AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

# Outcomes and Determinants of Success of a Performance Payment Scheme for Carnivore Conservation

Astrid Zabel[1], Göran Bostedt[2] & Stefanie Engel[1]

[1]Institute for Environmental Decisions (IED),
Environmental Policy and Economics
Swiss Federal Institute of Technology, ETH,
8092 Zurich, Switzerland
Corresponding author: Email: astrid.zabel@env.ethz.ch
Tel. +41-44-632 4605, Fax +41-44-632 11 10

[2]CERE, Center of Environmental and Resource Economics and Dept. of Forest Economics,
Swedish University of Agricultural Sciences, SLU,
S-901 83 Umeå, Sweden

**Paper prepared for presentation at the EAAE 2011 Congress**
**Change and Uncertainty**
Challenges for Agriculture,
Food and Natural Resources

August 30 to September 2, 2011
ETH Zurich, Zurich, Switzerland

*Copyright 2011 by [Astrid Zabel, Göran Bostedt, Stefanie Engel]. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.*

**Outcomes and Determinants of Success of a Performance Payment Scheme for Carnivore Conservation**

**Abstract:**

This paper presents a first empirical assessment of carnivore conservation under a performance payment scheme. The Swedish government issues payments to reindeer herder villages based on the number of carnivore offspring certified on their pastures. The villages decide on the internal use and distribution of the payments. It is generally assumed that benefit distribution rules are exogenously given. We develop a model to investigate such rules as endogenous decision. The empirical data reveals that villages' group size has a direct negative effect on conservation outcomes. However, there is also an indirect positive effect which impacts conservation outcomes through the benefit distribution rule. This result revises the general collective action hypothesis on purely negative effects of group size. The paper concludes that if limited hunting is legal, conservation success strongly depends on villages' potential for collective action and the benefit distribution rule they choose.

**Keywords**:

Conservation performance payments, Wildlife conservation, Collective action, Empirical policy assessment, Sweden

## 1 Introduction

Conservation performance payments constitute a fairly new approach within environmental policy design. This paper investigates the determinants of success of such an approach for carnivore conservation in Sweden. Performance payments can be placed within the larger group of payments for environmental services (PES). Their distinguishing characteristic is that incentives are tied to indicators of environmental outcomes. Other more conventional PES schemes, by contrast, often tie payments to the provision of inputs into the production process of an environmental good (Engel et al., 2008) which may cause distortion.

The most prominent advantage of the performance payment approach is that the conditionality on the provision of environmental outcomes provides very direct incentives, leaving maximum flexibility and room for innovations in the production process of the good (Musters et al., 2001, Goddard et al., 2008). Furthermore, direct performance payments are, under plausible conditions, found to be more cost-effective than other less direct conventional approaches (Ferraro and Simpson, 2002, Wätzold and Drechsler, 2005). Concerning acceptability of the approach, experience has shown that farmers prefer performance payments over tendering approaches, i.e. competitive bidding as in the US Conservation Reserve Program, because the latter induce competition which is feared to disrupt established social balances in farming communities (von Haaren and Bathke, 2007).

Challenges in scheme design arise when the identification of undistorted performance indicators is intricate, or secondary goals such as targeting payments to the poor need to be met. Also allocating payments for mobile environmental goods such as wildlife or water to individuals may prove difficult (von Haaren and Bathke, 2007). A solution is to rather allocate payments to groups of people, e.g. villages. The responsibility to find a suitable internal payment distribution mechanism is thus devolved to the group.

Previous work on performance payment schemes for wildlife conservation has mainly been descriptive. Zabel and Holm-Müller (2008) present an overview of the Swedish performance payment scheme for carnivore conservation. Several further studies suggest testing the performance payment approach as a new strategy to mitigate carnivore-livestock conflicts (Muhly and Musiani, 2009, Nyhus et al., 2005). To our knowledge the only theoretical investigation compares the incentives generated in a conservation performance payment scheme to those of a simple livestock compensation scheme (Zabel et al., (in press)). They find that both policies can theoretically provide sufficient incentives for a livestock herder to let a carnivore population increase to the social planner's optimum. Additional to theoretical investigations, empirical evaluations of conservation policies are of importance to facilitate learning from existing schemes and to improve the development of new schemes. Quantitative evaluation studies for conservation policies are however fairly rare (Ferraro and Pattanayak, 2006, Ferraro, 2009). In the literature, a rigorous empirical assessment of the outcomes and determinants of success of a larger conservation performance payment or incentive-driven scheme is still lacking (Abendsberg-Traun, 2009, Milne and Niesten, 2009).

The Swedish policy investigated in this paper collectively rewards Sami villages, i.e. groups of reindeer herders, for increases in the carnivore population on the village's territory. We hypothesize that the conservation outcome is determined by (i) each village's ability to engage in collective action to solve the common pool resource dilemma, (ii) the modalities of distributing the performance payment within the village, and (iii) the natural environment.

Since in the Swedish policy the rewards for carnivore conservation are issued to villages, the villages' members are required to manage the use or distribution of the money. The previous literature on common pool natural resource management (CPNRM) problems has generally assumed that benefit distribution rules are exogenously given (e.g., Ostrom, 1990, Agrawal, 2001). This paper adds to the theoretical concepts of CPNRM regimes by revisiting this assumption. A model to explore how a group internally decides on the allocation of resource benefits is developed. The

hypotheses developed are tested with village and household-level data collected in Sweden from participants of the first large-scale performance payment scheme for carnivore conservation. The contribution of this paper is twofold: it adds to the theoretical conceptions of common pool resource management problems and has particular policy relevance because it is the first empirical assessment of a large-scale performance payment scheme. Understanding the factors driving the success or failure of this type of scheme is crucial for designing similar policies elsewhere.

The remainder of the paper is organized as follows: Section 2 outlines the Swedish performance payment scheme. Section 3 discusses the theoretical concepts according to which conservation success at the village-level is assessed. The empirical investigation conducted in Sweden during 2008 and 2009 is presented and discussed in section 4. The last section concludes.

**2 The Swedish performance payment scheme for carnivore conservation**

Many large mammals including carnivores are globally endangered (Hilton-Taylor et al., 2009). On the IUCN Red List of Threatened Species wolverines (*gulo gulo*) are categorized as near threatened and lynx (*lynx lynx*) are listed in the category 'least concern'. Lynx are also listed as a protected fauna species in Annex III of the Bern Convention.

The Swedish government has set explicit population numbers as benchmark-goals for its lynx and wolverine conservation policy. The aspired goal for the reindeer herding area in northern Sweden, which covers approximately two-thirds of the country, is to annually have 90 wolverine offspring and 80 lynx offspring. These offspring numbers correspond to a total population of approximately 400 individual wolverines and 400 individual lynx. On a national level, i.e. including regions beyond the reindeer herding area, the goal is to have 300 lynx offspring or 1500 individual lynx (Swedish Government Bill, 2000).

