# Management over the forest resources in northern Sweden – an application of the influence ladder on consultations between forestry and reindeer husbandry

**C. Widmark*, P. Gong & G. Bostedt[1]**

Abstract

The forest resource in northern Sweden is used for, among other things, timber production and reindeer grazing in co-existence, and the two industries affect each other negatively. Forest companies are obligated to consult the reindeer industry before forest management actions, e.g., final felling and soil scarification, are taken. However, the power between the two industries is uneven since the forest resource is either owned by the government or private forest owners, and reindeer herders have grazing rights. The degree of influence for a weaker party in a consultation process can be conceptualized through an influence ladder. This paper uses the concept of the influence ladder as a starting point to discuss the effects of consultations and the optimal level of influence from an economic theoretical point of view. The paper then illustrates the theoretical model by using simulations based on the northern Swedish forestry-forestry conflict.

Keywords: *Co-management, Common pool resources, Social planner's solution*

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## 1. INTRODUCTION

Although the forest is capable of producing many different goods and services, property rights allocations are fundamental in determining the goals of forest management actions. The forestry-reindeer (*Rangifer t. tarandus*) husbandry conflict in northern Sweden provides a case in point as they simultaneously use the forest resource[1] although for different purposes. Forestry's main goal is production of pulpwood and sawn timber while reindeer husbandry use forestland for grazing to produce meat for sale and own consumption. Reindeer husbandry in Sweden is an exclusive right for the Sami, northern Scandinavia's indigenous people, and plays a key role in Sami cultural identity and traditions. The property rights situation of the forestry-reindeer husbandry land use is leading to conflicting situations over land use. The forestry sector (*i.e.,* forest companies, non-industrial private forest owners, and the Swedish government) is the owner of the forest resource while reindeer herders also has rights to use the land, constituted by usufructuary rights stated in the Swedish Reindeer Husbandry Act (1971:437).

This parallel land use can, according to Ostrom's (1990) definition, be defined as a common pool resource since, at least, two land users depend on the same resource but the possibility to exclude users is difficult and costly. One potential problem is however that the common use often leads to extensive harvesting and thus leading to deterioration of the resource (Hardin 1968). To avoid this "tragedy of the commons", institutional arrangements can provide a co-management solution, and in the forestry-reindeer husbandry conflict the consultations, installed in 1979 with revision for stronger implications in 1993, provide such an institutional arrangement. However, the co-management system seems to work rather poorly, especially since reindeer herders are not satisfied with the process and thus the consultation procedure cannot be a co-management system in the strong sense, which is one of the major results from Sandström and Widmark (2007) study. It was also found that the power distribution between the two stakeholders were uneven and together with the fact that consultations are considered late in forestry planning process, the influence in consultations are weak for reindeer herders and very strong for foresters (Sandström & Widmark, 2007; Widmark & Sandström 2008). The question remains what happens if a co-management system, in a stronger sense, is implemented. Widmark and Sandström (2008) show, through transaction cost theory, that the institutional costs are very unevenly distributed between the two stakeholders, making the economic burden on reindeer husbandry even more problematic. But by improving the consultation procedure concerning five issues, the institutional costs could become more evenly distributed (Widmark & Sandström 2008).

The grazing rights and the forest owner's obligation to consult, clearly show that the reindeer herders have some influence over management of the forest resource. The degree of influence in a co-management situation can be illustrated by a concept known as the influence ladder, first introduced by Arnstein in 1969, and further explored by, among others, Berkes in 1991 and 1994. The aim of this paper is to adapt the concept of the influence ladder for use in a resource economic model and analyze the effect of changing the consultation procedure on each of the two businesses in terms of optimal level of influence from a social planner's perspective.

[1] defined as standing trees and ground vegetation

The numerical version of this model, calibrated for a specific study area in northern Sweden, is used to simulate the economic effects of movements along the influence ladder.

To start with, section 2 introduces the study area and the two sectors. Section 3 follows with the theoretical underpinnings introducing the concept of the influence ladder and discusses different levels of influence with emphasis on the Swedish forestry-reindeer conflict. This is followed in section 4, by a theoretical model of the forestry-reindeer conflict, where the level of influence exerted by the weaker party is a decisive variable. Section 5 presents empirical simulations of economic outcomes, based on different levels of influence. Finally, section 6 presents discussions and some concluding remarks.

## 2. STUDY AREA

In northern Sweden, here defined as the counties of Norrbotten, Västerbotten and Jämtland, about 61 000 landowners collectively own forest land, divided among forest companies (50 %), non-industrial private forest owners (38 %) and the Swedish government (6 %) (Widmark 2006). On the same land, approximately 230 000 reindeer are managed by around 4700 reindeer owners organized in 51 Reindeer Herding Communities ('RHCs') (Statistics Sweden 1999). Reindeer husbandry is not only the provider for reindeer owners producing meat for sale and consumption and skins and hides, reindeer husbandry is also an important part for the Sami community, playing an important cultural role (Danell 2004; Riseth 2006; Widmark 2006).

