owners are only eligible for compensation in certain situations. Forest owner are compensated for damages on forest stands if the owner is not having control over the hunting e.g. when hunting rights are transferred to the communal hunting association (Charlez 2008, p.61). Alternatively, forest owners can ask compensation for protection measures. In other situations where the forest owner has rented out the hunting right voluntarily it is only possible to obtain compensation of the hunting right holder claiming the civil code and will only be eligible to compensation if the minimum number of animals killed stated in the hunting plan has not been achieved (Charlez 2008, p.63).

If the minimum harvest is not achieved in a season the beneficiaries of the hunting right may have to comply with different additional obligations the following hunting season, e.g. keeping a hunting diary. Assessments have shown that in most departments the aggregate harvest level is lower than the aggregate minimum harvest levels determined by the hunting plans.

To sum up, the current regulations of big game hunting in France is complex. It involves a tax on the individual hunters' harvest (the payment of bracelets), a levy on hunting licenses, schemes for compensating of land owners, and detailed administrative regulation of the number of animals shot. However, the regulation has not been able to ensure an optimal big game population in France (Poinsot 2008, p41).

We propose to simplify the existent system for regulation of hunting. It is assumed that the purpose of regulation is to achieve economic efficiency[5]. Instead of the existent system based on, among others, hunting plans and monitoring and taxing the harvest of each individual hunter we propose a tax/subsidy on the game population. Thus, individual harvest is not used as tax/subsidy variable. Individual harvest is measured in the existing system. However, without the bracelet system individual harvest is unobservable and the point of departure for our tax on game population is that there are high costs in connection with measurement of individual harvests exactly because of the bracelet system. Instead of using individual harvest as tax variable we purpose to use population size. This may reduce measurement costs. The market failure we address arises because hunters and regulators value the game population differently. For the regulators a larger game population gives a lower benefit than for hunters because of for example, the damage caused by browsing of trees. If the population is larger than the optimal/target population a tax is imposed. The tax is equal to the difference in populations times a variable tax rate that varies between hunters. Provided that the population is lower than the target population a subsidy is given and the subsidy is equal to the difference in populations times an individual, variable subsidy rate. The individual variable tax/subsidy reflects the difference in marginal net benefits between regulators and hunter. Such a tax secures a first-best optimum.

In this paper we analyse a break-even tax system. Thus we are interested in a tax system where the total tax payment is zero. Therefore, we may exclude the simple solution of a subsidy of hunting. A subsidy of hunting does not imply break-even. An alternative to the population tax could be a two-part tariff (see Turner, 1996). The point of departure for most two-part tariffs (a fixed tax and a subsidy per unit) is that the total tax payment shall be equal to zero. Then we could impose a fixed tax and a subsidy per unit harvest. The subsidy could be the difference in net benefits between regulator and hunter. In order to break even the fixed tax could be the total subsidy shared by the number of hunters. However, such a system does not secure a first-best optimum. Some hunters with a positive net benefit are excluded from hunting because of the fixed tax. If the fixed tax is larger than the hunters net benefit a hunter will not participate even though they have a positive rent. In general, the optimal two-part tariff involves a subsidy that is smaller than the difference in rents and the fixed tax that is smaller than the above mentioned fixed tax. Thereby, the welfare gain of correcting differences in rents is balanced against the welfare loss of excluding hunters due to the fixed tax. Thus, a two-part tariff only secures a second-best optimum. The advantages of our population tax are that a first-best optimum is secured.

[5] Other objectives than economic efficiency may determine the choice of hunting regulation, e.g. biological objectives or equity concerns. For example, the land owners' right of compensation for damages was originally introduced as a compensation to land owners for transferring the hunting rights to communal organizations.

The inspiration to our population tax is taken from the literature on non-point pollution. More specific, we use the ambient tax in Segerson (1988). With non-point pollution individual pollution cannot be observed but the aggregate pollution for several agents can be measured. In our paper exact individual harvest is expensive to observe but population size can be measured. Translation of non-point pollution mechanism to hunting is important due to the fact that hunting optimization involves a resource restriction. This is not the case for pollution.