Participants of the performance payment scheme are the indigenous Swedish Sami reindeer herders. The carnivore habitat overlaps with grazing grounds of their semi-domesticated reindeer. During winter, the diet of wolverines and lynx to a large extent consists of reindeer (Pedersen, 1999). On average, each lynx and wolverine is estimated to annually prey on 40 reindeer (Swenson and Andrén, 2005), causing major economic losses to the reindeer herders (Persson, 2005, Swenson and Andrén, 2005, Danell et al., 2006). Reindeer herding is of central importance to the Sami people and since centuries deeply enrooted in their culture. The herders are organized in 51 Sami villages, which are located from north of the Polar Circle to the more southern county of Dalarna. The term 'Sami village' refers to a community of reindeer herders, but also to the geographical area where a community has grazing rights, but not property rights. In the following, the term will refer to the community. The reindeer are kept in a nomadic herding system. They move from the coastal areas in winter to the mountainous regions close to the Norwegian border in summer. The reindeer herders have grazing rights to private land and forest. In this herding system, reindeer are rarely kept in protected corrals, rendering them fairly easy prey for carnivores.

Until 1996, a conventional compensation policy was installed. To claim compensation, the herders were required to find the carcass of a killed reindeer. Under a performance payment scheme searching for reindeer carcasses is unnecessary, but instead each winter the carnivores have to be inventoried. This is done in cooperation between herders and rangers and conducted according to very detailed regulations.

The amount of the performance payment (SEK 200,000 per offspring, SEK 1≈ USD 0.14) is computed to, on average, compensate slightly more than the damage a carnivore is expected to cause during its lifetime. Apart from simply compensating damage, tying the payment to the number of offspring is intended to provide pro-conservation incentives, i.e. incentives not to hunt. Long-term studies with radio-collared animals which started prior to the policy change found that illegal poaching was a serious issue counteracting wolverine and lynx conservation (Persson, 2007, Andrén et al., 2006).

To acknowledge the hardship that carnivore attacks can impose on the reindeer herding business, the current policy allows for limited 'protective hunting'. The Sami villages can apply for a permission to hunt certain individual animals that cause excessive damage. Given the different conservation status of wolverines and lynx, protective hunting permissions are granted more restrictively for wolverines than for lynx. The government decreed that lynx should persist in the reindeer herding area, but of the nationally aspired 300 offspring only 80 need to be in this area while the larger part of the population should be spread in Southern Sweden (Swedish Government Bill, 2000). Wolverines thrive in undisturbed mountain terrain, which implies that the core population will inevitably be in the reindeer herding area. Figure 1 depicts the development of lynx and wolverine offspring aggregated for all Sami villages since the start of the performance payment scheme. The number of certified lynx offspring has been above the policy's benchmark for more than a decade. The number of wolverine offspring passed the conservation goal for the first time in 2008. However, there is substantial variation in the number of lynx and wolverine offspring between villages.

(Figure 1 about here)

**3 Theoretical concepts**

In Sweden's performance payment scheme, the authority to decide on the final use and distribution of payments has been devolved to the individual Sami villages. From the villagers' perspective, the performance payment money thus is a common pool resource. A village will try to optimize its collective net benefit of performance payments subtractive of the cost of reindeer losses. For a rational *homo oeconomicus* type herder the decisive question will be whether his personal cost-benefit ratio is better with or without a marginal carnivore. In this paper, we test the hypothesis that the

conservation outcome at the village-level, measured in numbers of carnivore offspring, is determined by natural geographical factors and the villages' potential to solve the CPNRM problem.

In recent years, a vast literature on factors that impact collective action in natural resource management has emerged. Collective action is defined as an "action taken by a group (either directly or on its behalf through an organization) in pursuit of members' perceived shared interests" (Marshall, 1996, p. 64). A key issue for collective action in CPNRM regimes is the decision on how to allocate the benefits. Ostrom (1990) highlights that there should be congruence between the allocation of benefits and individuals' inputs. In the previous literature on CPNRM regimes, the decision on benefit allocation has generally been assumed to be exogenously given[1]. The conceptual contribution of this paper is to explain the allocation rule as a variable endogenously determined by the reindeer herders in each village (section 3.2). Figure 2 outlines the framework for the empirical analysis of the Swedish scheme.

(Figure 2 about here)

### 3.1 Collective action theory

Collective action theory compiles factors that are hypothesized to impact the outcomes of CPNRM problems (see Agrawal (2001) for a summary of this literature). For the analysis of the Swedish scheme, the following factors seem to be of particular importance (i) group size, (ii) heterogeneity, (iii) exit options, (iv) social capital, (v) resource system characteristics, and (vi) institutional arrangements.

#### Group size

Members of a small group or community often have multiple interrelationships and repeatedly interact among each other. Individuals' actions are more observable in small, closely knit societies than in larger more anonymous communities (Baland and Platteau, 1996). These features are hypothesized to reduce incentives to defect on contributing to collective action because members of small groups are more likely to reflect on the long-term aftermath and reputation effects of their actions than merely the short-term gains (Baland and Platteau, 1996). Agreements may also be easier and less costly to reach in small groups since the costs of communicating and bargaining are lower (Olson, 1965). These considerations support the hypothesis that small group size is beneficial for collective action. However, extremely small groups are hypothesized to exhibit low levels of collective action due to prohibitively high fixed costs of organizing collective effort (Gebremedhin et al., 2004).

In the Swedish Sami villages, the number of reindeer enterprises within each village can be used as a proxy for group size. Since organizational structures already exist in all villages, costs to initiate collective action are unlikely to be prohibitively large, even in very small villages. We rather expect the effects of personal interrelationships to dominate so that conservation success is negatively impacted by group size.

#### Heterogeneity

Sources of heterogeneity can be classified into two broad groups, economic heterogeneity and socio-cultural heterogeneity. Economic heterogeneity refers to different management interests and/or endowments. With respect to the provision of public goods, Olson (1965) suggests that some degree of heterogeneity is beneficial because otherwise no one would take a lead in managing the resource. Baland and Platteau (1999) further argue that while agents with greater endowments and a larger stake in the conservation of a resource may be incentivized to conserve a common property resource, agents with less endowments and less stake in the resource may have less incentives to do so. As inequality in endowments increases, setting up and adhering to rules for collective action of common property management becomes more difficult. Likewise, differences in asset ownership or wealth can give rise to feelings of envy or rivalry which may negatively affect collective action. Such effects can be especially disruptive in small groups (Baland and Platteau, 1996).

In the Swedish case, an individual's endowment is linked to the size of his reindeer herd. Differences in management interests can arise with heterogeneity in reindeer ownership. This heterogeneity may also be an indicator for problems of envy and rivalry which could hamper finding solutions for the management of the performance payments. If such intra-community problems are severe, applying for protective hunting may be a less onerous solution than conserving many carnivores on the village's territory. A negative relationship between heterogeneity and conservation success is thus likely. At the village-level, heterogeneity of reindeer ownership can be measured by a Gini index. An index value of zero indicates that all reindeer enterprises have equally many reindeer; the more unequal, i.e. concentrated the reindeer ownership is, the closer the value gets to one.