Reindeers are seasonal migrating animals depending on mature forests for fodder provision in the winter, basically lichens, ground (*Cladina* ssp.) and tree (*Alectoria* ssp. and *Bryoria* ssp.) lichen, close to the Baltic Sea while summer pastures are situated in mountainous inland regions, consisting of grasses and herbs (Statistics Sweden 1999; Bostedt *et. al.,* 2003). Extensive areas of land are needed for pasture, especially during winter grazing, since the animals do not convert fodder into meat sufficiently efficient to make provision of alternative sources of fodder over prolonged periods economically viable. Since reindeers dig for lichens, the weather conditions are also a critical issue to reindeer husbandry. Heavy snowfalls or swift changes in temperature combined with precipitation may have great affect on feeding (Statistics Sweden 1999). Consequently, ideally for reindeer husbandry, the forest management regimes should maximize the lichen resource with minimized effects of forestry to promote access to grazing areas. Additionally, forestry management, *e.g.,* thinning practices, is vital for lichen growth since it depends on suitable light and moisture conditions (Gaio-Olivera *et. al.,* 2006).

The simultaneous land use, albeit for different purposes, impose externalities on both sectors, although it has been argued that forestry cause greater externalities on reindeer husbandry than the opposite (Hahn 2000; Danell 2004). To help resolve conflicts from this common pool resource situation, consultations on all-year-around pastures where introduced in 1979 by the Swedish government and further voluntary extended by FCS (Forest Stewardship Council) including winter grazing areas in the consultation procedures as well (Swedish Forestry Act 1979:429; FSC 2000). The consultation procedure are, in the Swedish Forestry Act, formulated in rather general

terms, leaving the details to be settled within consultations (Swedish Forestry Act, §§ 20, 21, 31, 1979:429).

Issues discussed during consultations are e.g., harvest methods, soil scarifications and road planning and the consultations are conducted on the incentive from the forest companies. In most forest companies, the forest management follows three stages: strategic, tactic and operational planning. In the strategic planning process forest companies mainly consider care demanding area planning where the cultural and biological consideration are reflected. Next, in the tactic planning stage, the harvest rates are decided and further detailed harvest and road planning are conducted. In this stage, the consultations are also carried out. Last, in the operational planning process, the year-to-year harvest and regeneration planning are in focus and in this process the consultations with RHCs are held. The consultations are thus held rather late in the forest company's planning process, which limits the possibility for reindeer husbandry to affect forestry planning which also is shown in recent studies (Sandström & Widmark 2007; Widmark & Sandström 2008).

## 3. THEORETICAL UNDERPINNINGS ON CO-MANAGEMENT AND INFLUENCE

The first distinction of collaborative management, *i.e.,* co-management, is between state- and local-level systems. The state-level management consists of a centralized ruled system*, e.g*., by government while the local-level system is based on self-regulation but in practice these two systems are usually interfaced (Berkes *et. al.,* 1991). The fundamental problem when management is discussed is the issue of property rights. Indigenous peoples' land use is often characterized by a sense of ownership or that the people belong to the land rather than the opposite, as according to widespread governmental point of view. Thus, indigenous land use is seen as a usufructuary right rather than ownership, making conflicts over land use issues occurring between government and indigenous peoples (Berkes 1994). The state- and local-level management is combined in this situation as the forestry-reindeer herding interaction are regulated by boundary rules, *i.e.,* the legal framework, while the content of the interaction is set by the actors themselves, referred to the freedom-under-responsibility-regulation (Widmark & Sandström 2008; Sandström & Widmark 2007).

The question is then what co-management really means. Although there are multiple definitions of co-management in the literature, most seem to implicate that co-management is understood as interactions between the state- and local-level management systems and also, in different degrees, sharing of power and responsibility (*cf.* Berkes et. al. 1991; Berkes 1994; Pomeroy & Berkes 1997; Carlsson & Berkes 2004). Single or multiple actors can carry out these activities either jointly or separately and co-management is used as a tool to solve conflicting use of natural resources (Berkes *et. al.,* 1991; Carlsson & Berkes 2004). The term co-management will, in this paper, imply the sharing of power between forestry and reindeer husbandry in consultations, in practice how RHCs influence in forest management plans are included in the process where the power concept simply that "A has the power over B to the extent that he can get B to do something that B would not otherwise do", also known as the Dahlian notion of power (Dahl, 1957).

Complicating the description of co-management in the forestry-reindeer husbandry context is that the state has delegated the management to the stakeholders themselves (Kooiman 2003), in consultations, through institutional arrangements. Thus, the definition of co-management considers the relationship between forestry and reindeer husbandry as part of the state-community relationship. To understand this relationship, Carlsson and Berkes 2005, formulated images of co-management, as seen in fig. 1. to illustrate different possible co-management situations.

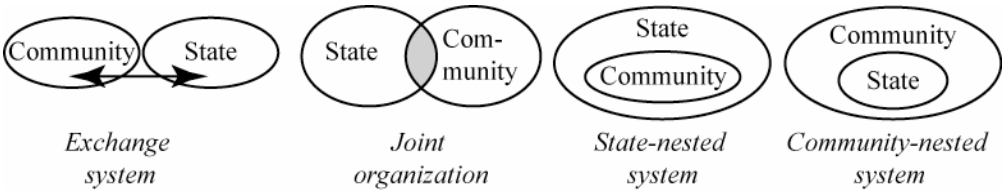


*Fig. 1. Images of co-management from the forestry-reindeer husbandry perspective* (adapted from Carlsson & Berkes 2005)

In the first image, exchange system, which also can be connected to the influence ladder discussed further down, the relationship consists only of exchanging information with no co-operation between the two sectors. The same relation is characterizing the second image, joint organization, but with the difference that some co-operation prevail. However, the stakeholders keep their authority and relative autonomy intact (Carlsson & Berkes 2005).