Within fisheries economics a number of contributions have attempted to translate non-point pollution mechanism to resource economics (Jensen and Vestergaard 2001, Jensen and Vestergaard 2006), Hansen et al 2006, and Jensen and Kronbak 2009). The main problem within fisheries is that individual harvest is unobservable due to illegal landings and discard. However, population size and, thereby aggregate harvest is assumed to be measurable. However, one difference arises between hunting and fisheries. Within fisheries the market failure arises due to a restriction that is not incorporated by individual fishermen. For hunting the market failure is due to a difference in net benefits between regulator and hunters. Second, it is easier to measure stocks for hunting than for fisheries. This makes stock taxes easier to apply for hunting. Thus, translation of non-point pollution mechanism to hunting is an important contribution to the literature.

Several studies have analyzed the welfare economic optimal management of hunting in the case where wild animals are both valuable and nuisance. Zivin et al. (2000) analyze hunting and trapping regimes in regulation of feral pigs in California, applying a bioeconomic model. A similar approach have been applied by Ropars-Collet and Le Goffe 2009a,b) in the analysis of big game in France. Rakotoarison et al. (2009) analyze the roe deer population dynamics and damage costs in a simulation model representing a South west region in France. Skonhoft (2005) and Skonhoft and Olaussen (2005) have analyzed the optimal management of moose in Norway taking into account hunting benefit as well as browsing damage, applying a spatial model where migration behavior is included explicitly. However, no of these studies address explicitly the implementation of an optimal management regime. Horan and Bulte (2004), Rondeau and Bulte (2005), and Bulte and Rondeau (2007) analyze measures of wildlife conservation with presence of hunting in a developing country context, i.e. with imperfect property rights. The measures analyzed include trade measures applied by the international community and compensations to peasants for damages caused by wildlife conservation.

The paper is organized as follows. Section 2 analyzes the proposed population tax while the tax is discussed in section 3. In section 4 the paper is concluded.

2. The mechanism

Within hunting individual harvest is currently measured exactly. Each hunter registers the harvest and reports this harvest to regulator. The reported harvest is, then, used as a basis for collecting a tax for every hunter. However, this system is expensive. It is costly for regulator to register the exact harvest for each individual hunter and impose the tax. We, therefore, search for an alternative to the current system. The point of departure for this alternative is that individual harvest is unobservable. Thus a moral hazard problem arises and therefore we use population size as tax variable. As mentioned in the introduction a market failure arises because hunters do not correctly estimate the benefits of the population. It is assumed that the hunters value the benefits of the population larger than regulator. If the regulators marginal benefit is smaller than the hunters' marginal benefit we have a market failure to correct. We study a population tax as a mechanism to solve this market failure. Note in connection with the model that we adopt a single-species assumption.

We consider a model with a regulator and hunters. Thus, we analyze a situation where hunting rights are transferred to an approved municipality hunting association. Therefore, we do not need to model the forest owner. However, the analysis easily generalizes to inclusion of a forest owner. To see this assume that regulator is interested in the largest possible welfare while the forest owner is interested in obtaining the largest possible profit from timber production and selling the hunting rights to hunters. Regulator could now impose a population tax equal to the difference between welfare and profit. This would give the forest owner correct incentives and we could model the relation between forest owner and hunters. However, we study the relation between regulator and hunter and, thereby, assume that the forest owner do not have the property right. The hunter is interested in the largest possible private net benefits. As mentioned above there is a difference between the net benefit of the population for the regulator and the hunter due to, for example, biodiversity and the damage on timber production caused by the game population. This fact makes regulation necessary. We consider a tax/subsidy solution to correct the market failure problem. The tax mechanism for individual *i* is specified as:

$$T_i(x) = t_i(x - x^*) \qquad (1)$$

where:

x is the game population size.

x^* is the target (optimal) game population size set by the regulator.

t_i is an individual tax/subsidy variable.[6]

$T_i(x)$ is the total individual tax/subsidy.

The focus in the following analysis is to find the optimal t_i that secures that $x = x^*$. Thus, in optimum the tax is at break-even, i.e. no tax is paid. Therefore, we want to find the t_i that gives that the actual population is equal to the target population. If $x < x^*$ (the population is less than the optimal population) $T_i(x) < 0$. Thus, individual hunters receive a subsidy. In the case the population is larger than the optimal population ($x > x^*$), $T_i(x) > 0$ and a tax is imposed on individual hunters.