The second broad group of heterogeneity mentioned is differences in culture. This refers to differences in ethnicity, race, or caste that may give rise to diverging modes of communication, or e.g., different interpretations of a timely fulfillment of an obligation. Engaging in collective action has been found to be more difficult for culturally very fragmented groups (Alesina and La Ferrara, 2000). Since only people of Sami origin can engage in reindeer herding, the scope for cultural differences within a village is very limited.

[1] A step towards endogenizing benefit contribution within local communities is made in Engel's (2005) game-theoretic model of community-based irrigation management in Ghana. Payoffs in her model depend on land distribution and the distributional rule for maintenance costs. Land distribution is modelled as an endogenous outcome based on consensus and are shown to depend on the (exogenous) cost distribution rule.

**Exit options**
Exit options refer to possibilities to derive income or means of living from sources beyond the resource at question. The classical hypothesis is that group members who do not, or cannot, make use of exit options have strong incentives to work towards a sustainable use of the resource. Members whose livelihoods are not bound to the local resource may have less interest in its long-term use (Baland and Platteau, 1996). In Sweden, exit options can be measured as percentage of working time that reindeer owners spend outside the reindeer business. Part-time reindeer herders naturally have less time to protect their reindeer from carnivore attacks and in consequence are likely to incur higher losses. Thus villages in which herders, on average, are strongly engaged in outside jobs may be more likely to apply for protective hunting which reduces conservation success. By contrast, villages with many full-time herders are likely to incur less reindeer losses per carnivore and may be willing to host more of them.

**Social capital**
In recent years, the interest in social capital as a factor enhancing collective action has greatly increased. Putnam (1995) defines social capital as features of social organization which can help to advance cooperation for mutual benefit and help resolve problems of collective action. Examples for such facilitating features are networks, norms, and social trust which can simplify coordination and amplify reputations (Putnam, 1995). Field (2003) states that in Putnam's view social capital contributes to collective action by raising the costs of defection, strengthening reciprocity, enhancing exchange of information on people's reputation, and providing a pattern for future cooperation.

With respect to the Swedish context, Putnam's proposition supports the hypothesis that social capital in a reindeer herder village may have a positive impact on conservation success as an outcome of collective action. Social cohesion can function as proxy for social capital.

**Resource system characteristics**
The largest variation in resource system characteristics in the Sami villages is found in their topography. The villages in the north and west have predominantly mountainous terrain with no tree cover at high altitudes whereas southern and eastern villages are less mountainous but have more forest cover. These natural geographical distinctions are important because wolverines live in mountainous habitat and lynx mainly stay in the forest.

'Boundaries of a resource' is a special characteristic that has been identified as important in the collective action literature. Boundaries are hypothesized to be necessary in order to distinguish exactly what the management system is to administer (Ostrom, 1990). In the Swedish context these boundaries are given through the defined limits of the villages and hence do not need further research.

**Institutional arrangements**
The prominent question concerning institutional arrangements is how the group members decide to use or distribute the benefits of the common pool resource, which in the Swedish case is the performance payment. The existing collective action literature has paid little attention to this question. However, since the benefit distribution rule is hypothesized to impact the outcomes of community-based natural resource management, it is important to understand the underlying mechanisms which lead to a certain distribution rule.

In the Sami villages the performance payment is either invested for community expenses or distributed to the individual reindeer herders proportional to their herd sizes. A model to explain the choice of payment distribution rule is presented in the following section.

**3.2 Decision on the optimal payment distribution**
Assessing the payment distribution decision at the village-level focuses on explaining which share of the performance payment money is retained for investments into common expenses and which share is distributed directly to individuals. In the Swedish Sami villages, typical common investments are for maintenance of facilities, such as fences or cottages, and fees for helicopters to round-up reindeer. If the payment is distributed to individuals it is commonly allocated according to herd size. However, there are two villages in which the money is paid per identified killed reindeer. Since the number of reindeer a herder loses, in the long run, is proportional to herd size, making payments based on killed reindeer can be interpreted as equivalent to issuing payments according to herd size.

We hypothesize that in a first step, each herder in a village computes the repartition of the money that would maximize his personal utility. Then in a second step, the herders collectively negotiate the final division of the money.

To determine an individual's optimal payment distribution we develop a simple Cobb-Douglas utility maximization model. In the model, the share of the total performance payment distributed directly to the individuals is termed $\alpha$, and the share retained for community expenses is $1-\alpha$. A reindeer herder maximizes his utility which is a function of his private income, $R$, and the community investment, $C$, both of which will depend on $\alpha$:

$$U(\alpha) = R(\alpha)^{\gamma} C(\alpha)^{1-\gamma} \quad (1)$$

where the elasticities $\gamma$ and $1-\gamma$ of the Cobb-Douglas function indicate an individual's preferences for private income versus community investments.
The herder's private income

$$R(\alpha) = p[F(x_i) - k(W)] + \pi_i + \alpha \frac{x_i}{X_T} V(W) \quad (2)$$

consists of the sum of revenue derived from the sale of reindeer meat, $p[F(x_i) - k(W)]$, his off-farm income, $\pi_i$, and his individual direct share of the performance payment money, $\alpha \frac{x_i}{X_T} V(W)$, where $W$ is the number of carnivores, and $\frac{x_i}{X_T}$ is the individual's share of the village's total number of reindeer, $X_T$. To maintain a constant reindeer stock, $x_i$, the herder is assumed to only sell the net growth of his herd. This is determined by the growth of his stock $F(x_i)$, which is a logistic growth function, minus the number of reindeer that are killed by carnivores, $k(W)$, (with $\partial k / \partial W > 0$). The exogenous price of reindeer meat, net of management and slaughtering costs, is given by $p$.

The total performance payment issued to the village, $V(W)$, is a function of the carnivore stock, with $\partial V / \partial W > 0$. The amount of money directly given to the herder can then be computed as $\alpha \frac{x_i}{X_T} V(W)$.

The community investments are simply:

$$C(\alpha) = (1-\alpha) V(W) \quad (3)$$

With equations (2) and (3) given, the herder maximizes his utility function specified in (1), or equivalently:

$$\max_{\alpha} \ln U(\alpha) = \gamma \ln(R(\alpha)) + (1-\gamma) \ln(C(\alpha)) \quad (4)$$

The first order condition derived from (4) is:

$$\frac{\gamma}{R(\alpha)} R'(\alpha) = \frac{(\gamma - 1)}{C(\alpha)} C'(\alpha) \quad (5)$$

where the prime indicates the derivative. Given (2) and (3), equation (5) can be rewritten as:

$$\frac{\gamma \frac{x_i}{X_T} V(W)}{p[F(x_i) - k(W)] + \pi_i + \alpha \frac{x_i}{X_T} V(W)} = \frac{(\gamma - 1)(-V(W))}{(1-\alpha) V(W)} \quad (6)$$

Solving for $\alpha$ yields the herder's individual optimality condition:

$$\alpha^* = \gamma - \frac{(1-\gamma)[p(F(x_i) - k(W)) + \pi_i]}{\frac{x_i}{X_T} V(W)} \quad (7)$$

Once all herders have identified their personally optimal alpha, the village's choice of payment distribution is assumed to be based on voting. A special characteristic of the Sami villages is that they have a weighted voting system. The number of votes is allocated according to an individual's reindeer herd size, with one vote corresponding to one hundred reindeer. This is a similar system as in shareholder meetings. Applying the median voter theorem to this special case implies that the village-level outcome will correspond to the 'median vote' rather than the median voter.
Equation (7) can be used to derive hypotheses on the determinants of the payment distribution rule that can then be empirically tested.