The next two images, state-nested and community-nested systems, are two sides of the same coin. In the community-nested system, the community or the private stakeholders have the ownership control and the state can issue some restrictions on management. In the state-nested co-management situation, the state has the legal power of the resource and private actors are given the right to manage the resource (Carlsson & Berkes 2005). Although the forestry owns the resource, the reindeer husbandry has the same right to use land, so the legal right to use land is equal to both actors. The state has delegated the management to the two sectors by installing consultations and thus leaving the day-to-day management to the two stakeholders (Sandström & Widmark 2007; Widmark & Sandström 2008). The relationship between forestry and reindeer husbandry is then best characterized by the community-nested system as well as the joint organization system.

Further, each of the four stages of co-management is often combined in practice, which also may be the case in fig.1 (Carlsson & Berkes 2004). The forestry-reindeer husbandry relationship features several of the co-management situations. Since the consultations do not consist of a strict co-management situation, the second image suits well, as exchange of information without any extensive decision-making characterize consultations. Also the fourth image, state-nested system suites well on the situation as consultations are installed, as discussed above (Sandström & Widmark 2007).

The images of co-management describe the relationship between the stakeholders; the question then is how the power between them is distributed. To investigate that, the concept influence ladder, first introduced by Arnstein (1969), is a powerful tool in

all its simplicity illustrating the opposite poles of information and partnership. The ladder is based on the minimalist definition of the Dahlian notion of power making, which may lead to exclusion of important factors of power, in contrast to the more complex definitions of the concept by *i.e.,* Bachrach & Baratz (1970) or Lukes (1974) who represents definitions of power too difficult to use empirically. The power of Arnstein's ladder, however with rather weak power assumptions, is the empirical application (see further discussion in Sandström & Widmark 2007).

In the influence ladder, see fig. 2. the influence over forest management through consultations is described. The rungs can also be divided into three sections. Complicating things is that all rungs cannot qualify as co-management arrangements. Pinkerton (2003) points out that co-management has to include decision-making in key decisions and thus, the three lowest rungs on the influence ladder is then disqualified (Jentoft 2003; Sandström & Widmark 2007).

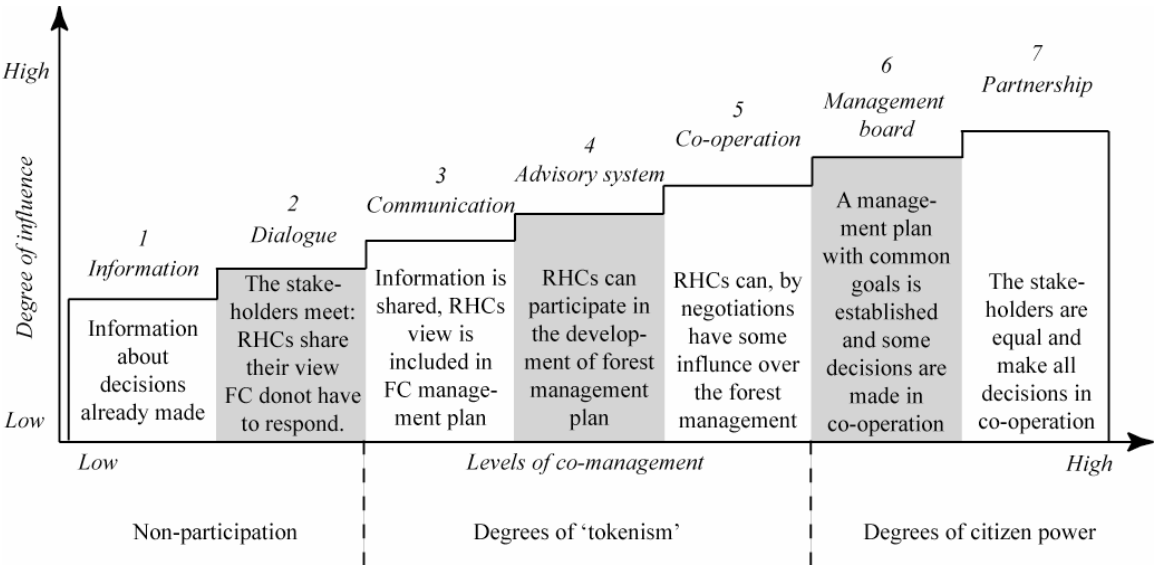


*Fig. 2. Influence and co-management*
(adapted from Arnstein 1969; Berkes 1994; Sandström 2004; Sandström & Widmark 2007) Comment: FC = Forest company, RHC = Reindeer Herding Community

Information and dialogue, the first two steps in fig.2., also characterized as non-participation, are the lowest form of participation where stakeholders are given the opportunity to hear and be heard however without the possibility to influence decisions (Arnstein 1969; Berkes 1994). In the relationship between forestry and reindeer husbandry, the information rung means that information is shared without any possibility of affecting the decisions made by forestry. The dialogue rung does not include any decision-making power either but reindeer husbandry is allowed to share their view but cannot demand response from forestry (Sandström & Widmark 2007).

