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Adaptation Strategies under Technological Change. A Comparative Study of Saami Reindeer Management Regions in Norway 1960-1990.

By

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1. Introduction

According to official Norwegian statistics, the Saami reindeer industry consists of approxi-mately 3.000 persons owning about 200.000 reindeer (Reindriftsforvaltningen, 1995). It has usufruct rights over about 40 % of the Norwegian land surface. Today it is the only specific Saami industry and plays an important role in sustaining Saami culture and identity.

The reindeer industry is based on utilizing vulnerable renewable common-pool pasture resources (CPR). The Saami people have lived off the reindeer from prehistoric times. The mode of production has changed from hunting via subsistence pastoralism to a motorized and market-oriented industry. The transition from a mainly subsistence based pastoralism towards a market-integrated industry has predominantly taken place in the period 1960-1990.

The land use pattern is mainly a reflection of the animals' need for different seasonal pastures. The land is a vulnerable resource, especially the lichen-rich fall and winter pastures. The pastures are also threatened by encroachment and other forms of external pressure. There is considerable variation in the different parts of the Saami area in Norway concerning resource situation and profitability. The large North Saami reindeer regions of Finnmark[1] have only about half the productivity of the South Saami regions North Trandelag and South Tr0ndelag/Hedmark[2]. This creates a great difference in net surplus[3].

A series of pasture surveys for Finnmark (Rundberg, 1982; Orvik and Prestbakmo, 1990; T0mmervik and Johansen, 1990) and a theoretic analysis (Moxness et al., 1993) substantiate a severe overgrazing of the lichen-rich winter and autumn pastures. The situation indicates a considerable need for reductions[4] in the number of reindeer for a longer period.[5] As an example, from 1976-1986 the number of animals in West Finnmark doubled. The slaughter weights were considerably reduced and there are also indications that the total yield passed its maximum in the early 1980's (Riseth, 1988). There are further reports (Prestbakmo, 1984) indicating that established social norms controlling pasture use have disintegrated while internal competition has intensified.

Contrasting this, the Trondelag regions seem to be rather well adapted to pasture resources and are prospering economically. The number of reindeer is stable and the total production has increased. Given that the North area has excellent natural conditions for reindeer, lagging performance in the North is a puzzle. It is also an important puzzle insofar as the problems of

1 the regions West Finnmark (Gouvdageaidnu) and East Finnmark (mainly Karasjokha).

2 per animal in spring herd (April, 1).

3 cf. section 4.1.

4 From the peak year 1989 until 1993-94 there has been a reduction of about 25-30% which is insufficient according to the surveys.

5 Even though it seems accepted that overgrazing is taking place, there is disagreement about its long run effects and how irreversible the process is. The pasture surveys have built their conclusions on standard ecological theory whereby ecological systems move towards a climax society (e.g., Odum, 1971). This theory is now challenged by new ecological theory of succession and range-animal interaction (Fox, 1995). This does still not influence the relevance of the problem studied here.

the North involve the main part of the reindeer industry in the Norwegian section of Saamiland. Resolving the problems is of importance for the long term sustainability of the system and has therefore important policy implications[6].

The aim of this article is to try to explain *why the transition from subsistence economy to market economy has been clearly more successful so far in the South than in the North.* It seems rather obvious that the problems with overgrazing or resource depletion in the North is the result of a badly functioning common property regime. But one may ask whether we are observing a simple disintegration of a previously well functioning system or whether the problem is lack of capacity to transform as the transition from subsistence to a market orientation has taken place. If so, the problem is to explain why the system was not able to adapt in the North, while in the South, transformation and adaptation processes seem to have been rather successful concerning resource conservation and income.

What makes the picture complex is that the reindeer industry during the period 1960-1990 experienced both technological, economical and political changes as well as general societal modernization processes. Market integration meant both specialization in meat production and a high degree of purchase of both consumer goods and means of production. The industry moved away from a nearly full dependence on animal and human muscle power to a high degree of dependence on motorized vehicles as snowmobiles, all terrain vehicles (ATVs) etc. Politically the step was taken from a limited civil servant rule to integration into an extended co-management system giving industry representatives a considerable influence over public sector policy. Parallelly, the Saami society came under the "protection" of the modern welfare state giving the reindeer Saamis access to extended schooling, housing, health care and social security.

Essential to the problem is the type of management regime existing. Reindeer herd management is a mix of individual and common property where the animals are individual property while herding and pasture are communal. Common pool resources can be managed either by some kind of regulation mechanism, a common property regime, or unregulated as open access. When the resource flow of appropriation is lower than the regeneration rate, open access can be compatible with sustainable resource use. The well known situation of the "Tragedy of the Commons" is a probable result only when the resource withdrawal is higher than the regeneration rate. The dynamics leading to resource depletion can, however, start at a lower intensity of resource use and can typically be described by the Prisoners Dilemma or other formal games with resembling structure.

Our analyses will be undertaken in three steps:

- First, we will characterize reindeer herd management of the Saami type - its resource base and basic institutions.

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6 which is also made clear in a governmental report to the Parliament (Landbruksdepartementet, 1992)).

* Second, we discuss the potential consequences of market integration and technological change in this type of society and develop a set of hypotheses to explain differences in adaptation due to characteristics both of the resource base and institutions.
* Finally, these hypotheses are confronted with (preliminary) empirical material[7] from the two areas of analysis.

2. Managing Common Pastures

2.1 A Theoretical Perspective

Bromley (1991) defines a *resource management regime* as a structure of rights and duties characterizing the relationship of individuals to each other with respect to that particular resource. He notes that the allegory "Tragedy of the Commons" arising from Hardin (1968) has confused both scholars and others giving *common property* a misplaced responsibility for resource degradation that properly belongs to a situation of *open access.*

Common property regimes are characterized by the features of:

* Private property for a group of co-owners
* Exclusion of non-owners
* Social units with definite membership and boundaries, common cultural norms and endogenous authority systems.

Bromley emphasizes that compliance protected and reinforced by the authority system is a necessary condition for the viability of any property regime. Breakdown will cause common property to degenerate into open access caused by internal processes and/or external pressure. Ostrom (1995) points to *rapid exogenous changes* as one of several threats to continuance of self-organized commons. Regime problems can also be a result of long term internal processes or an interplay between external and internal factors.

In studying the common-pool resource problems of the Saami societies, we will use the so-called Institutional Analysis and Development (IAD) framework (Berge, 1995; Ostrom, 1990; Ostrom, 1995; Ostrom, Gardner, and Walker, 1994). As a framework it can be used for organizing theories and explanations of different disciplinary origin.

The IAD framework is a general explanatory framework. Its basic concept is the *action arena.* It includes *actors* who are participants in *action situations.* Action situations refer to the natural and social space where individuals interact and is to be defined from the purpose of analysis. All situations are viewed as being composed of the same set of elements[8] compatible with those of a formal game. The opportunities and constraints given by the attributes of the *physical*

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[7] This part of the paper is built on a preliminary data collection. A more extensive analysis will follow in Riseth's PhD thesis.

[8] Participants, positions, actions, potential outcomes, a transformation function, information and cost/benefit.

world, the attributes of the *community* and *rules-in-use* are the constituents shaping the action situations as faced by the actors.

2.2 The Action Arena

The Saami herder societies have been dominantly acephalous[9], and have in the Norwegian case, existed for a long time as a minority enclave dominated by, but not politically integrated into a majority state society. The Saami production system consists of 3 production factors; *pasture, herd and labor.* The factors are mutually substitutable within certain limits. All 3 factors can be set under pressure from external forces. The pasture is normally administered under some form of a common property regime. The herd is consisting of animals which are herded communally by groups of households, but privately owned by household units which are the basic production units.

If the pasture exploitation is below the stock level of maximum sustainable yield (MSY), enduring resource use can be achieved independent of the character of the regime. When a critical level of aggregate pasture exploitation is arrived at, the action situation will be one of potential resource depletion. At the level of MSY the herding is already a zero-sum game, and after that a minus-sum. Subsidies can increase the exploitation beyond the point of break-even nearer to exhausting the resource.