The timing of the mechanism is shown in Figure 1.

t=0 Regulator announces the tax formula and target stock size	Hunting season	t = 1. regulator observe population and collects the tax

At the beginning of a hunting season the regulator announces the target population (x^*) and the individual tax/subsidy variable (t_i). Then the hunter extract of the resource during a hunting season. At the end of the hunting season the population size is measured and the total tax/subsidy ($T_i(x)$) is calculated and paid.

[6] We use the concept target population because the mechanism also works if x^* is set according to biological criteria. However, in the following analysis we assume that x^* is set according to economic criteria.

The individual hunter maximizes net benefits minus tax costs subject to a steady-state resource restriction. We assume Cournot-Nash expectations. Thus, when maximizing (2) subject to (3) individual hunters take the harvest of others as given. The objective of a hunter may be written as:

$$\underset{h_i, x}{Max}[B_i(h_i, x) - c_i(h_i, x) - T_i(x)] \qquad \text{for } i= 1, \ldots N \tag{2}$$

s.t.

$$F(x) - \sum_{i=1}^{n} h_i = 0 \tag{3}$$

where h_i is the harvest of an individual hunter and *F(x)* is the natural growth. $B_i(h_i, x)$ is the gross benefit associated with hunting. We assume that $\frac{\partial B_i}{\partial x} > 0$ and $\frac{\partial^2 B_i}{\partial x^2} < 0$. Thus, a larger population size implies a larger gross benefit but at a decreasing rate. In addition, it is assumed that $B_i(h_i, 0)$ $<c_i(h_l, 0)$. With this assumption we reach an interior solution and extinction is not optimal.

Furthermore, we assume that $\frac{\partial B_i}{\partial h_i} > 0$ and $\frac{\partial^2 B_i}{\partial h_i^2} < 0$, i.e. the hunters has utility of shooting animals and/or sell the harvest. A larger harvest implies a higher gross benefit but at a decreasing rate.

$c_i(h_i,x)$ is the cost function of hunter *i*. We assume that $\frac{\partial c_i}{\partial x} < 0$ and that $\frac{\partial c_i}{\partial h_i} > 0$. Thus a larger population implies a lower cost while a larger harvest implies a larger cost. We also assume that $\frac{\partial^2 c_i}{\partial x^2} > 0$ and $\frac{\partial^2 c_i}{\partial h_i^2} > 0$.[7] This implies that costs is increasing in h_i at a increasing rate and decreasing in *x* at an increasing rate.

[7] See Neher (1990) for a justification of the assumptions behind the derivatives.

Remark, that the maximization of (2) also occurs with respect to *x*. This may be questioned because individual hunters do not choose *x*. However, in a dynamic model h_i is the control variable while *x* is the state variable. Thus, with a dynamic formulation an optimality condition with respect to *x* is also included. When moving from a dynamic to a static formulation we, therefore, also need a first-order condition for *x*. Therefore, maximization in (2) also occurs with respect to *x*.

(2) is the same as maximizing long-run economic net benefit. Normally, we would maximize the present value of expected current and future net benefits (see e.g. Zivin et al. 2000, Ropars-Collet and Le Goffe 2009a, b). This would imply incorporation of discounting. However, we exclude discounting in order to keep the analysis simple but the analysis generalizes straightforward to inclusion of discounting[8].

In (3) *F(x)* is the natural growth. We assume that $\frac{\partial F(x)}{\partial x} > 0$ for $x < x_{MSY}$ and $\frac{\partial F(x)}{\partial x} < 0$ for $x > x_{MSY}$, where x_{MSY} is the population size corresponding to maximum sustainable yield. In addition, $\frac{\partial F^2(x)}{\partial x^2} < 0$. (3) states that the natural growth is equal to expected harvest. Thus, we are interested in a steady-state equilibrium. Normally, we would require that the change in population size between time periods shall equal the natural growth minus harvest. This is the case when we study adjustments towards equilibrium. Note, also, that the steady-state analysis generalizes to studies of adjustments towards equilibrium.