Rungs three through five is characterized by degrees of 'tokenism', meaning that the weaker part in the co-management arrangement is heard and have possibility to give their opinion. In the third rung, communication, information is shared and, to some extent, included in management plans and for instance, local knowledge is also taken into account in decision-making. However, the stakeholders have not the

power to ensure that their view is regarded (Arnstein 1969; Berkes 1994). Forest management plans are, at this rung, starting to include RHCs view of forest management and the aspects of reindeer herding. However, the final decision-making on forest management is still taken by forestry. There are also few restrictions on how much consideration forestry has to take to RHCs needs (Sandström & Widmark 2007). Further, in the fourth rung, advisory system, a two-way communication is implemented and the establishment of management plans includes all stakeholders (Arnstein 1969; Berkes 1994). RHCs are now invited, on the incentive of forestry, to participate in the development of forest management plans and the view of RHCs is thus taken into account to a greater extent than in previous rungs (Sandström & Widmark 2007). In the fifth rung, co-operation, a kind of partnership is starting to develop and the stakeholders are starting to make joint decisions (Arnstein 1969; Berkes 1994). In the co-operation rung, the RHCs have some portion of influence over the forest management since negotiations are initiated (Sandström & Widmark 2007).

In the last section, degrees of citizen power, the power over the resource is extensive for both stakeholders. The sixth rung, management board, negotiations are taken further as forest management plans are established with common goals and decisions are taken more extensive in co-operation. Stakeholders are also involved in implementation of management plans. In the last rung, partnership, the stakeholders are equal participants in the management of the resource with joint decision-making and common objectives of management (Arnstein 1969; Berkes 1994; Sandström & Widmark 2007). In a partnership situation, the forest companies and RHCs have equal parts of decision-making in formulating the forest management plan.

As with the images of co-management, several rungs in the influence ladder can be found in a co-management arrangement and the three lowest rungs are important in the development of a co-management arrangement. The view can also be different between the stakeholders in the co-management arrangement, which is the case among forestry and reindeer herders. Sandström and Widmark (2007) found that most RHCs considered themselves on a dialogue level in the influence ladder while forestry considered RHCs to be on a communication level.

Each rung in the ladder has an economic implication for each of the stakeholders as influence over the forest management is changing with each rung. As discussed before, the present institutional arrangement cannot be characterized as a co-management arrangement, at least not in the strict sense. By using the social planner's context, an alteration of the management situation toward co-management can be discuss resulting in economic implications of co-management. Next, a theoretical framework is introduced in which the influence ladder is explicitly modeled.

## 4. A THEORETICAL MODEL OF INFLUENCE OVER NATURAL RESOURCES

This section presents a dynamic model of the forestry-lichen-reindeer interaction, focusing on market-priced benefits of the forestry and reindeer industry, leaving analysis of possible cultural benefits of the reindeer industry (*cf.* Lundgren & Bostedt, 2008), as well as benefits of non-timber resources aside (*cf.* Gong *et. al.,* 2005). We first present the social planner's solution, which is compared with the forest owner's

and reindeer herder's problems. The model then considers the optimal level of consultation/influence.

*4.1 The single owner (social planner) solution*

Suppose that a reindeer herder owns the forest within her summer grazing area, or conversely, that a forest owner owns a reindeer herd. The reindeer/forest owner determines simultaneously the optimal path of timber harvest and the optimal path of reindeer harvest. Her objective is to maximize the present value of current and all future profits from reindeer and forest management. The intrinsic utility, or the existence value, of reindeer for the reindeer herding is assumed constant and thus omitted (*cf.*, Bostedt 2005). The single owners' then maximizes the net benefits, π:

$$\max_{h_F, h_R} \int_0^{\infty} \pi(h_F, h_R, F, R)\, e^{-rt} dt \tag{1}$$

where $h_F$ is the timber harvest, measured in areal units, $h_R$ is the number of reindeer harvested, F is the size of the reindeer grazing area (forests included in F are assumed to be homogenous in all aspects, stand age, site productivity, stock and growth of timber and lichen, ownership), R is the size of the reindeer herd, and r is the discount rate. Equation (1) is maximized subject to the restrictions given by:

$$\dot{F} = f(F) - h_F \tag{2a}$$

$$\dot{R} = g(R, F, L) - h_R \tag{2b}$$

$$\dot{L} = F * l(L) - h_L(R, F, L) \tag{2c}$$

$$w = W(R, F, L) \tag{2d}$$

where L is the per-hectare stock of lichen, $f(F)$ is the growth in the reindeer grazing area, $g(R, F, L)$ is the growth function for the reindeer stock, $l(L)$ is the per-hectare growth in the lichen stock, and $h_L(R, F, L)$ is the harvest of lichen through grazing. Maximizing (1) subject to the restrictions in (2a-d) gives rise to the following first-order conditions:

$$\frac{\partial \pi}{\partial h_F} - \lambda_F = 0 \tag{3a}$$

$$\frac{\partial \pi}{\partial h_R} - \lambda_R = 0 \tag{3b}$$

$$\dot{\lambda}_F - r\lambda_F = -\frac{\partial \pi}{\partial F} - \lambda_F \frac{\partial f}{\partial F} - \lambda_R \frac{\partial g}{\partial F} - \lambda_L \left( l(L) - \frac{\partial h_L}{\partial F} \right) \tag{3c}$$

$$\dot{\lambda}_R - r\lambda_R = -\frac{\partial \pi}{\partial R} - \lambda_R \frac{\partial g}{\partial R} + \lambda_L \frac{\partial h_L}{\partial R} \tag{3d}$$

$$\dot{\lambda}_L - r\lambda_L = -\lambda_R \frac{\partial g}{\partial L} - \lambda_L \left( F \frac{\partial l}{\partial L} - \frac{\partial h_L}{\partial L} \right) \tag{3e}$$