Hypothesis 1: Villages with comparatively higher carnivore populations are expected to allocate more of their performance payments directly to the individual herders. This hypothesis builds on the derivative of (7) w. r. t. W:

$$\partial \alpha_i / \partial W = (1-\gamma_i) X_T x_i^{-1} \left[ V(W)^{-2} [p(F(x_i) - k(W)) + \pi_i] + pV(W)^{-1} \partial k / \partial W \right] > 0,$$

which is always positive under the sufficient condition that growth of the reindeer stock is larger than predation $F(x_i) > k(W)$.

It suggests that an increase in a village's carnivore population is reflected in an increase in the performance payment and an increase in predation by carnivores. This will increase the optimal alpha for each villager and

cause a shift in the preference distribution of all herders in a village towards a larger alpha. In consequence, the median vote holder will also opt for a larger alpha.

If the condition $F(x_i) > k(W)$ were not satisfied, the carnivores would gradually eliminate the reindeer population. By law, the carnivore population in Sweden may not rise to a level at which reindeer herding is no longer possible (Swedish Government Bill, 2000).

Hypothesis 2: Villages in which the median vote holders have a higher preference for private income over community investments will, on average, allocate more of the performance payment directly to the herders. This can be seen from

$$\partial\alpha_i/\partial\gamma_i = 1 + \left[p\left(F(x_i) - k(W)\right) + \pi_i\right] X_T x_i^{-1} V(W)^{-1} > 0 \text{ for } F(x_i) > k(W).$$

We use the number of herders in a village as proxy for the preference for private income. The larger a group is, the more difficult it may be to collectively decide on the use and distribution of common investments, thus increasing the preference for private income.

Hypothesis 3: Villages with many reindeer and a high concentration of reindeer ownership will, on average, allocate a larger share of the payment directly to the herders. The derivative of alpha with respect to an individual's herd size

$$\partial\alpha_i/\partial x_i = X_T V(W)^{-1}(1-\gamma_i)\left[x_i^{-2}\left(p\left(F(x_i) - k(W)\right) + \pi_i\right) - p x_i^{-1}\,\partial F/\partial x_i\right]$$

is always positive under two sufficient conditions: growth being larger than predation, $F(x_i) > k(W)$, and marginal growth being negative, $\partial F/\partial x_i < 0$. The latter is likely to apply to the Swedish case because each village has a state-defined quota for total herd size which represents each village's reindeer carrying capacity. The villages' total herd sizes are close to the quota.

We hypothesize that villages in which some herders have very large numbers of reindeer will, on average, opt for a larger alpha. The concentration of reindeer ownership at the village-level can be expressed through a Gini coefficient. We hypothesize that an increase in the Gini coefficient is associated with an increase in alpha.

Hypothesis 4: More of the performance payment will be allocated directly to herders if there is inequality of losses to carnivore attacks on a village's winter pastures. In many villages, the reindeer are split into smaller groups during winter. Some may, for example, be closer to a forest and more prone to carnivore attacks than on a pasture close to a settlement. The variable $\delta_v$ takes the value 1 if there are systematic inequalities in carnivore attacks on different winter pastures and zero otherwise. This hypothesis is not directly based on equation (7). However, it implies that more of the payment will be distributed directly to herders if some suffer proportionally higher losses than others in the village.

Equation (7) contains two further parameters that can impact an individual's optimal alpha. First, a marginal increase in off-farm income decreases an individual's optimal alpha (see Appendix A.1). Unfortunately, it is not possible to infer from this individual-level variable to possible changes in the overall village-level preference distribution for alpha. It is thus not possible to make a statement on whether and in which direction the median vote for alpha would shift.

Second, an increase in the reindeer meat price would increase an individual's optimal alpha, i.e. he would prefer to personally obtain a larger share of the performance payment (see Appendix A.2). However, there is no substantial variation in reindeer meat prices across villages.

Since alpha, the share of money allocated to the herders, has corner solutions at 0 and 1, we apply a Tobit regression to empirically test our hypotheses. The Tobit model can be specified as follows,

$$\begin{aligned} \mathrm{A}_v^* &= \beta_0 + \beta_1 W_v + \beta_2 \gamma_v + \beta_3 \chi_v + \beta_4 \delta_v + u_v \\ \mathrm{A}_v &= \max\left(\mathrm{A}_v^*, 0\right) \end{aligned} \qquad (8)$$

where $\mathrm{A}_v$ is the observed value for the share ($\alpha$) of money given to the herders in village *v*. $\mathrm{A}_v^*$ is the latent variable and $u_v\left(0, \sigma^2\right)$ is the normally distributed error term. $\chi_v$ is a Gini coefficient expressing the inequality or concentration of herd sizes in a village, and $\delta_v$ is a dummy variable reflecting inequalities of damage, i.e. carnivore attacks on different winter pastures in one village. Based on the hypotheses developed above, we expect all four coefficients $\beta_1, \beta_2, \beta_3, \beta_4$ to be positive.

## 4 Empirical analysis

The data required for the analysis of the Swedish performance payment scheme for carnivore conservation were collected in two steps. In each village one reindeer herder is designated to be the village's carnivore representative. This person attends meetings on carnivore issues and is the contact person and mediator for all carnivore matters vis-à-vis the government. From August to October 2008 structured interviews were conducted with the carnivore representatives of all villages, except one who refused to participate in the study. The interviews were all conducted by one of the authors and, in most cases, took place in the interviewees' homes.

The household-level data was obtained through a mail survey. In February 2009, the survey was sent to a sample of 970 registered reindeer owners between 18 and 65 years of age, and in April a reminder was sent to all who had not yet responded. The sample population represents 25.3% of the total number of reindeer owners in this age cohort. The sample was stratified according to the villages' population. The final response rate obtained was 41.3%. Concerning representativeness of the responses we find that there is no significant difference between the mean age of the respondents (45.88 years) and the mean age of the sample population (46.12 years). The gender distribution of the respondents (59% men, 41% women) is not significantly different from that of the total population of Swedish reindeer herders (62% men, 38% women) (Sametinget, 2009). Furthermore, 84.5% of the sample population belongs to Sami villages in the county of Norrbotten, 7.6% to Västerbotten, and 7.8% to Jämtland. This regional repartition was also well-reflected in the responses and not significantly different from the sample: 86.9% of the responses came from villages in Norrbotten, 6.03% from Västerbotten, and 7.04% from Jämtland.