Solving (9) yields:

$$F(x) - \sum_{j \neq i} h_i = h_i \tag{4}$$

Substituting (4) into (2) yields:

$$\underset{x}{Max}[B_i(F(x) - \sum_{j \neq i} h_i, x) - c_i(F(x) - \sum_{j \neq i} h_i, x) - T_i(x)] \tag{5}$$

[8] Skonhoft and Olaussen (2005, p47-48) discuss the consequences of ignoring discounting

Note that we in (5) maximize with respect to population size. As mentioned above population size is a control variable in the individual hunter´s maximization problem. The first-order condition with a Cournot-Nash assumption is:

$$\frac{\partial B_i}{\partial x}-\frac{\partial c_i}{\partial x}+(\frac{\partial B_i}{\partial h_i}\frac{\partial h_i}{\partial F(x)}-\frac{\partial c_i}{\partial h_i}\frac{\partial h_i}{\partial F(x)})\frac{\partial F(x)}{\partial x}-t_i=0 \qquad (6)$$

Because $\frac{\partial h_i}{\partial F(x)}=1$, the first-order condition is reduced to:

$$\frac{\partial B_i}{\partial x}-\frac{\partial c_i}{\partial x}+(\frac{\partial B_i}{\partial h_i}-\frac{\partial c_i}{\partial h_i})\frac{\partial F(x)}{\partial x}-t_i=0 \qquad (7)$$

The assumptions about the second- order derivatives implies that the second-order condition is fulfilled.

By solving (2) subject to (3) with the Lagrange-method and setting the first-order condition for x equal to (7), the shadow price (user cost) of the resource restriction equals $\frac{\partial B_i}{\partial h_i}-\frac{\partial c_i}{\partial h_i}$. Thus, $\frac{\partial B_i}{\partial h_i}-\frac{\partial c_i}{\partial h_i}$ measures this user cost of the resource population as perceived by the hunter. According to (7) marginal net benefits is set equal to zero. The marginal net benefits consist of the marginal gross benefit ($\frac{\partial B_i}{\partial x}$), the marginal costs ($\frac{\partial c_i}{\partial x}$) the marginal tax cost (t_i) and the marginal user cost of the game population.

For regulator four types of net benefit occur. First, timber production gives a net benefit. Here, a large population of animals implies a lower timber production. Second, a game population has also a recreational value of forest visitors who are not hunters. This recreational value increases with population size. Third, the regulator has a benefit of biodiversity in forest. However, the biodiversity decreases with a large population size[9]. Fourth, hunter net benefit (benefits minus costs of hunting) is also a benefit for regulator. Now a large population implies a higher net benefit. Summing up all benefits regulator has a benefit function $D_i(x, h_i)$ where h_i is hunter i´s individual harvest. We assume that there are *n* hunters. It is assumed that for large *x* $\frac{\partial D_i}{\partial x} < 0$ while the marginal benefit of population size is positive for small *x*. This reflects that for large population size there is a large marginal loss in biodiversity and timber production of increasing population size while the marginal value of hunting and recreation is low. However, for small *x* the marginal benefits of hunting and recreational use of forests are high and the marginal loss in biodiversity and timber production is low. Regulators are interested in the largest possible welfare from biodiversity, timber extraction, recreation and hunter´s value extraction. We assume that $\frac{\partial D_i}{\partial h_i} > 0$, i.e positive marginal benefit of hunting which is part of the welfare hunting generates. In addition, we assume that $\frac{\partial^2 D_i}{\partial h_i^2} < 0$ and $\frac{\partial^2 D_i}{\partial x^2} < 0$. Thus, $D_i(h_i, x)$ is increasing in h_i at a decreasing rate and decreasing in *x* at a decreasing rate. We assume that for all *x* $\frac{\partial D_i}{\partial x} < \frac{\partial B_i}{\partial x}$. Thus, the hunter value population size larger than regulator. Thus, population will be two large with unregulated hunting. This is a market failure and the population tax in this paper is designed to solve this market failure,

The regulator maximizes:

$$\underset{h_i, x}{Max} E[\sum_{i=1}^{n} (D_i(x, h_i) - c_i(h_i, x)] \tag{8}$$

s.t.

$$F(x) - E[\sum_{i=1}^{n} h_i] = 0 \tag{9}$$

[9] Note that big game may also contribute positive to non-hunters recreational value of forest and that big game is also an element that contribute to biodiversity itself.

where *E* is an expectation operator included because individual harvest is not exactly measured to the regulator under the population tax. Note that the tax revenue is not included in the maximization problem of regulator. Thus, we do not adopt a double-dividend assumption in the paper.