Non-cooperative game theory is a powerful tool for predicting possible outcomes of standard rule games. Games with negative dynamics like Prisoners Dilemma are the outcome of certain rule configurations related to the open access situation. Ostrom, Gardner and Walker (1994:96) show, however, that the match between rules and the physical domain are essential and that minor changes in rules can lead to major changes in outcomes. Furthermore, experimental studies (op.cit.:219) suggest that capabilities for communication, monitoring and sanctioning will strongly improve the opportunities for sustainable outcomes in CPR dilemmas. Recent achievements in evolutionary psychology (Hoffmann et al., 1995) also suggest that humans can be genetically preprogrammed to achieve cooperative outcomes more than assumed by non cooperative game theory. This means that even relatively *weak common property* regimes can be rather effective and prevent resource depletion when the match between rules and the physical domain is good, but also that the system can be vulnerable to changes.

2.2.1 The Physical World

In developing this reasoning further, let us look more in detail at the dynamics of the elements constituting our action arena. Assume a ungulate herd migrating between but 2 season pastures. Following Klein (1968) the capacity of the winter pastures limits herd size while the potential

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9 There is no single internal authority above group level.

of green pastures (summer) determines the growth and production potential of the herd via each animal. From this the *seasonal pasture balance* can be expressed[10] by (Riseth, 1997):

$$H_S * \{a - s\} = H_W * m \qquad (1)$$

where H_S is herd size at summer pasture and H_W at winter pasture, a is realized herd growth rate, s is the rate of harvest and m is mortality.

Solving (1) for s gives the herd zero isocline[11]:

$$s = a - (H_W / H_S) * m; \quad \text{for } dH_S/dt = 0 \text{ and } dH_W/dt = 0 \qquad (2)$$

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Equations (l)-(2) are equilibrium conditions for each CPR. The actual development is dependent on the individual household and collective group strategies pursued. Considering (1) we note that each of the variables *a, s* and *m* can influence herd size. The realized herd growth rate, *a,* is a compound variable of the intrinsic growth rate *r* and the functional response of pasture exploitation[12]. The main human influence on stability is via *s* by design of the *composition and size* of the herd. Changing the herd's age and sex composition can increase *r* and thereby increase the herd productivity *(a).* Mortality, m, is partly a function of level of pasture exploitation and partly a random variable.

If no collective constraints are imposed, the single household will be motivated to increase its herd by increasing the rate of harvest up to the level where marginal yield equals each household's cost of labor, driving resource rents to zero. In this context there is thus no incentive for the individual household to also consider the effect of its activity on the productivity of the resource for other households. We are facing a classical *appropriation externality* where one user's increased appropriation activity reduces the yield obtained by other users.

Further, mortality is confronting each household with the problem of *uncertainty.* This problem can be met by individual or collective strategies. An individual strategy is increasing the herd; which *ceteris paribus* means increased *individual* security. Even if the level of over all security is lowered, the larger herd will give increased security for the individual compared with a small one when overgrazing, as a result of this very same logic, comes into being. Achieving long run sustainable solutions will thus require collective security considerations.

The number of households is not reflected in the equations above. A certain use of labor is necessary both to harvest the biological production and to maintain a minimum *degree of tameness.* The number of households is a decisive factor for total herd size and resource

10 cf. Appendix I for a more complete explanation of this dynamics.

11 The requirement for a stabile herd size on both season pastures.

12 cf. Appendix I.

exploitation, since the total effort level can be increased by both *horizontal*[13] and *vertical* growth[14] (Brox, 1990:233). High attractivity and low entry barriers will support horizontal growth while the resource strategies of the households will determine vertical growth.

Equation (2) describes the herd equilibrium condition when there is balance between the capacity of season pastures. If one of the season pastures is in deficit, different CPR's can be distinguished according to which resource is limiting:

$$H_{S\,Max} \begin{array}{c} > \\ = \\ < \end{array} H_W (1 - m) \quad \begin{array}{l} \text{winter pasture limited (WPL)} \\ \text{in balance} \\ \text{summer pasture limited (SPL)} \end{array}$$

A CPR with affluent winter pastures, but insufficient summer pastures, is *summer pasture limited (SPL)* (cf. Meløy, 1996). It can support a big, but low productive herd. Conversely a CPR with limited winter pastures and affluent summer pastures, *winter pasture limited (WPL)*, can support a smaller, but high productive herd (op.cit). Imbalance between season pastures can be met by different strategies. These strategies are however influenced by the shape of the CPR.

Presence of *natural borders* is an important feature in the variable configuration of pasture areas. Mountain ridges, steep valleys and major rivers constitute barriers in the landscape. Herding without borders requires more work and can lead to lower productivity. The type of landscape will give opportunities and constraints for both the seasonal use and the size of each CPR. Regarding seasonal use, an open landscape gives opportunities for using areas out of season. If summer pastures are insufficient for a big herd, winter pastures could be partly used for summer grazing, creating a *pulsating summer herd (PSH) CPR* (Meløy, 1996). This strategy results in higher production in the short run, but leads to resource depletion and herd reduction in the long run. This is important both since the annual cycle has a structuring effect of its own and because using areas out of season will have a tendency of undermining the current regime.

In a broken landscape each *local common* will naturally be used by only a few households communally (Seabright, 1993). Open landscapes will as a rule have greater CPRs used by many users in common. Typically the most open landscapes with bigger size CPRs will require a *nested organization* (Ostrom, 1990) where a CPR is used of *groups of users* instead of single households. Generally we would expect that small size CPRs with a few households would have closer social relations than CPRs of a greater size and also would have a greater capacity to absorb changes.

An open landscape is an invitation to expansion and creates demand for inter-group rules and on-the-border herding. Ostrom, Gardner and Walker (1994:62-68) have, for a general class of CPR-games, shown that regardless of the benefit of extra resource units, the size of the

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13 growth in number of participants.

14 growth in effort, i.e. herd size per participant.

probabilities of monitoring and detection, the size of the fine for getting caught and the expense of monitoring, there will always be some tendency to take more resource units than one's share.

2.2.2 Attributes of the Community

A production system which has been subsistence-oriented will be colored by this also under a process of market integration. The household being the unit of both production and consumption will imply that the household's subsistence needs will be the ultimate goal of production (cf. Chayanov, 1966). Households will therefore tend to act with reference to *income targets* so that excess income often will be invested in herd increase.

In the Saami societies the organizing social unit is the *siida* consisting of from a few up to about ten households. Kinship ties through birth and marriage have been important elements of the social web. Further social values such as *independence* and *assurance* against uncertainty play an important role. In the anthropological literature about the North (Paine 1964, 1970, 1971; Pehrson, 1964) the object of "becoming a big owner" is also very pronounced. "Respect for others persons pasture areas" is another value noted in the literature on the North, (e.g. Solem, 1970; Paine, 1994). This value contrasts with the "big owner"-objective and may have played a major role as a social brake impeding degeneration of pasture commons into open access where physical boundaries are lacking.

Saami societies do not seem to have a high approval of majority rule. A general observation from a great number of formal meetings among Saami herders is that they put great effort in search for *consensus solutions* - which seem to have a considerable social value. This is consistent with the traditional lack of internal top-level-authority.

According to Duany (1992:1), societies without internal top authority "tend to be deeply ingrained in tradition. They work well so long as the central organizing principles of traditional ways can be maintained." This indicates vulnerability to changes. We would generally think that rapid changes are more difficult to handle than slow ones (Ostrom, 1995), and we would therefore expect that herder societies having gone through changes over a longer period of time will have better possibilities for making adjustments. We would also expect societies with local leaders capable of promoting common interests and able to influence the design and implementation of governance systems in accordance with people's cultural taste, will tend to achieve better results in a process of change (cf. Cornell and Kalt, 1990).

