NORGES LANDBRUKSHØGSKOLE

Agricultural University of Norway

DOCTOR SCIENTARIUM THESES 2000:1

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A Comparative Analysis of Regional Development Paths in West Finnmark, North Trøndelag, and South Trøndelag/Hedmark, Norway

Volume I

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ISSN 0802-3222
ISBN 82-575-0411-4

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Abstract

The Sámi is recognized as the indigenous people of large parts of Fennoscandia. The reindeer has been an important source of living since prehistoric times, and the reindeer industry is still important for the sustenance of Sámi culture. It has a mixed management regime where the pasture resource regulated by common property produces inputs to the production functions of individual owners.

During the period 1960- 1990 reindeer industry in Norway were exposed to considerable technological changes with a shift from animal and human muscle power to motorization during a couple of decades. Parallel to this an extensive Co-Management reform was implemented. The intentions included promoting good resource utilization and sustaining the industry as a part of Sámi culture. The outcome was regionally diverse. During the 1980's the southernmost regions experienced prosperity, while the northernmost regions encountered both low income and an increasing overgrazing of vulnerable lichen pastures due to growth in animal numbers.

The two cases are investigated by comparative analysis based on the IAD Framework and a theoretical analysis of reindeer management production systems and institutions. The explanations suggested include differences in nature geography, institutional features and historical inter-ethnic relations.

To Lin

Thank you very much for excellent instruction during the spring term 1996 and the great time I had at the Workshop.

Jan

May 30, 2000

Preface

This study is conducted as a partial fulfillment of the requirements for the degree Dr. Scientarium in Natural Resource Economics at The Agricultural University of Norway (AUN), Department of Economics and Social Sciences. My research has been a project under the Norwegian part of the UNESCO programme "Man and Biosphere" (MAB) which was administered by the Research Council of Norway (NFR). I was a research fellow with basic payment from MAB/NFR for 3 years and 1 month running from September 1, 1994. During this period and until November 30, 1971 was on leave of abscence from my position as an Assistant Professor at Narvik College, Environmental Engineering. Narvik College has paid a part of my wages and a part of my expenses. During 1999 Sami Institute, the Network of Indigenous People (Urfolksnettverket) and The State Agency of Reindeer Management (Reindriftsforvaltningen) have in common sponsored a part of my wages to promote the commisioning of my dissertation.

I was raised as a farmers boy in Snåsa, North-Tr0ndelag, with South Sámi children going to the same school. However, my knowledge of their world and way of life was limited. Therefore my start became theoretical. As a student of Nature Conservancy at AUN I attended a course in reindeer management. The course, with Dag Lenvik as main instructor, was excellent, and I became curious on reindeer management.

After graduation, fortune was on my side and I received a position at the recently established State Agency of Reindeer Management (Reindriftsadministrasjonen) in Alta, Finnmark. Starting the summer 1980 I joined the professional staff of Director Ole K. Sara under the direct instruction of State consultant Ansgar Kosmo. I stayed in Alta and the Agency for 10 years, most of the time as a part of the leadership. During this period I was through most of the undertakings of state officials in reindeer management. I learnt about realities of the life of reindeer managing Sámi from the all over the country cooperating with them individually and in groups. I worked in extension service, as an excutive officer, as a project organizer, as a teacher, as a policy planner and served as secretary or chair in diverse committees.

Resource control questions were an important task for the Agency and the department I headed. Even though it in the early 1980's seemed quite clear that some kind of limitation on the total herd size in Finnmark was necessary, due to pasture capacity, as professionals we experienced that the reindeer managing Sámi of Finnmark was reluctant to implement quotas for herd size in Finnmark. How could then the resource use be kept under control? Some people thought we worried without reason. Others found that we hesitated too much. What was the right thing to do? Why did not the herding Sámi themselves take action earlier? The questions queued up and the good answers were few.

Having a background mainly from natural science, I recognized that to deepen my understanding of Sámi reindeer management the crucial deficit of knowledge probably was to find somewhere in the social sciences. During the 1980's I found several opportunities to conduct both formal and informal studies in diverse social sciences, but I did not find an appropriate approach before Arild Vatn taught a course in institutional economics at AUN in the fall term 1993. At that time I had moved to Narvik and lectured engineering students basic environmental science. Arild found my examples from the field of reindeer management interesting and we start to cooperate. The MAB-programme included resource problems in Sámi reindeer management and I applied successfully.

My agreement with my college was that my base was to be in Narvik, but I had to travel for all my course work, mostly to AUN at Ås, but also to Tromsø, Oslo and Aarhus, Denmark. My major trip was to USA. I had soon realized that I needed a broad approach to handle the complex problems I wanted to sort out. I received contact with Professor Elinor Ostrom at The Workshop in Political Theory and Policy Analysis at Indiana University, Bloomington. She invited me to attend their seminar and stay as a Visiting Scientist for one year. I managed to get half a year financed, and after a lot of arrangements, my family and I spent the Spring term 1996 in Bloomington. The excellent introduction to the world of Common Property I received at the Workshop provided me a firm basis for my research design, and we all had a great time.