According to the theoretical framework outlined in Figure 2 and discussed above, we conduct econometric analyses to explain the payment distribution rule and conservation success at the village-level under a performance payment scheme. Table 1 provides a summary overview of the variables used.

(Table 1 about here)

The dependent variables for conservation success are measured as total number of lynx respectively wolverine offspring per village that were certified between 1996 and 2006. The key variable indicating the villages' payment distribution decision, 'Share_herders', expresses the percentage of the payment directly distributed to the herders.

Herd size data is obtained from secondary information on all enterprises in a village. Unfortunately, the data is not available for seven villages located in the north-east of Sweden, bordering Finland.

The availability of exit options is approximated as the average percent of working time respondents spent outside of the reindeer herding sector during the past year. The proxy for social capital is computed as a village-level average that is based on responses from the household survey. Respondents were asked to indicate their opinion on the statement that most members in their village are interested in their common welfare and only few are solely interested in their private welfare. To obtain data for the 'Damage_inequality' variable, the carnivore representatives of each village were asked whether all herders suffer proportionally equal reindeer losses in winter. Village's forested and mountainous areas are used as proxies for natural geographic characteristics because lynx habitat is the forest and wolverines prefer mountains.

### 4.1 Test of model for payment distribution decision

The empirical data allows for a test of the model on the village internal payment distribution decision developed in section 3.2. Table 2 presents the results for the instrumental variable Tobit models. An instrumental variable approach is necessary because we hypothesize that the number of carnivore offspring, i.e. conservation success, is also an outcome of the payment distribution rule. The instrument chosen is the sum of forested and mountainous area in each village. In brackets behind the names of the independent variables are the model parameters that are being proxied and their predicted sign.

The model presented in column 2a tests all four hypotheses developed in section 3.2. Only the coefficient for 'Group_size' is significant and has the expected sign. Apart from the coefficient for 'Gini_herd' the other variable's coefficients have the expected sign but are not significant. Unfortunately, for several villages there is no data available on the variable 'Gini_herd' which proxies the concentration of reindeer ownership. Column 2b thus presents the same model but without this variable. There, the coefficients remain largely unchanged, only the significances for 'Group_size' and 'Damage_inequality' increase.

(Table 2 about here)

Referring to the hypotheses set up in section 3.2, we thus cannot reject hypotheses 2 and 4 but reject hypothesis 1 and 3. The results suggest that group size, which in terms of our model proxies the preference for private income, is an important factor determining the payment distribution rule. Costs of negotiating on community expenditures are likely to increase with group size. High negotiation costs in turn render private income preferable over community investments. Furthermore, it is interesting that the absolute number of carnivores seems to be of lesser importance while inequalities of damage on winter pastures within a village has an impact on the payment distribution rule.

**4.2 Empirical analysis of conservation success**

Conservation success, measured in numbers of offspring, is hypothesized to be a function of collective action within a village, a village's payment distribution rule, and its natural-geographical features. Tables 3 and 4 each present three models for lynx respectively wolverine conservation success at the village-level. The first column in both tables is a theory-driven model where the payment distribution rule is hypothesized to endogenously depend on the conservation outcome. This endogeneity assumption is derived from the model developed in section 3.2. A two-stage least squares (2SLS) approach is applied to account for endogeneity. In the tables below, column (a) presents the results of the first stage and column (b) the results of the instrumental variables regressions. The instrumental variable for the share of money distributed directly to herders is 'Damage_inequality', i.e. systematic differences in severance of carnivore attacks on different winter pastures. However, results of Wu-Hausman-tests for the 2SLS regressions in Table 3 ($F(1,33) = 0.9244$) and Table 4 ($F(1,33) = 0.5825$) both indicate that the payment distribution variable 'Share_herders' is not endogenous. This finding is in accordance to the finding that 'Carnivores' was not significant in Table 2 of section 4.1.

Column (c) in both tables thus presents an OLS regression model in which the payment distribution rule is treated as an exogenous variable. Column (d) in both tables presents OLS regression results for a model including only the natural-geographical variable 'Forest', respectively 'Mountain'.

(Table 3 about here)
(Table 4 about here)

In a first step we conduct F-tests to assess whether the socio-economic variables together significantly aid in explaining more of the variance in conservation success than simply the natural-geographic variables. The tests reveal that in the lynx case ($F(5,34)=2.57$) the addition of the socio-economic variables significantly improves the model's explanatory power whereas in the wolverine case ($F(5,34)=0.78$) it does not. These results are reinforced by the results of Ramsey RESET tests which test for omitted variables (Cameron and Trivedi, 2009). For the wolverine model in column (d) of Table 4 the test indicates that there are no omitted variables ($F(3,45)=2.31$). The corresponding test for the regression of 'Lynx' on 'Forest' in Table 3 ($F(3,45)=6.98$) states that there are omitted variables.

These findings are interesting because they point to important policy differences for lynx and wolverine management. For lynx, legal hunting permissions have been granted quite generously because the government has decreed that the total lynx population may decrease in the reindeer herding area. This supports the implication that our regression models show collective action factors that impact the decision on legal lynx population management within the villages.

The important policy difference in the wolverine case is that permissions for protective hunting have been granted only very restrictively. Although it may seem likely that the factors impacting the villages' lynx population management decisions also apply in the wolverine case, they do not. The variable 'Group_size' is significant and has the hypothesized negative sign. The variable 'Gini_herd' is also significant but does not have the expected sign. However, an F-test for a comparison of model (4c) with and without these two variables ($F(2,34)=1.69$) reveals that their addition does not significantly improve the explanatory power of the model. The main factor impacting wolverine conservation success is abundance of mountainous area. This single variable can explain nearly three-fourths of the variation. Since we cannot detect a significant impact of socio-economic variables, the data allows for the conclusion that the herders, at large, let the wolverine population develop naturally, i.e. refrain from illegal poaching.

The regression results for lynx conservation reveal that the variables 'Share_herders' 'Group_size', and 'Forest' have a significant impact. The coefficient for 'Share_herders' is positive suggesting that issuing a larger fraction of the performance payment directly to herders, on average, is advantageous for lynx conservation. As hypothesized, group size has a negative impact on conservation success. The larger the group the less frequent are personal interrelationships between all members. Anonymity increases while the incentives to consider reputation effects may decrease. Also, as group size increases communication and bargaining costs increase. These characteristics may decrease the benefits of conservation to such a degree that, for large groups, applying for permission to hunt a lynx becomes the preferable outcome. In other terms, in large groups the costs of collectively agreeing to engage in conservation may be higher than the benefits derived from the performance payments, i.e. the performance payments subtractive of the cost of reindeer losses.

The abundance of tree-covered areas measured by the variable 'Forest' clearly has a positive and strongly significant impact on lynx conservation success. The model in column (d) of Table 3 reveals that this variable alone captures nearly 30% of the variation in the number of lynx offspring.