2.2.3. Rules-in-Use and Property Rights

Rules are generally agreed-upon and enforced prescriptions that require, forbid or permit specific actions for more than a single individual (Ostrom, 1986). In the Saami society the most important *position rule* on household level is the *ised* (household principal). Household principals herding in common in a siida consider themselves as partners. The Saami pastoral siida is led by a primus inter pares; *siida-ised.* The main decisions of siida-ised are herding decisions, but in case of conflict he has the ultimate right to decide membership in the siida (Vorren and Manker, 1976).

The pasture areas both in north and south Norway are divided into *Reindeer Pasture Districts*[15] (RPDs). An RPD may be one siida area, but there are also big RPDs with several siidas, i.e an RPD may be everything from a single local common to a large nested second order common. The herders in each RPD are required to elected a *district leader* to represent in contacts with authorities/settlers. This leader has also some internal monitoring duties.

Boundary rules specify how positions are entered or left. The traditional rule of access[16] is very open: every young male born by reindeer saami parents should have the opportunity to establish himself as a reindeer management household principal. There has traditionally been no specific *withdrawal rules*[17] limiting the number of animals appropriators might keep on pasture, even though some of the pastoral values could have such a function. *Management rights*[18] are kept at the siida-level, and the most important rule of authority is the siida-ised power of *exclusion*[19] in case of conflict in the siida. The exclusion rights are on siida-level and not from the industry as such. In the case of multi-siida RPD's, the elected district leader is assigned some monitoring authority from the government, but the dominant regulation mechanism is dialogue between siidas. The main control mechanism is the competent herder's knowledge about reindeer, landscape and climate giving the basis for judgement of information produced by others (Paine, 1970; Ramstad 1967; Riseth, 1996).

3. Potential Consequences of Market Integration and Technological Change

What capacity has a system like the above to adapt to rather rapid changes in technological and market access opportunities? In this section we will discuss this issue and propose a set of hypotheses that afterwards will be confronted with data about the actual developments.

Historically the Saamis have been nomads. Market integration succeeded a process of family settlement to sedentary life with separation between family and herd. This process was generally promoted by obligatory schooling and in the South also by a change in production by abandoning

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15 In order to control reindeer management when frontier agricultural settlements expanded into Saami area and caused conflicts, the pasture areas were in 1983 divided into RPDs so the settlers could claim damage whenever reindeer came into their fields (cf. Severinsen, 1979).

16 The right to enter a defined physical property.

17 The right to appropriate (harvest) product flow from a resource, e.g. of letting a certain number of animals graze a certain number of days per year.

18 The right to regulate internal use patterns and transform the resource by making improvements.

19 The right to determine who will have an access right and how that right might be transferred.

intensive[20] summer milking (Falkenberg, 1985). The process started about the turn of the century and lasted at least up to the second world war (Fjellheim, 1991; Solem, 1970:39; Vorren, 1964). Especially in West Finnmark (North) changes took part even later as a significant portion of the households still had firm contact with the herd in the late 1950's (Vorren, 1964:5)[21].

The process of *market integration* is basically lagged with the family settlement process. Up to the wartime the meat was sold to independent merchants. In the 1950's the government supported construction of slaughterhouses both in the South and the North, but the changes in reindeer management before 1960 were still limited.

In the 1960's some important changes in the *technological opportunities* developed. Motorization of transport became successively an option. New insights about how to increase biological productivity also became available. These technologies had the potential of both making life easier and increase the outcome of production. They could also induce processes threatening the balance between pasture yields and withdrawal.

3.1 Technology Characteristics and Adaptation Strategies

In our system motorized vehicles can increase productivity by more efficient *pasture* utilization and increased *labor* productivity. Let us call this *type A* technology. New knowledge about biological dynamics may be utilized to increase *herd* productivity[22] — here denoted *type B* technology.

Type A technology may be introduced mainly to make herding easier. It will, however, also tend to increase the level of pasture exploitation. By increased herder mobility greater herds and larger areas can be utilized by the same family and thus increase the potential pressure on the given pastures. The increased monetary costs related to acquiring the technology, will in itself motivate for larger herd sizes to cover the extra expenditures (increased "subsistence minimum" costs).

Existing common property rules may not be strong enough to cope with the dynamics of such a technology. It would give the user an immediate competition advantage. This advantage could only be leveled out by adaption of the technology by all potential competitors. Such a technology would therefore have a tendency to expand fast forcing users to invest in order to avoid loss in competition. At the aggregate level this could result in resource over-exploitation.

Type B technology can be acquired through education or other processes combining scientific

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20 Summer milking was never practized in the same intensive way in the North.

21 This can be explained on the basis of a combination of the special configuration of the winter pasture areas and the development of the communication pattern in the surrounding society (Vorren, 1964:6).

22 cf. Appendix I.

knowledge and time-and-place information (von Hayek, 1945:521). It is first of all implemented through changes in *herd composition* (structure of age and sex)[23]. It will make the biological transformation process from plant material via animals to marketable animal products more effective implying higher intrinsic herd growth *(r)* and productivity. It can be relatively inexpensive in monetary terms and will not give reason to a notable rise in "subsistence minimum". On the other hand it can give considerable increase in monetary income if the biological potential is not fully utilized in beforehand.

To be efficient, however, technology B would typically require some collective action. One could illustrate some of the basic reasoning by, in the spirit of Hardin, imagining a herder's marginal consideration of which kind of animal he should invest in. Having harvested what he needs for consumption and cash needs, he will set on one animal of the age and sex that he believes will give the highest amount of meat growth from one autumn to the next.

A standard answer could be to invest in a male calf which would give a *varit* (1 l/2yrs. bull) 10 kilograms heavier next autumn. An alternative answer could be to invest in a fertile female giving 20 kilograms in a new calf next autumn. The standard answer is relatively unconditioned. Since the doe (adult female) have to be minimum 60 kg to avoid reduced reproduction (Lenvik, 1989), the alternative strategy is conditioned upon that herd size is kept below MSY-level. That is, the alternative choice can give an upward shift in the productivity curve if the total herd size is limited in one way or the other. Following Paine's (1964) terminology, type B technology will require not only collective herding, but also to some extent collective husbandry. One consequence of this requirement is that type B technology will not tend to expand as fast as type A technology.

The possible combined effect of both type A and type B technology is interesting. If the increased revenue gained by type B technology is great enough, it could be used to (partly) pay for the increased costs imposed by the type A technology and the effect of increased minimum herd subsistence level could thus be easier avoided.

The above reasoning can be formalized in a game theoretical framework. In a system with exploitation far below MSY, the game takes the form of a *Prisoners Dream.* Introducing type A technology, may change the game to a standard *Prisoners Dilemma,* while introducing both type A and B technology, may move the game towards a game of *Assurance.* For those unfamiliar with the concepts, the reasoning is more fully developed in appendix III.

3.2 Choice of Adaptation Strategies – Hypotheses

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23 Young reindeer have a higher potential meat productivity (growth of meat per unit pasture) than elder, females a higher productivity than males when offspring is included. An optimal strategy biologically would be to go for a herd with a high percentage of reproducing females giving high offspring by slaughtering a high percentage of calves, especially males, selecting for onset of high-weight animals, slaughtering all males at the age of 1 1/2 years insofar as the young males are able to accomplish the necessary mounting their second autumn. All this is conditioned upon the individual animals realizing their full biological growth potential; i.e. herd size below MSY-level (Lenvik, 1989).

From the above, the alternatives for the herders are four fold:

* Strategy I - Avoid technology implementation
* Strategy II - Implement type A technology
* Strategy III - Implement type B technology
* Strategy IV - Implement both type A and type B technology.

The choice will depend on the character of the natural resources and the existing common property regime. Strategy I is to some extent observed in societies with strong normative institutions defining the "right" way of life (ex. the Amish communities in the US and Canada). Due to the competition advantage of type A technology it is very difficult to avoid its use even though it may threaten the resource base. This tends to make strategy III unlikely as a major strategy too. Thus the realistic choice in our context will most probably be between strategies II and IV. We will however not reject I and IV on purely theoretical grounds, but wait for the empirical judgement.