(9) may be solved to yield:

$$F(x) - E[\sum_{j \neq i} h_i] = E[h_i] \tag{10}$$

(10) may be substituted into (8) which gives:

$$\underset{x}{Max} E[\sum_{i=1}^{n} (D_i(x, F(x) - E[\sum_{j \neq i} h_i]) - c_i(F(x) - E[\sum_{j \neq i} h_i], x)] \tag{11}$$

The first-order condition may be written as:

$$E[\frac{\partial D_i}{\partial x}] - E[\frac{\partial c_i}{\partial x}] + E[(\frac{\partial D_i}{\partial h_i}\frac{\partial h_i}{\partial F(x)} - \frac{\partial c_i}{\partial h_i}\frac{\partial h_i}{\partial F(x)})\frac{\partial F(x)}{\partial x}] = 0 \text{ for } i = 1,..,n \tag{12}$$

From (10) we have $\frac{\partial E[h_i]}{\partial F(x)} = 1$. Thus, (12) may be written as:

$$E[\frac{\partial D_i}{\partial x}] - E[\frac{\partial c_i}{\partial x}] + E[(\frac{\partial D_i}{\partial h_i} - \frac{\partial c_i}{\partial h_i})\frac{\partial F(x)}{\partial x}] = 0 \text{ for } i = 1...,n \tag{13}$$

The assumptions about the second-order derivatives imply that the second-order condition is fulfilled.

If we solved (8) subject to (9) with a Lagrange-function we would reach

$$E[\frac{\partial D_i}{\partial x}] - E[\frac{\partial c_i}{\partial x}] + E[\lambda \frac{\partial F(x)}{\partial x}] = 0$$

.

$E[\lambda \frac{\partial F(x)}{\partial x}]$ is a the expected marginal user cost of changes in growth in the population. Setting (13) equal to the first-order condition with the Lagrange method we reach $E[\lambda \frac{\partial F(x)}{\partial x}] = E[(\frac{\partial D_i}{\partial h_i} - \frac{\partial c_i}{\partial h_i})\frac{\partial F(x)}{\partial x}]$. Thus, $E[(\frac{\partial D_i}{\partial h_i} - \frac{\partial c_i}{\partial h_i})\frac{\partial F(x)}{\partial x}]$is the expected marginal user cost of harvesting one unit more. According to (13) expected net marginal benefit is set equal to zero. The expected marginal benefit is $E[\frac{\partial D_i}{\partial x}]$ while the expected marginal cost is the expected production cost ($E[\frac{\partial c_i}{\partial x}]$) and the user cost of the population of animals.

By setting (7) equal to (13), we reach the following expression for the optimal marginal tax:

$$t_i = \frac{\partial B_i}{\partial x} - \frac{\partial c_i}{\partial x} - E[\frac{\partial D_i}{\partial x} - \frac{\partial c_i}{\partial x}] + (E[\frac{\partial D_i}{\partial h_i} - \frac{\partial c_i}{\partial h_i}] - [\frac{\partial B_i}{\partial h_i} - \frac{\partial c_i}{\partial h_i}])\frac{\partial F(x)}{\partial x} \quad (14)$$

From (14) we see that information about individual benefit and cost functions is necessary. Thus, the mechanism requires huge information requirements. From (14) it is seen that the marginal tax consist of two elements.First, the difference between the marginal net benefit for the hunter and the expected marginal net benefit of the regulator is included. This is reflected in $\frac{\partial B_i}{\partial x} - \frac{\partial c_i}{\partial x} - E[\frac{\partial D_i}{\partial x} - \frac{\partial c_i}{\partial x}]$ and this term corrects the market failure associated with hunting. Second, the difference in user cost (shadow value) for the hunter and expected user cost for the regulator is incorporated ($(E[\frac{\partial D_i}{\partial h_i} - \frac{\partial c_i}{\partial h_i}] - [\frac{\partial B_i}{\partial h_i} - \frac{\partial c_i}{\partial h_i}])\frac{\partial F(x)}{\partial x}$). Because of these two terms each hunter pays the full marginal damage caused by the population. Thus, incentives to free-riding are excluded.