Although not significant, the collective action variables 'Gini_herd', which proxies heterogeneity, 'Exit_option', and 'Social_capital' all have the expected negative sign. According to the theory presented above, the negative sign for 'Gini_herd' may point to rivalry and envy which increase with inequality of reindeer ownership and hamper collective action in the communities. Also in line with the theory, the negative sign for the social capital index suggests that, on average, conservation success is lower in villages where members feel there is little community cohesion. The negative coefficient for 'Exit_option' indicates that when herders, on average, spend less time in the reindeer business, conservation success is lower.

## 5 Concluding remarks

This paper has empirically assessed the outcomes and determinants of success for the first large-scale performance payment scheme for carnivore conservation. We hypothesized that conservation success is a function of the natural-geographic environment, collective action, and in particular the villages' decision on how to internally allocate the monetary benefits of conservation, i.e. the performance payments. Although the rules governing the distribution of benefits of common pool resources are often stated to be an important determinant for the success of collective resource management (Ostrom, 1990, Agrawal, 2001), little work has been done on explaining how these rules emerge. This paper contributes to the theory by presenting a simple model to address this question. The model is empirically tested with data from Sweden. The main findings are that, on average, a larger group size as well as prevailing differences in the likelihood of experiencing carnivore attacks on different winter pastures in a village will induce the village members to allocate a larger share of the performance payments directly to the individual members.

The econometric analysis on village-level wolverine conservation success indicates that the abundance of mountainous area, which is wolverines' preferred habitat, was found to be the most important sole factor impacting the number of wolverine offspring. The collective action variables do not significantly add to the explanation of conservation success.

Contrary to the wolverine case, socio-economic variables do significantly add to the explanation of lynx conservation success. We ascribe this difference to the fact that applications for protective hunting of lynx were granted quite generously. Essentially, the outcome of the decision on whether to apply for protective hunting or to let the carnivore population develop and subsequently reap the performance payments depends on a village's potential for collective action. Among the indicators for collective action, group size was most significant and suggested that there is a negative relationship between group size and conservation success. Concerning the payment distribution rule, the regression results pointed to a positive relationship between the allocation of performance payments directly to individuals and increased lynx conservation success.

It is interesting to see that group size impacts lynx conservation success in two ways. On the one hand, the direct effect is negative as predicted by collective action theory and shown in Table 3. On the other hand, by analyzing the payment distribution rule, we found that villages with more members allocate more of the performance payments directly to the herders, which has a positive effect on conservation success. This result, at least in part, revises the general collective action hypothesis that an increase in group size necessarily has negative effects on collective action.

Together with the significance of the payment distribution variable, this finding highlights the importance of investigating mechanisms leading to a specific benefit distribution rule in common pool resource problems. The paper provides a simple model for the Swedish case which, however, could easily be adapted to other applications.

The empirical results of the study allow for several policy implications for cases of wildlife-livestock conflicts. In particular, the recommendations refer to cases in which communities' or groups' conservation efforts are collectively evaluated. The first is that if strict conservation is required due to the status of a carnivore species, providing pro-conservation incentives, such as performance payments, additional to regulations can generate favorable results.

Performance payments can also be implemented in situations without strong regulations for wildlife conservation. For such cases, the results of the unique Swedish experience suggest that conservation success depends on a group's potential to engage in collective action. Group size was found to be a particularly important factor in Sweden but other characteristics such as economic or cultural homogeneity, social capital, and exit options are also likely to be important. The authority to distribute the benefits within the group can be devolved to the group itself. However, the general advice may be to allocate as much as possible directly to individual group members.

The Swedish payment scheme is currently unique in its kind. To enhance the understanding of this type of incentive mechanism, further experiments and applications are necessary. An interesting question for further research would thus be to test the transferability of the performance payment approach to a developing country setting, for instance the tropics where wildlife-livestock conflicts are often especially severe. If attacks on livestock threaten the resilience of poor rural farmers the latter have an incentive to hunt the damage-causing carnivores. In such cases, performance payments may be an interesting alternative to existing more conventional conservation policies.

## Appendix

A.1) $\partial\alpha_i/\partial\pi_i = -X_T\left(1-\gamma_i\right)/x_iV\left(W\right) < 0$

A.2) $\partial\alpha_i/\partial p = -X_T\left(1-\gamma_i\right)\left(F\left(x_i\right)-k\left(W\right)\right)/x_iV\left(W\right) < 0$ if $F\left(x_i\right) > k\left(W\right)$

## References


M. Abensperg-Traun, CITES, sustainable use of wild species and incentive-driven conservation in developing countries, with an emphasis on southern Africa, *Biological Conservation* **142**, 948-963 (2009).

A. Agrawal, Common Property Institutions and Sustainable Governance of Resources, *World Development* **29**, 1649-1672 (2001).

A. Alesina and E. La Ferrara, Participation in Heterogeneous Communities, *Quarterly Journal of Economics* **115**, 847-904 (2000).

H. Andrén and O. Liberg, Den svenska lodjursstammen 2004-2008, Report Grimsö research station, Grimsö (2008).

H. Andrén, J. D. C. Linnell, O. Liberg, R. Andersen, A. Danell, J. Karlsson, J. Odden, P. F. Moa, P. Ahlqvist, T. Kvam, R. Franzén, and P. Segerström, Survival Rates and Causes of Mortality in Eurasian Lynx (Lynx lynx) in Multi-use Landscapes, *Biological Conservation* **131**, 23-32 (2006).

J.-M. Baland and J.-P. Platteau, Halting Degradation of Natural Resources. Is there a Role for Rural Communities?, Clarendon Press, Oxford (1996).

J.-M. Baland and J.-P. Platteau, The Ambiguous Impact of Inequality on Local Resource Management, *World Development* **27**, 773-788 (1999).

A. C. Cameron and P. K. Trivedi, Microeconometrics Using Stata, Stata Press, College Station, Texas (2009).

A. C. Danell, H. Andrén, P. Segerström, and R. Franzén, Space use by Eurasian lynx in relation to reindeer migration, *Canadian Journal of Zoology* **84**, 546-555 (2006).

S. Engel, Endogenitäten im partizipativen Ressourcenmanagement: Politökonomische Aspekte des Bewässerungsmanagements in Ghana, Duncker und Humblot GmbH, Berlin (2005).

S. Engel, S. Pagiola, and S. Wunder, Designing payments for environmental services in theory and practice: An overview of the issues, *Ecological Economics* **65**, 663-674 (2008).

P. J. Ferraro and H. Gjertsen, A Global Review of Incentive Payments for Sea Turtle Conservation, *Chelonian Conservation and Biology* **8**, 48-56 (2009).

P. J. Ferraro and S. K. Pattanayak, Money for Nothing? A Call for Empirical Evaluation of Biodiversity Conservation Investments, *PLoS Biol* **4**:e105 (2006).

P. J. Ferraro and R. D. Simpson, The Cost-Effectiveness of Conservation Payments, *Land Economics* **78**, 339-353 (2002).