As to strategies II and IV the types of seasonal pasture balance is of importance. SPL commons will tend to favor strategies of herd expansionism while WPL commons will tend to favor strategies of herd stabilization. We would further expect strategy IV and herd stabilization to be more probable in a broken landscape, with winter pasture limited, small size commons due to the physical boundaries, closer social relations and a greater capacity to absorb changes. However, we should be aware that strategy IV can be successfully combined with herd expansionism insofar as herd size is well under MSY-level.

Conversely, we would expect to find strategy II and herd expansionism in an open landscape with large scale/nested second order commons. Large size CPRs give more space for competition and expansion, and collective action endeavors would require more effort. The probability is even increased if we consider a pulsating summer herd common.

We would expect the tendency to invest excess income in the herd to reinforce herd expansionism promoted by attributes of the physical world. Choice of strategy IV is the more demanding for CPRs with relatively loose institutions. In situations with external pressure and ongoing changes we would expect strategy II to be more probable than strategy IV if the changes are rapid and extensive. Entry-exit rules are fundamental for governing commons (Ostrom, 1990:90) and become especially important in situations of growth (Brox, 1990).

In situations of institutional change we would expect legitimacy of the changes to be connected with user participation and influence (Ostrom, 1990). Following our previous discussion, it seems to be of great importance to have locally accepted leaders that are able to act as entrepreneurs in the process of proposing and implementing solutions to the evolving problems.

Herder societies that are able to combine implementation of both type A and type B technology will have better prospects of sustaining a strong common property regime and thereby avoid resource depletion connected with open access than a society importing only type A technology.

More specifically we would expect these features or variables to be in favor of strategy IV:

(H1) *Winter pastures being the limiting factor (WPL) in seasonal pasture balance*
(H2) *A relatively broken landscape with high abundance of natural borders yielding relatively small scale CPRs*
(H3) *Relatively slow processes of change*
(H4) *Local influence in institutional change processes and the existence of internal entrepreneurs able to promote action*[24]

Conversely the opposite features will be in favor of strategy II. For (H2) we should in the case of big scale CPRs expect that *lack of or insufficient specification of higher level institutions would favor strategy II even more* (H2b).

We will in the following examine the hypotheses based on a preliminary provided material for the two regions.

4. The North versus the South

4.1 **Characterizing the development**

4.1.1 The North

Comparative lichen vegetation analyses of a number of sample patches conducted both in 1960 and 1990 in West and East Finnmark show a clear development pattern. The winter pastures which in 1960 had a fully intact cover of lichen carpets were in 1990 clearly reduced due to intensive grazing. The autumn/spring pastures, which to some extent had reduced lichen already in 1960, were in 1990 heavily grazed down (Prestbakmo, 1994). In as much as lichens are the most vulnerable part of the biological system, the evidence of overgrazing is quite clear, with spring/autumn pastures being most severely affected.

According to official statistics the total herd size of Finnmark has been remarkably stable varying basically within the range 60 - 90.000 animals for the whole period 1835-1974[25]. From 1974 to 1988 the total number[26] grew from 80 to 200.000 (+150%) followed by a decrease to 145.000 in 1995 (Reinbeitekommisjonen, 1967; Reindriftsadministrasjonen, 1980-1994; Reindriftsforvaltningen, 1995). The strong growth seems first to have affected the spring/autumn pastures negatively, and later the winter pastures. Up to the late 1970's the West Finnmark winter pastures were not fully utilized. The situation from the late 1980's and on is qualitatively new. There was no unused area to move to (Riseth, 1996).

24 cf. Ostrom's (1990: 101) design principle #7 (minimal recognition of rights to organize).

25 A few sudden drops are known due to random incidents due to irregular weather conditions causing reindeer starvation, e.g. 1918 and 1968.

26 It is necessary to make some reservation about the preciseness of the numbers, but the pattern is so clear that our conclusions are not affected.

The growth include both a horizontal and a vertical component. The horizontal, encompassing (nearly) a doubling of the number of households[27], and persons[28] is rather even for the whole period 1950 - 1990. The vertical growth, i.e. growth in herd size per household/person, started in the early 1970's and resulted in a doubling up till 1990[29]. The growth of total herd size in the 1970's and 1980's [30] is partly a recapture of reductions following the catastrophic losses in 1968 (extreme weather conditions), and partly a growth to a new and much higher level. The growth of the 1980's is clearly greater in the inner districts[31] adjacent to the common spring/autumn pastures, than in the outer (Reindriftsadministrasjonen, 1980-1994).

The material is consistent with a fairly good balance between expanding and stabilizing strategies in the period before 1970. *From the mid 1970's and during the 1980's a change to strategy 11 seems to be dominating.* Type A technology was introduced and rapidly spread. Mobility was radically improved year-around and herding techniques made more effective. Herd expansionism was the over all dominant response to the new technological possibilities, with vertical expansion being a lagged response to the technology import. In West Finnmark spring herd, as an example, was doubled in the period 1976-1988 (Riseth 1988). The aggregate result was increased competition over pasture resources (Reindriftsadministrasjonen, 1980-1994; Nilsen and Mosli, 1994).

This does not mean that we do not observe any herd restructuring. The doe percentage increased from 55 in 1980, via 61 in 1988 to 64 in 1995 (Reindriftsadministrasjonen, 1980 and 1988; Reindriftsforvaltningen, 1995). The rapid herd increase seems, however, to obstruct the potential for converting this into increased productivity. As we remember, enhanced productivity was conditioned upon the does' physiological status which was negatively influenced by herd expansion. This observation is further in accordance with a very modest increase in the relative proportion of calf-slaughter from about 10 % in the late 1970's to about 25 % in 1985-1987. A sudden jump to about 50 % 1988-1991, followed by a decrease to a traditional below 20% level in 1993-1994, is the result of an extra herd reduction subsidy for the peak years (Reindriftsforvaltningen, 1995:25-27).

The effect of all this was that the annual productivity[32] per animal was reduced from 11.3 kg in 1976 to 7.2 kg in 1988. The total production[33] reached a peak in the mid 1980's and decreased afterwards (Riseth, 1988). At the same time costs increased strongly from the mid-1970's both

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27 from 260 to 514 (+98%) in the period 1950-1990 (Økonomisk Utvalg, 1994).

28 from 1200 to 2139 (+78%) for the same period (Økonomisk Utvalg, 1995).

29 The herd/household ratio increased from 201 to 399 from 1970 to 1989.

30 5.13 % average annual growth rate 1970-1989.

31 The inner districts (cf. Appendix II for the pasture configuration) have a annual herd growth rate of 6.6 % while the outer have 3.3%. The former have also an average total annual growth (herd increase plus harvest) of 34.3 % while the latter have 28.3% (Reindriftsadministrasjonen 1980 - 1989). Statistical analyses confirm the difference (Kosmo, pers. com.).

32 annual harvest plus investment in animals.

33 the sum of annual harvest and annual herd increase.

absolutely and in proportion to the production value (Sara, 1987). The average productivity for the years 1991-93 was still but 7.5 kg. The average gross production income per standard man year was for these years about NOK 58.000 and the production costs NOK 50.000 yielding a production surplus of only NOK 8.000 (0konomisk utvalg, 1992-1994). We thus observe negative rents. State subsidies helped increase net standard man year income to NOK 32.000. The development indicates that a No Problem situation was changed to a standard Prisoners Dilemma game.

4.1.2 The South

In this area the first postwar period was unstable partly as an effect of the war and partly due to wolf predation. From about 1960 to the mid 1970's, however, the total herd size seem to have been relatively stable with a total of about 20.000 animals. In addition an uncertain number of reindeer belonging to neighboring herders from the Swedish side of the national border were exploiting the pastures more or less regularly for parts of the year. This stopped in the early 1970's due to erection of a convention border fence (see section 4.2.2). Not all portions of the pasture area were in regular use. There are however signs of local overgrazing[34] in some of the inner districts adjacent to the national border in the 1960's and early 1970's.