3. Discussion

Some aspects of the incentive scheme proposed here must be discussed further. Hunters will be opposed to taxes since part of their net benefit is exhausted. This conclusion applies to the mechanism in this paper if the actual population size is above the optimal population size.

Therefore, it can be argued that population taxes are impossible to implement for hunting. However, with our tax the tax payment is zero because the population is equal to the target population, therefore, the total tax is zero. In addition, one could propose a combination between individual transferable quotas and taxes to secure a fair distribution of the net benefits between regulators and hunters if quotas are grandfathered away. Thus, by selecting the share of taxes and quotas we select the share of rent to regulators and hunters. However, by introducing individual quotas we make exact information about individual harvest necessary. Thus, we are back with the information requirements of the existing system. Another solution could be to pay back at least a part of the collected tax revenue to hunters as a lump-sum transfer if the actual population is above the optimal population. Furthermore, it can be argued that the tax arrived at in this paper is not different from the present harvest tax. An optimal harvest tax with economic objectives is the difference in net benefits as for the tax in this paper. However, with regard to harvest taxes an important difference arises. In this paper it is population size, not harvest, that is the tax variable.

A problem is that in practice most hunting activities harvest multiple species. Thus, the single-species assumption in this paper makes the population tax of little value. However, the analysis generalizes to a multi-species setting. In this case welfare for owner´s and rents for hunters is defined over several species and multiple restrictions are included. However, the multi-species analysis becomes reasonable complicated because species interaction must be taken into account but in theory we could have multi-species taxes. An additional problem arises in connection with collusion among hunters. We could imagine that hunters collude in order only to pay the population tax once. However, compared to fisheries and pollution, it is reasonable easy for forest owners to measure the number of participants. If the number of participants is observable collusion is not possible and, thus, the problem with collusion is of minor importance for hunting

Another criticism of the mechanism proposed here is that it does not secure budget-balance. By budget-balance we mean that the welfare gain of moving to the optimal harvest is transferred back to the hunters. This criticism is part of the motivation for the work by Xepapadeas (1991) and Govinsdasmy et al (1994) on non-point pollution. Xepapadeas (1991) propose a random penalty mechanism to solve non-point pollution problems, while Govinsdasmy et al (1994) suggest an environmental ranking tournament. Even though it is relevant to discuss the environmental ranking tournament and random penalty mechanism for hunting, a fairly simple solution to the budget-balance problem is to pay back the social benefit from falling in line with the optimal harvest to hunters. In this manner, budget-balance can be secured.

Furthermore, the information requirements of the proposed tax mechanism could be discussed. This point is part of the motivation for the work by Hansen (1999) and Hansen (2001). Within hunting economic taxes could be criticized for posing too many information requirements. The information requirements can be seen from the mechanism in this paper because individual benefit and cost functions must be known. However, this also represents a challenge for the existing regulation, because any attempt to regulate in an optimal fashion depends on reliable cost and benefit data. For example, in setting an optimal individual quota, regulators are also dependent on reliable cost and benefit data. A question that arises is how reliable cost and benefit data can be collected if hunters knew they were used to calculate a population tax. A solution to this problem could be to collect the data by participating in random selected hunting trips. Another solution could be to collect cost and benefit data by revealed or stated preference studies. For example, Ropars-Collet and Le Goffe (2009a) estimate hunters' marginal implicit prices for game hunting in eastern French forests using the hedonic price method on a sample of hunting lease prices. It is also possible to reduce the information requirements by adopting simplifying assumptions. For example, we could work with groups of homogenous hunters. This would reduce the information requirements. Another solution to the information requirement problem is to offer various combinations of individual taxes and target population sizes. We can, then, let hunters select the tax and target population size that is preferred to him. Thus, we let hunters self-select into groups just as for a club good. Furthermore, in practice the information demands are not larger than the necessary information needed when the ambition is to regulate in an optimal fashion using the current tax or mandatory regulations on harvest. Note, also, that the increased information requirements are due to the fact that more realistic assumptions about the information structure are allowed. In other words, the paper is conducted within what Russell (1994) calls complex regulation. Under complex regulation more realistic discussions of regulatory regimes are allowed by dropping some simplifying assumptions traditionally used. The price of the increase in reality is increased complexity. The issue of complex regulation arises in another way.