J. Field, Social Capital, Routledge, London (2003).

B. Gebremedhin, J. Pender, and G. Tesfay, Collective action for grazing land management in crop-livestock mixed systems in the highlands of northern Ethiopia, *Agricultural Systems* **82**, 273-290 (2004).

R. Gorddard, S. Whitten, and A. Reeson. When should biodiversity tenders contract on outcomes?, Annual conference of the Australian Agricultural and Resource Economics Society, Canberra (2008).

C. Hilton-Taylor, Pollock, C. M., Chanson, J. S., Butchart, S. H. M., Oldfield, T. E. E., Katariya, V., State of the world's species, in: "Wildlife in a Changing World – An Analysis of the 2008 IUCN Red List of Threatened Species" (J.-C. Vié, C. Hilton-Taylor, and S. N. Stuart, Eds.), IUCN, Gland, Switzerland (2009).

G. Marshall, Oxford Concise Dictionary of Sociology. Oxford University Press (1996).

S. Milne and E. Niesten, Direct payments for biodiversity conservation in developing countries: practical insights for design and implementation, *Oryx* **43**, 530-541 (2009).

T. B. Muhly and M. Musiani, Livestock depredation by wolves and the ranching economy in the Northwestern U.S., *Ecological Economics* **68**, 2439-2450 (2009).

C. J. M. Musters, M. Kruk, H. J. De Graaf, and W. J. T. Keurs, Breeding Birds as a Farm Product, *Conservation Biology* **15**, 363-369 (2001).

P. Nyhus, S. Osofsky, P. J. Ferraro, F. Madden, and H. Fischer, Bearing the costs of human-wildlife conflict: the challenges of compensation schemes, in: "People and Wildlife: Conflict or Coexistence?" (R. Woodrooffe, S. Thirgood, and A. Rabinowitz, Eds.) Cambridge University Press, London (2005).

M. Olson, The Logic of Collective Action, Harvard University Press, Cambridge, MA. (1965).

E. Ostrom, Governing the Commons: The Evolution of Institutions for Collective Action, Cambridge University Press, New York (1990).

V. A. Pedersen, J. D. C. Linnell, R. Andersen, H. Andrén, M. Lindén, and P. Segerström. Winter Lynx *Lynx lynx* Predation on Semi-domestic Reindeer *Rangifer tarandus* in Northern Sweden, *Wildlife Biology* **5**, 203-211 (1999).

J. Persson, Female wolverine (Gulo gulo) reproduction: reproductive costs and winter food availability, *Canadian Journal of Zoology* **83**, 1453–1459 (2005).

J. Persson, Järvens status och ekologi i Sverige, Report for the Governmental Commission on the Large Carnivores (Utredningen om de stora rovdjuren). Dept. of Ecology, Grimsö Wildlife Research Station, Swedish University of Agricultural Sciences Grimsö. (2007).

R. Putnam, Bowling alone: America's Declining Social Capital, *Journal of Democracy* **6**, 65-78 (1995).

Sametinget, Broschyr med statistik om rennäringen i Sverige, Kiruna (2009).

Swedish Government Bill, Sammanhållen rovdjurspolitik, 2000/01:57, Stockholm (2000).

J. Swenson and H. Andrén, A Tale of Two Countries: Large Carnivore Depredation and Compensation Schemes in Sweden and Norway, in: "People and Wildlife: Conflict or Coexistence?" (R. Woodrooffe, S. Thirgood, and A. Rabinowitz, Eds.) Cambridge University Press, London (2005).

C. v. Haaren and M. Bathke. Integrated landscape planning and remuneration of agri-environmental services: Results of a case study in the Fuhrberg region of Germany, *Journal of Environmental Management* **89**, 209-221 (2008).

Viltskadecenter (a), Slutgiltiga resultat från inventeringar av järv i Sverige 2008, Riddarhyttan (2009).

Viltskadecenter (b), Resultat från inventeringar av lodjur i Sverige vintern 08/09: Preliminär nationell sammanställning över länsstyrelsernas resultat av inventeringar av lodjur, Riddarhyttan (2009).

Viltskadecenter (c), Preliminära resultat från inventering av järv 2009, Riddarhyttan (2009).

F. Wätzold and M. Drechsler, Spatially Uniform versus Spatially Heterogeneous Compensation Payments for Biodiversity-Enhancing Land-Use Measures, *Environmental and Resource Economics* **31,** 73-93 (2005).

A. Zabel and K. Holm-Müller, Conservation performance payments for carnivore conservation in Sweden, *Conservation Biology* **22**, 247-251 (2008).

A. Zabel, K. Pittel, G. Bostedt, and S. Engel, Comparing Conventional and New Policy Approaches for Carnivore Conservation – Theoretical Results and Application to Tiger Conservation, *Environmental and Resource Economics*, Special Issue (in press).

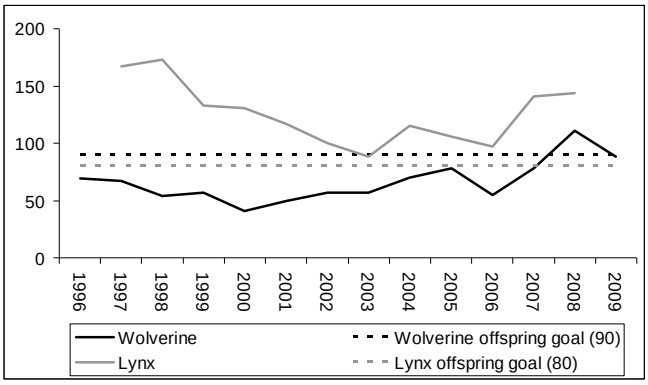


**Figure 1:** Development of lynx and wolverine offspring in Swedish Sami villages
Data sources: (Viltskadecenter, 2009 a,b,c, Andrén and Liberg, 2008)
Note: Data for 2009 is only preliminary.