From the mid-1970's until the late 1980's the total herd size grew modestly reaching a new level about 20 % higher than the level of the 1960's. There are no significant signs of overgrazing and the appropriation is considered to be sustainable. Herd restructuring started from the mid-1970's in several RPD's. This practice spread during the 1980's and the herd productivity increased in most districts. Numbers for North Trandelag demonstrate this clearly. The doe percentage increased from 59 in 1980 to 75 in 1988 and 79 in 1995 (Reindriftsadministrasjonen, 1980 and 1988; Reindriftsforvaltningen, 1995). The relative proportion of calf-slaughter increased gradually from 12 % in 1977 levelling out at about 70-75 % in the early 1990's. The South Trandelag/Hedmark development is comparable (Reindriftsforvaltningen, 1995)

The herd sizes were stable or increased modestly. Costs also increased, but this was compensated by increased net production. *This pattern of development is thus clearly compatible with strategy IV.* The total production was high and the economic surplus much larger than in the North. For the whole region meat productivity per animal was 12.8 kg in 1980 and 13.3 kg in 1988. (Reindriftsadministrasjonen 1980 and 1988) For the years 1991-1993 the average productivity had reached 16.9 kg for North Trandelag and 17.0 kg for South Trondelag/Hedmark.

As to the economic result, average standard man year gross income in North Trandelag was approximately NOK 196.000 for this three year period. Average costs were NOK 105.000 yielding a net product of NOK 91.000. In this region the average subsidy level was NOK 96.000

34 some of these cases were taken under control by internal CPR-processes while others were solved in cooperation with the government.

making up a total net income of NOK 187.000. Figures for South Trondelag/Hedmark are comparable to these (0konomisk utvalg, 1992-1994).

In these regions, the coastal areas kept a traditional intensive herding up to the post second world war period, while the inner ones, which were influenced by reindeer management on the Swedish side of the border, abandoned this early in the century (Fjellheim, 1991). The pressure from Swedish neighboring districts seem to have limited the expansion in most of these districts.

The diffusion pattern of technology A is not different from that of the North. What separates is the technology B-revolution, which started in some of the RPDs that had experienced problems in the 1960's and early 1970's. During a decade strategy IV became dominant in the whole region. In the South the income from technology B seems to have paid for the costs of technology A. By this development the game seems to be moved in the direction of a game of Assurance.

4.2. Explaining the differences

How well do the observed developments conform with our hypotheses? Let us start by considering the North.

4.2.1. The rent dissipation of the North

(H1) The North areas are considered to be SPL[35]. The climate of the winter pastures is very stable with a relatively light snowcover and have therefore high accessibility for the reindeer[36]. The observed pattern of pasture graze-down and herd increase indicates that the expansion of the last couple of decades was predominantly conducted by herders of the inner areas. These herds became PSHs, first expanding on and overgrazing the spring and fall commons, and finally the winter pastures. All this seems to have been a competitive race with the larger herds from the inland as the forerunners.

(H2) The landscape in the North must be described as very open. This is especially the case for the winter pastures, but also the spring/fall pastures are fairly open making expansion and a transition to PSH possible. The summer pastures are predominantly of moderate scale. The siidas of the North consist generally of more households than in the South. The big scale of the fall/spring and winter pastures and the open landscape give expansion opportunity for the followers of strategy II. Both physical factors (H1 and H2) are thus clearly in favor of strategy II for this area.

(H2b) This conclusion is strengthened by the fact that the *over-siida level* is traditionally non-

35 by Reinbeitekommisjonen (1967) especially West, but also East Finnmark (less extent).

36 D_w is relatively small (cf. Appendix 1)

existent. Top level interaction is *inter-siida,* laterally coordinating activity through dialogue with a basis in kinship/social webs. The elected RPD leadership in the second order commons have had limited influence.

From 1980 a new institutional structure was introduced. Regional and National Boards, both levels with extensive herder representation, and the Central State Agency constituted the core of the system. The herders of each RPD had the duty to elect a local Board among themselves. The Reindeer Management Policy developed into a formalized sector policy[37] during the 1980's. The strategic decisions were to a large extent made by consensus in an inner circle of decision makers encompassing the leaders of the Agency, the Ministry of Agriculture and the herders organization NRL[38] (cf. Riseth 1991:136). These bodies however met credibility problems whenever they tried to conduct a restrictive policy promoting herd stabilization. A new herder organization (BES)[39] was established in the North in 1987 strongly criticizing NRL and its cooperation with state authorities in the creation of regulations (Paine, 1994).

This indicates that the inter-siida relations have been sufficient when pasture exploitation was limited and technology A was non-existent. In the new situation one seems to have failed to create a necessary, authoritative over-siida level in the North.

(H3) The whole period from 1960 -1980 encompasses fast changes both in settlement patterns and production methods. This tendency becomes even more pronounced when we compare it with the preceding decades with rather stable conditions. Speed is a relative concept, though, and its effect is difficult to judge without comparison with areas confronted with less or even more rapid changes (see 4.2.2).

(H4) Entrepreneur capabilities are to some extent random. What is less random is the potential to influence institutional change process insofar this is conditioned by the characteristics of the actual action arena - both community attributes and rules in use.

A study of a herder organization magazine (Reindriftsbladet 1953-1964) and the extension magazine (Reindriftsnytt, 1968-1990) indicates that most herder entrepreneurs of the North were mainly engaged in property right claims and sustaining traditional culture while their demand for solutions following technology B was limited. Following Snell and Snell (1975) they could be labeled "culturalists" in so far as ethnic identity seems to be their main concern. Some Northern leaders from the late 1980's could however be subsumed under the opposite term "occupationalists" focusing much more on standard economic rationality. An early Northern "occupationalist" entrepreneur was the former Lapp Sheriff of West

37 or more precisely a subsegment policy (cf. Kalstad 1992).

38 founded 1947.

39 there are good reasons to believe that BES had about the same number of members as the NRL in the North, perhaps even more.

Finnmark. He was appointed undersecretary of the Ministry of Agriculture in 1973, From 1980 he became the leader of the new State Agency of Reindeer Management. He played a key role in developing the new institutional structure implemented the 1980's. Our analysis thus indicates that Northern occupationalists so far seems to have had problems with finding governance systems in accordance with their people's cultural taste.

Increased herds may not necessarily be a function of the technology. Nilsen and Mosli (1994) argue that women's wage labor income from the new and growing public job market was the most important factor behind West Finnmark herd increase, at least in the 1980's. The extra income was to some extent invested in the herd. Starting with women's separation from the family herds about 1960 and continuing with the promotion of the rapid spread of snowmobiles around 1970, women's changing position and contribution in the household of reindeer management could thus at least be an additional explanatory factor.

We do not question this, while one may go even further and ask whether this is a process governing both investment in technology A and herd increase. To discuss this we need to compare with the Southern region.

4.2.2. The prospering South

(H1) Most of the South area is typically WPL. The inland winter pastures[40] have thicker snowcover than the ones of the North[41] while the subcoastal ones have a more unstable climate. These factors seem to have limited the potential for herd expansionism to become a dominant strategy. Even though there are indications of some CPR-problems also in South WPL areas, the magnitude are limited.

Concerning H1 we need to observe that some of the costal[42] commons are actually SPL. Still, the problems of the North is avoided. This may be due to the fact that these areas experienced intensive management up towards 1960. Still, this observation indicates that WPL may not be a necessary condition for avoiding problems, at least as far as other factors limiting herd expansion are existing. Natural borders may be such a factor.

(H2) The South has a clearly more broken landscape than the North and mainly small scale commons consisting of one or two siidas. This is very different from the North. The summer grazing areas of the inner districts are, however, relatively open towards Sweden, and some of the local commons have had rather weak natural borders between themselves. This relative openness seem to have been contributing to the noted

40 cf. Appendix 2.