The partial derivatives with respect to the harvest of timber, $h_F$, and reindeer, $h_R$, (3a) and (3b) states that the marginal benefit of the harvest must be weighed against the effects of harvest on the stock through the shadow price on the growth constraints (2a) and (2b), $\lambda_F$ and $\lambda_R$. The co-state equation in (3c) can perhaps be more easily interpreted if rewritten as $r - \frac{\dot{\lambda}_F}{\lambda_F} = \frac{\partial f}{\partial F} + \frac{\partial \pi / \partial F}{\lambda_F} - \frac{\lambda_R}{\lambda_F}\frac{\partial g}{\partial F} - \frac{\lambda_L}{\lambda_F}\left( l(L) - \frac{\partial h_L}{\partial F} \right)$. Here, the left-hand side can be described as "own rate" of interest for the stock F, a rate that is not observable in the marketplace. This must be equal to the marginal rate of growth on this stock plus the marginal effects of increasing the stock on net benefits and growth of reindeer and lichen divided by the shadow price on the growth constraint. The co-state equations in (3d) and (3e) can be rewritten and interpreted in similar ways.

*4.2. The effect of consultation*

Now, disregard the social planner's solution and, consider a private forest owner and a reindeer herder. The forest owner consults with the reindeer herder about the harvest of the forest. The forest owner determines the path of forest harvest. The reindeer herd determines the optimal path of reindeer harvest conditional on the forest owner's decision.

Define $\alpha \in [0, 1]$ as the share of the profits from reindeer husbandry, which is "transferred" to the forest owner as a symbolic compensation for the conformation of management from forestry's point of view toward reindeer husbandry. The lower and upper bounds of $\alpha$ denote the two extreme cases of no consultation (when $\alpha = 0$) and completely integrated management of forestry and reindeer husbandry (when $\alpha = 1$), respectively.

The forest owner's problem is to maximize:

$$\max_{h_F} \int_0^\infty \left[ \pi_f(h_F, F) + \alpha \pi_r\left( h_R^*(F), R^*(F) \right) \right] e^{-rt} dt \tag{4}$$

subject to the restriction given by:

$$\dot{F} = f(F) - h_F \tag{5}$$

Where $h_R^*$ and $R^*$ is the optimal harvest and the optimal population of reindeer, respectively.

The reindeer herder's problem is to maximize:

$$\max_{h_R}(1-\alpha)\int_0^{\infty} \pi_r(h_R,F,R)\, e^{-rt}dt \tag{6}$$

subject to the restrictions given by:

$$\dot{R} = g(R,F,L) - h_R \tag{7b}$$

$$\dot{L} = F * l(L) - h_L(R,F,L) \tag{7c}$$

$$w = W(R,F,L) \tag{7d}$$

where the stock of the forest, F, is an exogenous variable.

The forest owner's problem in (4) and the reindeer herder's problem in (6) can be integrated into the following optimization problem:

$$\max_{h_F,h_R} \int_0^{\infty} \left[\pi_f(h_F,F) + \alpha\pi_r(h_R,F,R)\right] e^{-rt}dt \tag{8}$$

subject to the restrictions given by:

$$\dot{F} = f(F) - h_F \tag{9a}$$

$$\dot{R} = g(R,F,L) - h_R \tag{9b}$$

$$\dot{L} = F * l(L) - h_L(R,F,L) \tag{9c}$$

$$w = W(R,F,L) \tag{9d}$$

Given an $\alpha$, the optimal paths of forest harvest and reindeer harvest is determined simultaneously by solving this problem. Note here that $\alpha$, which can be interpreted as the degree of influence the reindeer herder has over forest management, is an exogenous variable for both the forest owner and the reindeer herder. The variable is exogenous because the political process, thus the process of enacting law, and its overall responsibility to regulate the relationships between forestry and reindeer husbandry (Widmark 2006; Sandström & Widmark 2007).

## 5. SIMULATION RESULTS

### *5.1. Material and methods*

The chosen area is a typical RHC in Västerbotten County, Ran RHC, with winter grazing areas close to the Baltic Sea and with all-year-around grazing areas in the mountainous areas. Ran RHC has about 70 members, divided into about 25 reindeer herding companies and is carrying together about 11 000 reindeers (Samecenter 2008; Nutti 2008). The selected area is defined as a key area for the RHC and is a rich lichen pasture and about 12 000 ha large, and can be considered representative

selection of grazing areas. There are both non-industrial private forest and forest company ownership in the specific area.

The area was chosen mainly with consideration of data collection. There are three main studies: Björklund 2000, Persson 2000 and Wilhelmsson 2000, conducted in this particular area considering reindeer grazing and forestry and thus provide rich possibilities to gather material for this study. Complements considering reindeer data have been made from the study by Moxnes *et. al.,* 1998. The simulations was conducted in a Pascal program with 30 iterations using the data presented in Appendix 1 where Table 1 and Table 2 present the variables in the study and its origin.

To implement the outlined framework, using existing data from forestry and reindeer husbandry, trade-offs between forestry and reindeer husbandry was simulated with the restriction of reindeer husbandry's influence over forest management decisions. Forestry and reindeer husbandry are treated as two separate companies. Forestry is maximizing its profits while reindeer husbandry have to conform to the decisions made by forestry when maximizing their profits.