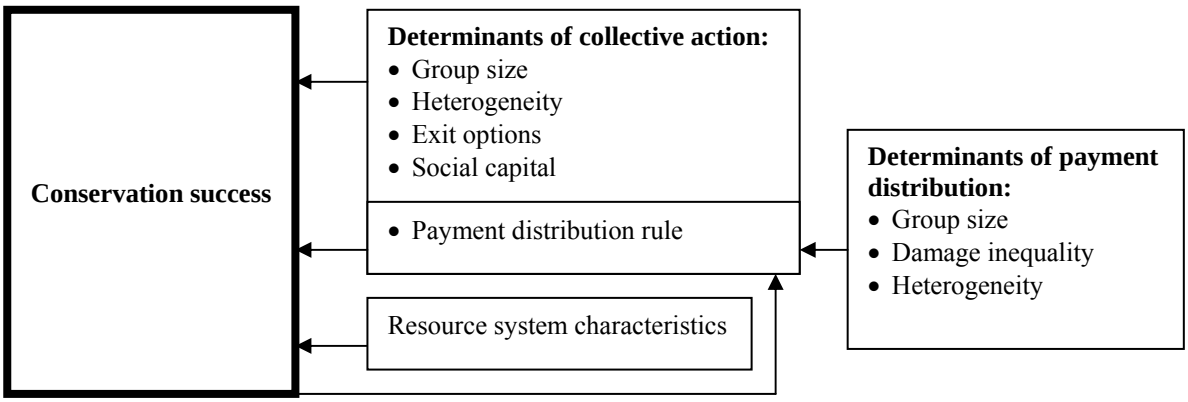


**Figure 2:** Framework for empirical assessment of conservation success under a performance payment scheme

| VARIABLES | | Mean | Std. Dev. | Min | Max | N |
|---|---|---|---|---|---|---|
| Lynx | Lynx offspring 1996-2006 per village | 33.39 | 35.55 | 0.00 | 141.50 | 50 |
| Wolverines | Wolverine offspring 1996-2006 per village | 13.92 | 15.99 | 0.00 | 63.23 | 50 |
| Share_herders | Percentage of performance payment allocated to individuals directly in each village | 0.43 | 0.39 | 0.00 | 1.00 | 50 |
| Group_size | Number of reindeer enterprises in each village | 35.17 | 43.74 | 2.00 | 220.00 | 50 |
| Gini_herd | Gini index measuring heterogeneity resp. concentration of reindeer ownership in each village | 0.39 | 0.16 | 0.02 | 0.66 | 43 |
| Exit_option | Average for each village of respondents' percentage of working time spent outside reindeer herding sector | 58.08 | 24.86 | 0.00 | 87.50 | 49 |
| Social_capital | Average score for perception of cohesion in each village (1=high, 5=low perceived cohesion) | 2.68 | 0.77 | 1.00 | 4.33 | 49 |
| Carnivores | Sum of lynx and wolverine offspring per village 1996-2006 | 47.30 | 40.20 | 0.00 | 158.99 | 50 |
| Damage_inequality | Dummy indicating if carnivore attacks are systematically more severe on some of a village's winter pastures than on others | | | 0.00 | 1.00 | 50 |
| Forest | Forested area per village in units of 1000 square kilometers | 2.76 | 2.27 | 0.14 | 9.33 | 50 |
| Mountain | Mountainous area per village in units of 1000 square kilometers | 0.68 | 0.72 | 0.00 | 3.06 | 50 |
| Forest_mountain | Sum of forested and mountainous area per village in units of 1000 square kilometers | 3.44 | 2.51 | 0.55 | 10.20 | 50 |

**Table 1:** Variables used in the analysis of the Swedish performance payment scheme

| VARIABLES | 2a 1st stage | 2a IV tobit | 2b 1st stage | 2b IV tobit |
|---|---|---|---|---|
| Carnivores (W,+) | | 0.004 | | 0.005 |
| | | (0.004) | | (0.004) |
| Group_size (γ,+) | -.576*** | 0.012** | -.308*** | 0.010*** |
| | (0.211) | (0.005) | (0.089) | (0.003) |
| Gini_herd (χ,+) | 4.116 | -0.145 | | |
| | (31.254) | (0.652) | | |
| Damage_inequality (δ,+) | 16.930* | 0.346 | 13.477 | 0.427** |
| | (9.315) | (0.211) | (8.242) | (0.211) |
| Forest_mountain (+) | 9.450*** | | 9.228*** | |
| | (1.827) | | (1.547) | |
| constant | 17.576 | -0.383 | 17.080* | -0.563* |
| | (12.196) | (0.292) | (8.997) | (0.293) |
| N | | 43 | | 50 |
| Log likelihood | | -236.116 | | -274.181 |
| Pseudo-$R^2$ | | 0.36 | | 0.36 |
| left-censored | | 16 | | 18 |
| uncensored | | 22 | | 24 |
| right-censored | | 5 | | 8 |

Standard errors in parenthesis, *** p<0.01, ** p<0.05, * p<0.1

**Table 2:** Results of village-level IV-Tobit analysis for 'Share_herders', i.e. the percentage of performance payments directly distributed to the reindeer herders. The dependent variable for the 1st stage is 'Carnivores'.

| VARIABLES | (3a) 2SLS (first stage) Share_herders | (3b) 2SLS Lynx | (3c) OLS Lynx | (3d) OLS Lynx |
|---|---|---|---|---|
| Share_herders (+/-) | | 69.35* | 31.80** | |
| | | (41.691) | (13.320) | |
| Group_size (-) | 0.006** | -0.835** | -0.570** | |
| | (.003) | (.373) | (0.245) | |
| Gini_herd (-) | 0.024 | -37.56 | -36.45 | |
| | (.411) | (34.107) | (33.701) | |
| Exit_option (-) | 0.0001 | -0.215 | -0.232 | |
| | (.002) | (.195) | (0.192) | |
| Social_capital (-) | 0.073 | -4.247 | -1.325 | |
| | (.069) | (6.577) | (5.750) | |
| Forest (+) | 0.015 | 6.858*** | 7.377*** | 8.526*** |
| | (.025) | (2.125) | (2.030) | (1.898) |
| Damage_inequality (+) | 0.244* | | | |
| | (.123) | | | |
| Constant | -0.166 | 45.45* | 45.84** | 9.823 |
| | (.274) | (21.516) | (21.269) | (6.760) |
| Observations | 41 | 41 | 41 | 50 |
| R-squared | 0.301 | 0.369 | 0.489 | 0.296 |
| Adj. R-squared | 0.178 | 0.258 | 0.398 | 0.281 |

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

**Table 3:** Results for the analysis of lynx conservation success.

| VARIABLES | (4a) 2SLS (first stage) Share_herders | (4b) 2SLS Wolverines | (4c) OLS Wolverines | (4d) OLS Wolverines |
|---|---|---|---|---|
| Share_herders (+/-) | | -10.11 | -0.253 | |
| | | (13.288) | (3.984) | |
| Group_size (-) | 0.005* | -0.109 | -0.169** | |
| | (0.003) | (0.105) | (0.072) | |
| Gini_herd (-) | 0.071 | 25.47** | 24.96** | |
| | (0.388) | (9.362) | (9.442) | |
| Exit_option (-) | -0.0003 | -0.008 | 0.001 | |
| | (0.002) | (0.057) | (0.057) | |
| Social_capital (-) | 0.074 | 0.190 | -0.599 | |
| | (0.069) | (1.967) | (1.703) | |
| Mountain (+) | 0.061 | 20.368*** | 19.5*** | 19.221*** |
| | (0.081) | (2.252) | (1.977) | (1.567) |
| Damage_inequality (+) | 0.225* | | | |
| | (0.124) | | | |
| Constant | -0.137 | -3.408 | -3.549 | 0.844 |
| | (0.268) | (6.129) | (6.193) | (1.548) |
| Observations | 41 | 41 | 41 | 50 |
| R-squared | 0.305 | 0.744 | 0.783 | 0.758 |
| Adj. R-squared | 0.182 | 0.699 | 0.745 | 0.753 |

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

**Table 4:** Results for the analysis of wolverine conservation success.