41 D_w is greater than for the North, cf. Appendix I.

42 cf. Appendix II.

occurrence of some CPR-problems. The erection of a convention border fence in the early 1970's seems to have reduced the difficulties and supported a more stable situation.

(H3) The change process of technology A went at a about the same speed over the whole region and was parallel to the one observed in the North. The spread of technology B started in some districts and spread gradually by diffusion. The pattern indicates that personal choice processes was important.

(H4) Historically the Saami ethnopolitical activity was dominated by the South. Most of the leaders of NRL up to the mid-1970's were as an example from this district. Leaders of this region played a central role in the design of the resource control system introduced in the Act of Reindeer Management[43] of 1978, including both RPD and household herd quotas. They played a similar role in the development of the Main Agreement of Reindeer Herd Management[44] that was agreed upon in 1976. A preliminary field-work (Riseth, 1995 and 1996) indicates that in the 1960's and early 1970's there was a felt crisis among a wide circle of persons in the South area and a growing demand for new solutions among the herders. There are several examples of herders trying to find new opportunities and new ways of practicing reindeer management (Elgvin, 1993; Ramstad 1967). Herder leaders were generally active promoting various proposals towards the governmental authorities. Professionally trained agronomists were employed in the old Lapp Sheriff positions in both South and North Trondelag in 1969 and 1973 respectively. An extensive cooperation was developed to support productivity increase. In the Snell and Snell (1973) terminology the South entrepreneurs can be labeled "occupationalists". These leaders have actively promoted alliances with the extension service establishing a industry policy hegemony in spite of a diversity of apprehensions.

Returning to our considerations about the consequences of women's new wage labour income in the 1970's and 1980's we have to ask whether women went through the same changes in South as their fellow sisters of the North. For most of the South, women's separation from the family herd was completed around the Second World War, but in some parts, especially those towards the coast, the contact lasted as long as in West Finnmark, i.e. up towards 1960. The growth of women's job opportunities took place later and followed a fairly similar pattern over the whole country. We do not have any reason to expect that South Saami women have used the job opportunities different from their sisters of the North. Generally, the economic surplus in the South reindeer management was rather modest in the 1960's and early 1970, and we would therefore expect growing wage labor income opportunities to be utilized as soon as they became available. By this we do not say that external wage income in the North did not influence herd size. We only observe that parallel conditions in the South did not set off any pronounced herd increase.

43 Norges Lover (1979) Lov om reindrift (Reindriftsloven).

44 Landbruksdepartementet (1976) Hovedavtale for reindriftsnaeringen.

It is not possible to draw a more firm conclusion on the basis of the available material. The effect of labor market income may be different because of possible differences in culture, maybe the value of "becoming a big owner". To make a more valid comparison of this we need to study the developments in households where women adapted differently to the labor market.

5. Discussion

As we have seen, the physical factors seasonal pasture configuration (H1) and brokenness (H2) give the South area a clearly better startpoint for both preventing and handling CPR-problems. We should however note that (H1) does not seem to be a necessary condition. Observations in the South show that other factors may compensate for the effect of summer pasture limitation.

The importance of speed in change processes (H3) is difficult to discuss on the basis of our material. So far we can conclude that the South has managed to develop strategy IV in spite of a rather rapid change in conditions. Time may still be a very important factor. It can however not explain the difference between the South and the North.

The importance of local influence in the process of institutional change (H4) also seems strong. The leaders of the South managed to develop a policy and cooperation with professionals and governmental sector authorities and at the same time gain sufficient support among their fellow herders. It must be added though that the physical factors, as size and pasture configuration, may have made the task of gaining support for a certain policy much easier.

As we are left with hypotheses (H2) and (H4) as core conditions, we will hold that there are a dynamics between the two. For the leaders of the South the size and brokenness of the area obviously made the task of achieving both influence with respect to the national political system and sufficient support from their own people easier. On the other hand it is also probable that the openness and size of the North area may have influenced how North leaders and herders considered the resilience of the system .

Initially we asked whether the development in the North was a sign of disintegration of a previously well functioning system or a lack of capacity to adapt. Our preliminary empirical material give support to a conclusion that the common property regime about 1960 was sufficient to balance the resource use. When new technology was implemented, however, the regime was not strong enough to handle the new dynamics as the attempts of changing the system failed.

We have in our analyses chosen to give priority to local dynamics. The action arena of national policy and the role of the state government and its bodies is clearly undercommunicated both theoretically and empirically. Even though the role of herder leaders is discussed, a more direct focus on the political processes on the level above the saami societies could have added valuable insights. Parallel, a discussion of the effects of state subsidies is needed, even though we are again left with a situation where the conditions have been fairly equal in South and North.

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Vegetation (lichen) zero isocline becomes:

(A10) $H_w = (4g*L / c*K_w)\ (L+D_w)\ (1-(L/K_w))$ for $dL/dt = 0$

The general equilibrium condition is:

(A11) $H_{S\,Max} \gtreqless H_w\,(1-m)$

- $>$ winter pasture limited (WPL)
- $=$ in balance
- $<$ summer pasture limited (SPL)

The equilibrium adaption will be given by the optimum spring herd size $H_w\,(1-m)$ and an equilibrium lichen biomass, L^* which is near, but< L_{MSY}, which again is the optimum biomass for the winter herd size, H_w.