The forest sector's decision is to maximize:

$$\max_{H} \Pi_{h_f}(H) = \int_0^{\infty} \pi_f\left(h_F(t), \gamma\right) e^{-rt} dt \qquad (10a)$$

where the parameter γ represents allowable harvest level and is used to simulate the trade-offs between profit of the forest sector and the profit of reindeer sector. Let H*(γ) denote the optimal forest harvest plan, and denote the associated forest states over time by F*(γ). The decision problem of the reindeer sector is modeled as:

$$\Pi_R\left(H^*(\gamma)\right) = \max_{R} \int_0^{\infty} \pi_f\left(h_F^*, F^*(\gamma), R(t)\right) e^{-rt} dt \qquad (10b)$$

The consultations or the influence over forest management is measured by transferring profits from reindeer husbandry to forestry. In terms of the model, the forest owner would choose the optimal allowable harvest level:

$$\max_{\gamma} \ \Pi_{h_F}(H^*{}_{(\gamma)}) + \alpha \Pi_{h_R}(H^*{}_{(\gamma)}) \qquad (11)$$

Equations (10) and (11a-b) is used in the simulations to simplify the optimization procedure. This is of course not the actual case, but serves as a tool to measure consideration of reindeer husbandry in the forest decisions. By setting restrictions, (γ) in equations (10) and (11 a-b), between 0,1 and 1, where 0,1 correspond to very high consideration, to 1 where no consideration to reindeer husbandry is taken. From these assumptions the slaughter of reindeer is optimized, thus maximizing reindeer husbandry's profits.

*5.2. Simulation results*

Figure 3 presents the trade-off between forestry and reindeer husbandry with respect to influence over forest management.

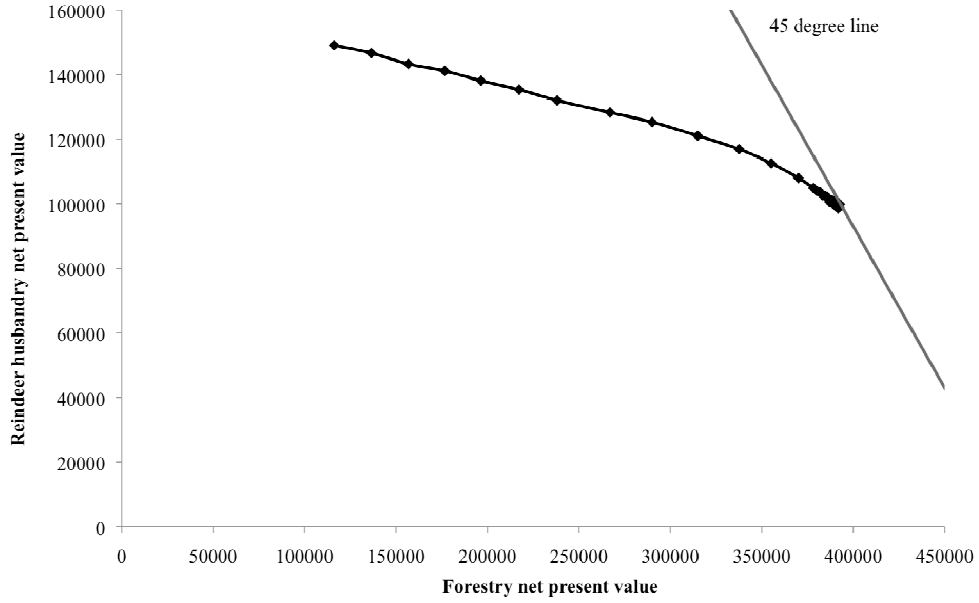


*Fig. 3. The trade-off between forestry and reindeer husbandry*

As the figure show, the socially optimal solution is a corner solution in the sense that the present value of forestry is maximized, and the results imply that optimal behavior for forestry is to take no or very low consideration to reindeer husbandry in forest management. The net present profits from forestry are 392.416 MSEK while the corresponding net present profits from reindeer husbandry are 98.491 MSEK.

A sensitivity analysis was conducted with respect to possible effects of timber harvest on reindeer husbandry by incorporating a harvest effect multiplier in the optimization model. The harvest effect multiplier illustrates how large area, in edition to the actual harvested area that is affected grazing possibilities for reindeer husbandry. Examples can be roads (the herd, or parts of it, can wander longer distances in presence of a road making round-up more difficult) or heavier snow packing in areas close to clear-cut areas. A harvest effect multiplier of 1,5 corresponds to an area effect of 50 % in addition to actual harvested area while a harvest effect multiplier of 2 corresponds to an area effect of 100 %. As fig. 4. show, the trade-off curves are shifted downward and becomes more linear as the harvest effect multiplier is increased. However, the optimal influence in forest management is still a corner solution, thus it is socially optimal with low or no influence for reindeer husbandry.