The regulatory structure proposed here is complex, since it combines target population and taxes. However, it must be noted that the present regulatory structure is at least as complex.

The discussion of information problems are related to the analysis by Cabe and Herriges (1992), who mention two points in connection with non-point pollution. First, the tax scheme will only work if hunters perceive they have a significant influence on the game population size. Thus, hunters must react to the population tax by taking some account on their effect on the population. If hunters do not react in this way, the tax would be ineffective. Hunters would interpret it as a lump-sum tax, which does not influence marginal incentives to harvest. This is the same as saying that the tax works best in small groups. In small groups hunters believe they influence the population size. Note, also, that the tax will work if biological criteria are used to determine the target population. All that is required is that the marginal value of harvest is determined. Second, the mechanism requires a reliable population estimate and an estimate of the natural growth. Within hunting it has proven difficult to estimate populations. Furthermore, game populations and growth information is based on harvest data and because harvest is imprecise measured it may be difficult to obtain population and growth estimates. However, the mechanism also works if we only have a rough indicator for population size. In this case regulator announces a target population size and individual variable tax rate based on expected values. Hunters react to this and a second-best optimum is received. Note, however, that the paper does not attempt to solve the problems mentioned by Cabe and Herriges (1992) but it could be argued that these problems are not as significant within hunting as within fisheries and non-point pollution.

4. Conclusion

In France, the current regulation of hunting is very complex. It involves a tax on the individual hunters harvest (payment of bracelets), a levy on hunting licenses, schemes for compensation of land owners, and detailed administrative regulation of the number of animals harvested. We propose to simplify this regulation. The point of departure for the analysis in the present paper is that without the bracelets individual harvest is unobservable. Thus, individual harvest cannot be used a tax/subsidy variable. The market failure that is analyzed in this paper is that hunters and regulators value the game population differently. For the regulators the marginal value of population size is larger for hunters than the regulator for large population sizes. We propose to make the population the tax/subsidy variable. If the actual population is above the optimal population each hunter pays a tax equal to the difference in populations times a variable tax that varies between individual hunters. Provided the actual population is below the optimal population each hunter receives a subsidy reflecting the difference in population times an individual variable subsidy rate. The variable tax/subsidy reflects difference in marginal valuation of population size between regulator and hunter and differences in user costs of populations between the two actors. This tax scheme will secure a first-best optimum. Note, also, that the population tax works if there are problems in measuring population size. This requires that we fix an expected population size and now the mechanism can secure this. A measure of population could be obtained in same way as in the existing hunting plans. Here recommendations of minimum and maximum harvest are based on expected population size. However, several problems arise with the tax/subsidy mechanism. Among these can be mentioned lack of budget balance, large information requirements, problems with measuring population size, multi-species hunting and collusion among hunters. Important topics for future research involve developing mechanisms that solve these problems. For example, it could be of interest to develop a mechanism that secures budget-balance and raises minimum information requirements.

References

Alphandéry, P., Fortier, A., 2007. A New Approach to Wildlife Management in France: Regional Guidelines as Tools for the Conservation of Biodiversity. Sociologia Ruralis, 47(1), 42-62.

Bédarida, G., François, A. (2008). Impact de la baisse du nombre de chasseurs sur la gestion du sanglier et perspectives. In Klein,F.,Guibert, B. Baubet, E. (Eds.) Proceeding of workshop "Modalités degestion du sanglier", Reims March 1-2, 2007, Paris F.N.C.-O.N.C.F.S. : 206-214.

Bulte, E., Rondeau,R. 2007. Compensation for wildlife damages: Habitat conversion, species preservation and local welfare. Journal of Environmental Economics and Management 54: 311-322.

Cabe, R. and J.A. Herriges, (1992). The Regulation of Non-Point-Source Pollution under Imperfect and Asymmetric Information, Journal of Environmental Economics and Management, 22, pp. 134-146.