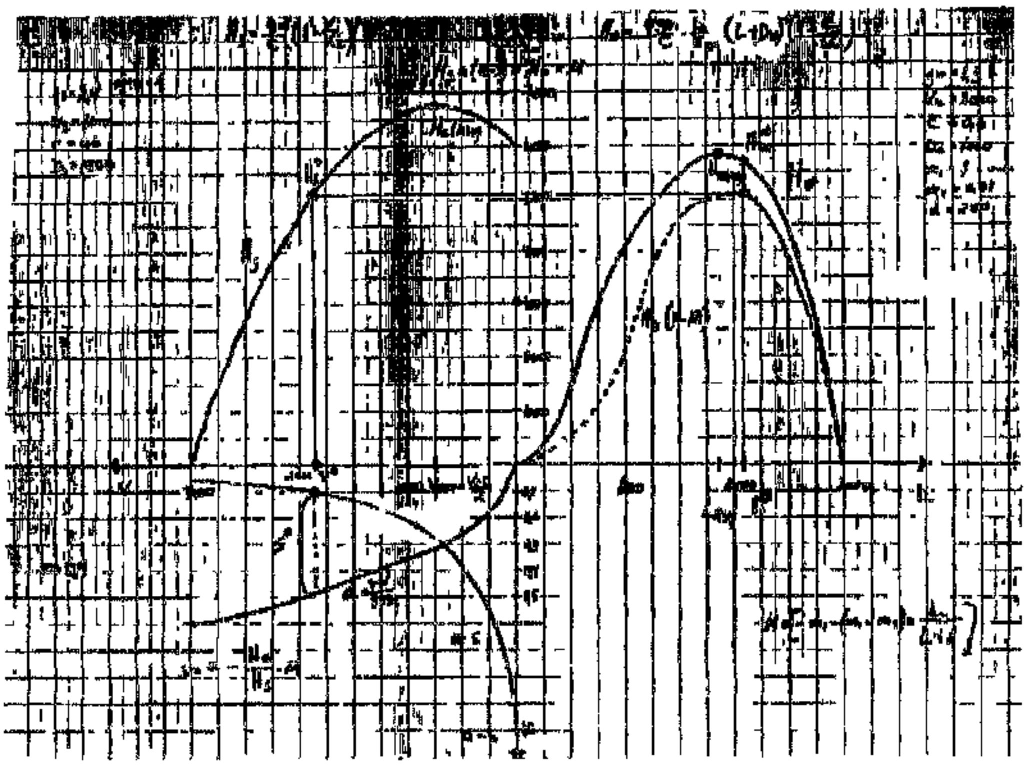
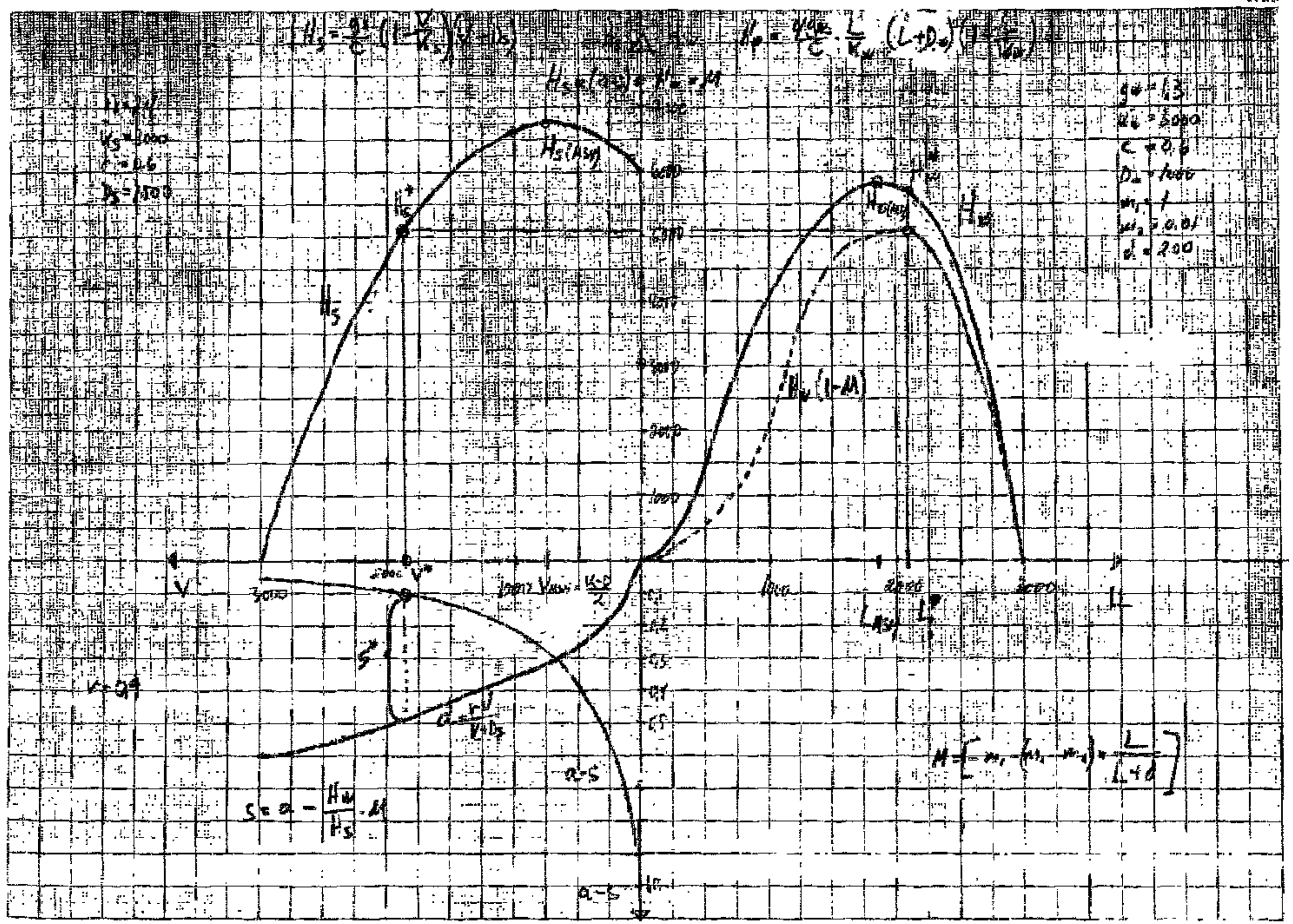


Figure A1. 2-pasture dynamics for reindeer herd management

Exploring the possible influence of different technologies, technology type A (motorized vehicles) will increase pasture utilization by reducing the value of D_w and D_s (which is measures of permanent levels of availability of the pasture for the animals) and increasing the reproductivity rate (a) of the animals giving increased instability if not balanced by an increase in the offtake s. Technology B (herd structuration) will increase the maximal reproduction rate, r and decrease the natural mortality, m, also resulting in increased instability if not balanced by an increase in the harvest rate s.


H_S
$H_{S(Asy)}$
H_w
$H_{w(Asy)}$
$H_w(1-M)$
V
L
$V_S = 1000$
$r = 0.6$
$D_S = 1500$
$g = 1.5$
$c = 0.6$
$D_w = 1400$
$m_1 = 1$
$m_2 = 0.01$
$d = 200$
$S = a - \frac{H_w}{H_S} \cdot M$
$a = \frac{rV}{V + D_S}$
a-S

7. Appendices

Appendix I. A two pasture reindeer model.

We can model the biological system of reindeer herd management by simplified assume a herd migrating annually between 2 season pastures (summer (grass and herbs) and winter (lichen)) which are *perfect complements*. This means that herd size is decided by the season pasture being the ecological minimum factor. Generally this is assumed to be the winter pasture, which is also reflected in the Klein (1968) hypothesis. The system can be modelled by differential equations[45] for both the herd and the season pastures (Riseth, 1997). The seasonal equations of motion for the herd are:

(A1) $dH_W / dt = H_S *[r V/ (V+D_S) -s]$; where H_W is winter herd, H_S is spring herd, r is intrinsic herd growth rate, V summer vegetation biomass, D_S halfsaturation level for summer vegetation and s harvest rate.

(A2) $dH_S / dt = H_W*(- m_1-(m_1-m_2)* L/(L+D_M)$; where m_1 is maximum mortality, m_2 minimum mortality , L lichen biomass and D_M is halfsaturation level for mortality.

The total equilibrium condition becomes, dH/dt =0 = >

(A3) $dH_S/ dt + dH_W /dt = 0$

(A4) $\mathbf{H_S *[r V/ (V+D_S) -s] = H_W *[- m_1 -(m_1 -m_2)* L/(L+D_M)]}$

Simplifying by setting $rV/V+D_S$ equal to *a*, effective reproduction rate and $[- m_1-(m1 -m_2)*L/(L+D_M)] = M$, effective mortality rate;

(A5) $H_S * (a -s) = H_W * M$

Solving (A5) for s yields:

(A6) $s = a - (H_W / H_S)* m$; for $dH_S / dt = 0$ and $dH_W / dt=0$)

Each of the season pastures have their own internal dynamics between the season herd and season pasture.

Summer pasture equation of motion:

(A7) $dV/dt =Vg_S(1-V/K_S)-H_S*c[V/(V+DS)]$; where g_S is summer vegetation growth rate, K_S is maximum summer vegetation biomass and c the herbivore consumption rate.

Vegetation zero isocline:

(A8) $H_S = g_{Ss}/ c (1-V/K_S) (V+D_S)$ for $dV/dt =0$

Winter (lichen pasture) equation of motion:

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[45] Equation (A1), (A7) and (A8) is identical (note different parameter names) with the basic equations in the single-pasture herd model used by Skonhoft (1997).

(A9) $dL/dt = 4g_w*L/K_W*[1-(L/K_W)]-H_W c*[L/(L+D_W)]$; where g_W is lichen growth rate, K_L is maximum lichen biomass and D_W the halfsaturation level for lichen.

Vegetation (lichen) zero isocline becomes:

(A10) $H_W = (4g*L \,/\, c*K_W)\,(L+D_W)\,(1-(L/K_W))$ for $dL/dt = 0$

The general equilibrium condition is:

(A11)

$$H_{S\,Max} \begin{matrix} > \\ = \\ < \end{matrix} H_W(1-m) \quad \begin{matrix} \text{winter pasture limited (WPL)} \\ \text{in balance} \\ \text{summer pasture limited (SPL)} \end{matrix}$$

The equilibrium adaption will be given by the optimum spring herd size $H_W(1-m)$ and an equilibrium lichen biomass , L^* which is near, but $< L_{MSY}$, which again is the optimum biomass for the winter herd size, H_W.