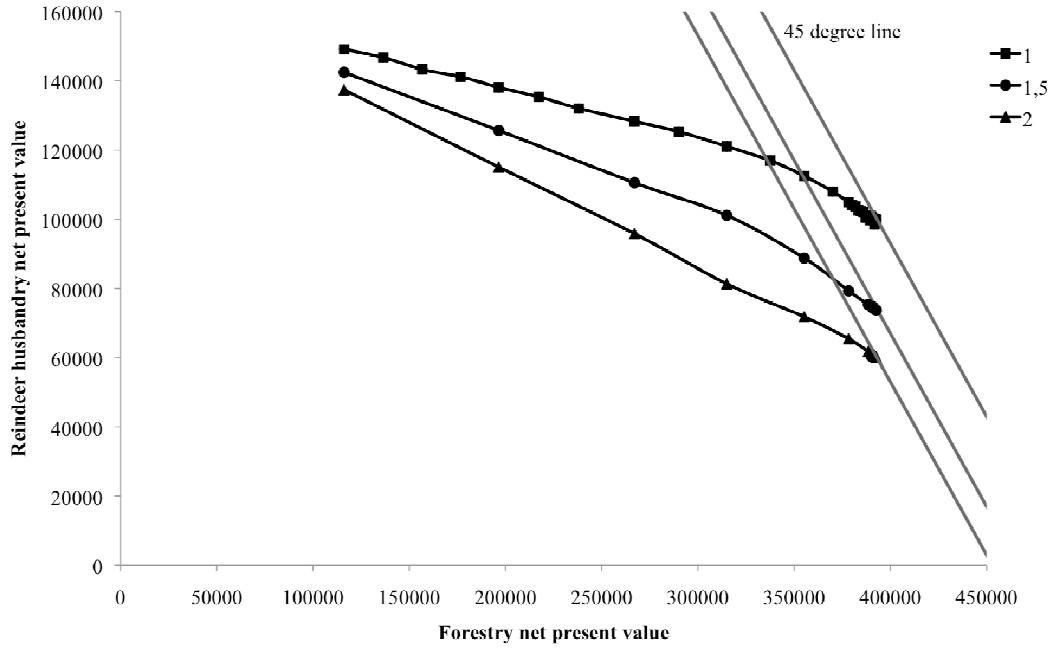


*Fig. 4. The trade-off between forestry and reindeer husbandry with harvest effect multipliers 1,5 and 2.*
Note: 1 equals harvested area, no multiplier effect.

To further examine the effect of consultations, thus influence in forest management, alpha ($\alpha$) is used as an artificial instrument. The value of alpha can be interpreted as a measure of the effective influence of consultations on forest management. In table 1 the present value profits are presented with respect to alpha based on the formulas 10 (a-b) and 11.

*Table 1. Optimal net present profits for forestry and reindeer husbandry respectively with respect to alpha*

| | 1 | | 1,5 | | 2 | |
|---|---|---|---|---|---|---|
| Alpha | Forestry net present profits | Reindeer husbandry net present profits | Forestry net present profits | Reindeer husbandry net present profits | Forestry net present profits | Reindeer husbandry net present profits |
| | MSEK | | | | | |
| 0,1 | 392.416 | 99.707 | 392.636 | 73.741 | 392.636 | 60.197 |
| 0,2 | 392.416 | 99.707 | . | . | . | . |
| 0,3 | 392.366 | 99.929 | . | . | . | . |
| 0,4 | . | . | . | . | . | . |
| 0,5 | . | . | . | . | . | . |
| 0,6 | . | . | . | . | . | . |
| 0,7 | . | . | . | . | . | . |
| 0,8 | . | . | . | . | . | . |
| 0,9 | . | . | . | . | . | . |
| 1 | . | . | . | . | . | . |

As the table show there are small differences between the net present profits for each sector between the different alphas. The profits are about 392 and 100 MSEK

for forestry and reindeer husbandry respectively. The levels are very similar between the different alphas and with alpha 0,3 to 1, the net present profits are the same.

When the effect on other land than the actual harvested area is considered, thus harvest effect multiplier 1,5 and 2, the differences in net profits for forestry is modest, increasing about 200,000 SEK and remains on the same level regardless of alpha. The net present profits to reindeer husbandry decreases with increased multiplier, 27,000 SEK for multiplier 1,5 and 40,000 SEK for multiplier 2.

## 6. CONCLUDING DISCUSSION

As previous research shows, the influence of reindeer husbandry on forest management is presently weak and by altering consultations, and thus increasing influence over forest management, the economic prerequisites for each of the sectors would improve, as conflicts over land use would decrease. The question is however what the economically optimal level of influence is from a societal point of view.

By using a case study area in which reindeer grazing is sensitive, *i.e.,* a key grazing area, a model over influence in forest management based on the social planner's model was created. From these models, the intention was to test what level of influence according to the influence ladder that is optimal for the two sectors from a social point of view. Connecting the influence ladder and alpha means that the higher on the influence ladder, the larger alpha is.

The results indicate that, from a societal point of view, the level of influence at present is the most optimal, illustrated by the corner solution (see fig. 3.) when the trade-off between forestry and reindeer husbandry is analyzed. The differences between the different levels of alpha is however very small close to the tangent point implying that very small changes in the consultation process, leading to increased influence from reindeer husbandry's point of view over forest management, result in small changes in the trade-off.

This point is also illustrated by the examination of alphas and the optimal net present profits (see table 1.). The difference of net present profits to forestry is very small between the different alphas.

To broaden the analysis to reflect the effect of timber harvest on reindeer husbandry the harvest effect multiplier effect was incorporated in the simulations. The effect of timber harvest on grazing areas does not only affect the actual harvested area, but also the surrounding area as grazing may be affected in the border region. The building of roads to transport timber is also a large problem since reindeer tend to wander long distances spreading the herds making round up more problematic. The trade-offs with harvest effect multiplier 1,5 and 2 do not show any different results from the ones already presented. The total trade-off is decreasing as multipliers increase which is natural since the area available for grazing is lessening as multipliers increase. The net present profits do not show any other result either.