Charlez, A. (2008). Plan de chasse et dégâts à la forêt : l ' évolution. Faune sauvage, 281, 56-63.

Fédération Nationale des Chasseurs 2011. L'Association Communale de Chasse Agréée (A.C.C.A.). http://www.chasseurdefrance.com/documents/plaquette_acca.pdf

Govinsdasamy, R.J., J.A. Herriges, and J.F. Shogren, (1994): Nonpoint Tournaments in C. Dosi, and T. Tomasi, eds., Nonpoint Source Pollution Regulation: Issues and Analysis, (Dordrecht: Kluwer Academic Publishers), pp. 87-104.

Hansen,L.G. (2002). "Regulation of Non-Point Emissions – A Variance Based Mechanism," Environmental & Resource Economics 21(4), pages 303-316, April.

Hansen, L.G. (1998). "A Damage Based Tax Mechanism for Regulation of Non-Point Emissions," Environmental & Resource Economics 12(1), pages 99-112, July.

Hansen, L.G., Jensen, F., Brandt, U.S. and Vestergaard, N. Illegal Landings: An Aggregate Catch Self-Reporting Mechanism. American Journal of Agricultural Economics. 2006. 88, pp.974-985.

Horan, R.D., Bulte, E.H. (2004). Optimal and open access harvesting of multi-use species in a second best world. Environmental and Resource Economics, 28(3): 251-272.

Jensen, F. And Kronbak, L.G. 2009: Random Penalties and Renewable Resources: A Mechanism to Reach Optimal Landings in Fisheries. Natural Resource Modelling 22. 3, pp.393-414.

Jensen, F. and Vestergaard, N. Moral Hazard problems in Fisheries Regulation: the Case of Illegal Landings and Discard. Resource and Energy Economics. 2002. 24. pp. 281-299.

Jensen, F. and Vestergaard, N. Asymmetric Information and Uncertainty: The Usefulness of Logbooks as a regulation Measure. Ecological Economics. 2007. 63, pp. 815-827.

Mis en forme : Anglais (Royaume-Uni)

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Code de champ modifié

Code de champ modifié

Code de champ modifié

LE GOFFE, P., & VOLLET, D. (2008). Economie et politique de la chasse : constats, analyses et idées pour l'action. Colloque SFER "Chasse, Territoires et Développement durable Outils d'analyse, enjeux et perspectives " March 27-29, 2008 – Enitac Clermont-Ferrand, France

Rakotoarison, H., Point, P., & Malfait, J. J. (2009). A dynamic model for estimating the economic costs of roe deer browsing in the Gascogne forests. Colloque SFER « Chasse, Territoires et Développement durable Outils d'analyse, enjeux et perspectives » March 25-27, 2009 – Enitac Clermont-Ferrand, France

Ropars-Collet, C. & Le Goffe, P. (2009a). La gestion du sanglier : modèle bioéconomique , dégâts agricoles et prix des chasses en forêt. Working Paper SMART – LERECO N°09-11, INRA-SMART-LERECO, France.

Mis en forme : Anglais (Royaume-Uni)

Ropars-Collet, C., & Le Goffe, P. (2009b). Nuisible ou gibier ? Une analyse économique de la chasse des grands animaux en France. Working Paper SMART – LERECO N°09-18, INRA-SMART-LERECO, France.

Skonhoft, A. (2005). The costs and benefits of a migratory species under different management schemes. Journal of Environmental Management, 76: 167-175.

Segerson, K. (1988): Uncertainty and Incentives for Nonpoint Pollution Control, Journal of Environmental Economics and Management, 15, pp. 87-98.

Skonhoft, A., Olaussen, J.O. (2005). Managing a migratory species that is both a value and a pest. Land Economics, 81(1): 34-50.

Turner, S. (1996): Regulation Theory, Chapter 14.

Zivin, J., Hueth, B.M., Zilberman, D. (2000). Managing a multiple-use resource: the case of feral pigs in California rangeland. Journal of Environmental Economics and Management, 39(1): 189-204.

Xepapadeas, A.P. (1991): Environmental Policy under Imperfect Information: Incentives and Moral Hazard, Journal of Environmental Economics and Management, 2, pp. 113-126