Figure A1. 2-pasture dynamics for reindeer herd management

Exploring the possible influence of different technologies, technology type A (motorized vehicles) will increase pasture utilization by reducing the value of D_w **and** D_s (which is measures of permanent levels of availability of the pasture for the animals) and increasing the reproductivity rate (a) of the animals giving increased instability if not balanced by an increase in the offtake s. Technology B (herd structuration) will increase the maximal reproduction rate, r and decrease the natural mortality, m, also resulting in increased instability if not balanced by an increase in the harvest rate s.

Appendix II. Pasture configuration of the North and South.

The winter pastures of the North are situated on the lichenrich bedrock inland plateau, spring/autumn pastures in a more hilly highland zone while the corresponding summer pastures are mainly on coastal peninsulas (*njarga)* and islands *(suolo),* but partly also on the outskirts of the inland mountain plateau *(orda).* The winter and fall/spring pastures are commons for a great number (around 50 up to nearly 70) of groups of herder households, *siidas.* The winter area is a fully open landscape and the fall/spring area is naturally divided into 3 parts. Even there are 3 types of summer areas it is for our purpose sufficient to divide into two types; inner and outer areas where as some siidas go to the inner and some to the outer.

```
*****************************************************
*                                                   *   WINTER  PASTURES
*                                                   *   (2nd order commons)
*****************************************************
*                  |                       |        *   FALL AND SPRING
*    (West)        |        (Medium)       |(East)  *   PASTURES
*                  |                       |        *   (2nd order commons)
*****************************************************
*      *      *      *      *      *      *      *      *   INNER SUMMER
*      *      *      *      *      *      *      *      *   PASTURES
*      *      *      *      *      *      *      *      *   (Local commons)
*       *       *      *      *      *      *      *      *   [Orda, inner njarga]
*****************************************************
*      *      *      *      *      *      *      *      *   OUTER SUMMER
*      *      *      *      *      *      *      *      *   PASTURES
*      *      *      *      *      *      *      *      *   (Local commons)
*      *      *      *      *      *      *      *      *   [outer njarga, suolo]
*****************************************************
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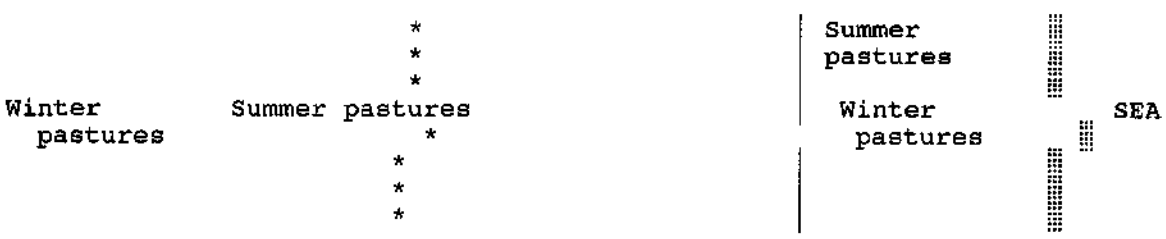
Figure A2. North pasture configuration

The main differences between inner and outer summer districts are that the siidas utilizing the former can calve at spring pasture and have shorter seasonal migrations as well. The winter pastures are without natural borders and the relations to the neighboring siidas are therefore very important. The danger of intermingling with other herds is a challenge to cope with both in autumn and winter[46].

In the South the main traditional winter pastures are in the (east) continental Swedish inland (pine) forests[47], but also on islands and peninsulas and low mountains on or near the Norwegian coast. The summer pastures are mainly in the mountain ridge which the Norwegian-Swedish border follow. Traditionally there have been two types of herding in this area, a mountain type with long migrations to continental winter pastures and a coast type with shorter migrations. The bare mountain areas on the Norwegian side are divided by wide spruce forest areas rather sparsely populated by a farmer population. Some districts lack natural borders.



46 A more accurate description of management and strategies in the commons of Finnmark is given by Kristiansen and Sara (1991).

47 The migration across the border has been reduced since its origin in 1751 and the use of winter land in Sweden by Norwegian Saamis is today limited.

SWEDEN National Border NORWAY Physical Border (Fjord or valley)

Figure A3. South pasture configuration

Appendix III. A game theoretic exposition.

Using a *game theoretic perspective* we may inquire a simple action situation with two players having the choice between the strategies *Cooperate* or *Defect* and a payoff matrix with the parameters a,b,c, and d[48], cf. figure A4a for a general 2 player matrix. C= Cooperate, D= Defect.

	PLAYER II		
		C	D
	C	a a	b c
PLAYER I	D	c b	d d

Figure A4a. General 2 player matrix

For all situations we will study here, both a and b > both c and d. If a>b>c>d there is a *No Problem (Prisoners Dream) situation* and if b>a>d>c the game structure is a *Prisoners Dilemma* (P.D.), while with a>b>d>c it takes the form of a game of *Assurance*. Starting out with a No Problem situation a relative increase in the relations b/a and c/d making them >1 will turn the game structure to a P.D. This structure can be turned to Assurance if the b/a-relation becomes <1. Axelrod (1984) have demonstrated that for repeated n-persons games marginal changes in the payoff structure can change the percentage of strategy choices and thereby the overall game structure. Ostrom, Gardner and Walker (1994) found in experimental studies that the opportunities of communicating and sanctioning improved the abundance of cooperation strategies clearly. These findings were also in accordance with their field data.

Placing our reindeer herd CPR in a No Problem start situation we can imagine strategies II and IV and implementation of the technologies A and B as changes in the payoff-matrix[49] in a repeated n-person game.

	PLAYER II		
		C	D
PLAYER I	C	5 5	4 3

48 thinking of the parameters as a: temptation, b: reward, c: loss and d - punishment might make the logic easier to follow.

49 The succesive pay-off matrixes for a single 2-person-game is here written out as an illustration.

	D	3 / 4	2 / 2

Figure A4b. Action situation 1: a>b, c>d. No Problem.

Implementing technology A (strategy II, see main text) can increase b and reduce c thereby changing the game structure to a P.D[50], cf. figure A4c. Pursuit of strategy II will be to stay in this situation and have the consequences of increased herd growth and internal competition between household units setting common property institution under pressure and increasing the risk of resource depletion. A core feature of this strategy would be *herd expansionism.* At a low level of pasture exploitation herd expansionism is unproblematic, but when MSY is exceeded, fierce resource competition and resource depletion can be the consequence if there are no institutional brakes available.

	PLAYER II		
		C	D
PLAYER I	C	5 / 5	6 / 1
	D	1 / 6	2 / 2

Figure A4c. Action situation 2: a<b, c>d. Prisoners Dilemma.

Implementing technology A and B together (strategy IV) means an increase in a to a', changing the game structure to Assurance[51], cf. figure A4d. This strategy requires some changes in the rules to restrict herd expansionism. In a situation where MSY is reached, the herder society as a whole cannot increase production and income from animal products by expanding herd size. Strategy IV thus opens new opportunities by increasing biological productivity of the existing herd, i.e. total production and income can be increased while herd size is kept on a level requiring pasture exploitation below MSY. The individual household can choose between strategy II and strategy IV, but the pay-offs are conditioned upon the fact that the limitations from the common property regime is working.

	PLAYER II		
		C	D
PLAYER I	C	8 / 8	6 / 2
	D	2 / 6	3 / 3

50 We should note that the change of game structure here is without change i total payoff (zero-sum)

51 We here assume that the change include an increase in total payoff (a pluss-sum situation)

Figure A4d. Action situation 3: $a' > b$, $c > d$. Assurance. The pay-offs demand a herd restricting regime.