In this study, the existence value of reindeer for the reindeer herding was ignored. The reindeer and reindeer husbandry plays an important role for the Sami cultural

identity and traditions, as discussed in the introduction. The problem is that the economic value of reindeer for the Sami culture has not been estimated empirically. The results of this study would probably change if the existence values where incorporated. A problem when analyzing these two sectors is the difference in size, in active companies and employed people, and turnover. About 4 700 people own reindeer, while about 61 000 own forestland in northern Sweden. These facts are also complicating comparisons in economic terms.

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APPENDIX 1.

*Table 1. Reindeer herding related parameters and their origin*

| *Description* | *Value* | *Unit* | *Source* |
|---|---|---|---|
| Winter pasture area (lichen covered) | 11876 | ha | Statistics Sweden, 1999 |
| Lowest winter feeding level | 0,35 | | Moxnes et al., 1998 |
| Summer feeding level | 0,9 | | Moxnes et al., 1998 |
| Initial lichen stock | 1008 | ton/ha | Björklund 2000 |
| Maximum lichen share | 0,9 | | Moxnes et al., 1998 |
| Minimum lichen share | 0,82 | | Moxnes et al., 1998 |
| Carrying capacity winter pasture | 6000 | kg/ha | Moxnes et al., 1998 |
| Initial nr. of animals after harvest(96/97) | 8126 | nr | SSR, 2008 |
| Normal body weight per breeding stock | 72,3 | kg | Moxnes et al., 1998 |
| Standard meat weight per adult | 40 | kg | Statistics Sweden, 1999 |
| Standard meat weight per calve | 21 | kg | Statistics Sweden, 1999 |
| Average price meat | 42 | SEK/kg | SJV, 2008 |
| Maximum harvested adult | 0,6 | % | |
| Minimum harvested adult | 0,2 | % | |
| Calves left (98/99) | 51 | % | Statistics Sweden, 1999; SJV 2008 |
| Calves harvested (98/99) | 49 | % | Statistics Sweden, 1999; SJV 2008 |
| Discount rate | 3 | % | |

*Table 2. Forestry related parameters and their origin*

| *Description* | *Value* | | | | | *Unit* | *Source* |
|---|---|---|---|---|---|---|---|
| Species and age class* | Spruce | | | | | ha/site index and age class | Sw. National Forest Inventory, 2008<br>Wilhelmsson 2000 |
| | | -18 | 19-20 | 21- | | | |
| | 0-19 | 536,44 | 438,37 | 362,86 | | | |
| | 20-39 | 616,09 | 503,46 | 416,74 | | | |
| | 40-59 | 487,71 | 398,55 | 329,90 | | | |
| | 60-79 | 417,28 | 340,99 | 282,25 | | | |
| | 80-99 | 289,81 | 236,83 | 196,03 | | | |
| | 100-119 | 487,30 | 398,21 | 329,62 | | | |
| | 120- | 809,12 | 661,20 | 547,30 | | | |
| | Total | 3643,75 | 2977,62 | 2464,70 | 9086,07 | | |
| | Pine | | | | | | |
| | | -18 | 19-20 | 21- | | | |
| | 0-19 | 355,38 | 63,01 | 86,95 | | | |
| | 20-39 | 127,79 | 22,66 | 31,27 | | | |
| | 40-59 | 52,63 | 9,33 | 12,88 | | | |
| | 60-79 | 177,55 | 31,48 | 43,44 | | | |
| | 80-99 | 231,59 | 41,06 | 56,67 | | | |
| | 100-119 | 310,74 | 55,10 | 76,03 | | | |
| | 120- | 706,32 | 125,23 | 172,82 | | | |
| | Total | 1962,00 | 347,87 | 480,06 | 2789,93 | | |
| Total productive forest land | 11876 | | | | | ha | Wilhelmsson, 2000 |
| Volume | 139 | | | | | m3sk/ha | Wilhelmsson, 2000 |
| Total growing stock | 1651 | | | | | 1000 m3sk | Wilhelmsson, 2000 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Maximum mean annual increment | Pine | Spruce | | | m3/ha/year | |
| | 1,9 | 2,0 | | | | |
| | 3,1 | 3,2 | | | | |
| | 4,7 | 4,9 | | | | |
| According to Sw. Forestry Act lowest harvest age | 90, 80, 70 | | | | years | Sw. Forestry Act, 1979:429 |
| Regeneration costs | Pine | Spruce | | | SEK | Statistical Yearbook of Forestry 2007 |
| | 5850 | 5050 | | | | |
| | 6650 | 5450 | | | | |
| | 7250 | 6250 | | | | |
| Timber price | Pine | | Spruce | | SEK | Statistical Yearbook of Forestry 2007 |
| | Sawn | Pulp | Sawn | Pulp | | |
| | 335 | 190 | 295 | 205 | | |

Comments: * For Vindeln municipality which is greater than the study area. However, the forest type was compared with a study by Wilhelmsson in which the particular study area is used, and the distribution between spruce and pine are 18 respectively 82 % which is close to the numbers for Vindeln municipality and thus makes it possible to use the numbers for Vindeln municipality.