Back in Norway data collection and field work became a major undertaking. In this phase former colleagues and contacts were important. I had chosen to compare West Finnmark, which I denote as North performance with that of Trøndelag denoted as South. For the South I mainly sought advice from the professional seniors of the "service", Dag Lenvik and Ansgar Kosmo, which both first had been my teachers and later been co-workers through a number of years. For the North I have had important discussions with foremost two other earlier co-workers, Johan Ingvald Hætta and Jon Aarseth Meløy, but also with others. The fieldwork brought me closer to the thoughts of a number of reindeer managing Sámi than before. They came up with many of the jig-saw parts I had missed for a long time.

I have met positive interest and encouragement everywhere, and there are lot of people I want to thank for their support. First I will thank both the practioners of reindeer management and all my former colleagues for the knowledge they gave me in the 1980's. Second I want to thank particularly everybody both from the industry and the service which have helped me now during this study. I also want to thank the workshoppers of Bloomington for their support during our stay - in particular Tom and Kristin for being our closest family friends, Hans Petter and Bente in Bodø for practical advice about Bloomington, Randi's colleagues for their assistance in cleaning our house before we went to the US. When we were abroad Oddveig, my sister-in-law, took care of our domestic correspondence. At Ås I have enjoyed the hospitality of Øystein and Kristi during shorter and longer stays. Øystein has also had comments of parts of my manuscript. Arild has been a firm and encouraging instructor through the whole process. His constructive criticism has added much clarity to my thoughts and writings. Carl Etnier has at one stage improved my English considerably. Leif Andreassen has designed very accurately some very complex illustrations. My College, my department and my colleagues have also encouraged me when my work load have been heavy. Thanks a lot to all mentioned persons and more not mentioned.

Partially I have felt the doctoral study as a kind of "inner exile". The workload has taken much time and consideration away from family and domestic undertakings. This has been a major challenge to my closest family. However, Randi has brought with her experience from her Sámi home, with a father having to be much away to *birget* (to maintain) his household. In addition to her own professional undertakings she has developed the adminstrative systems of our every day life a lot the recent years. John Reidar, Bernt Henrik and Inga Marie have had to manage more by themselves, and everybody is bored to see me with the laptop. Even though they all have encouraged me and helped me when they could. I appreciate that very much and look forward to share more of their time.

Narvik, January, 2000

Jan Åge Riseth

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Summary

Background

The Sámi is recognized as the indigenous people of Northern and Middle Fennoscandia. Sapmi, Sámiland, covers middle and northern Norway, northern Sweden and northern Finland and the Kola Peninsula of Russia. The Sámi people, once autonomous, is currently an ethnic minority in all four nation states.This is a study of the development of the reindeer management branch in the Norwegian part of Sapmi, Sámiland. Sámi reindeer management covers most of the four northernmost counties (Finnmark, Troms, Nordland, and North Trøndelag) and parts of two more (South Trøndelag and Hedmark). Reindeer management has a mixed property regime where the animals are private, but the pastures are communal. The Sámi have lived off the reindeer from prehistoric times. During the preceding century the production system has changed from subsistence pastoralism to a motorized and market-oriented livelihood.

Much of the change has taken place in the period 1960-1990 parallely with major changes in governmental sector policy. While the regulations still in force at the beginning of the period were designed for a passive liquidation of reindeer pastoralism, the objectives changed during the periods to sustainable and positive development. Parallelly, the Sámi society came under the "protection" of the modern welfare state giving the reindeer managing Sámi access to extended schooling, housing, health care and social security. Politically the step was taken from a limited civil servant rule to integration into a co-management system giving industry representatives a considerable influence over public sector policy. The reform included a regulation act and an main agreement for the industry, and had intensions of. During the same period, the reindeer industry experienced both technological, economical and political changes. Market integration meant both specialization in meat production and a high degree of purchasing of both consumer goods and means of production. The industry moved away from a nearly complete dependence on animal and human muscle power to a high degree of dependence on motorized vehicles as snowmobiles, cars, and all-terrain-vehicles (ATVs)..

During the 1980's, the development of Sámi reindeer management proved to be regionally diverse. What is particularly remarkable is that the lichen-rich winter and autumn pastures of Finnmarksvidda have become severely overgrazed. The overgrazing was connected with a considerable growth in total herd size. In addition reindeer management in Finnmark have produced low operating profits. Contrasting this, Sámi reindeer management in Trøndelag stabilized herd size, and also managed to keep operating profits on a high level.

The aim of this study is to try to explain why the major technological change has been connected with overgrazing, resource depletion, and low yield in the region of West Finnmark. The total picture is complex and other studies have pointed to diverse explanations. Generally there seem to be no problem finding variables that at least have some explanatory power. The challenge is to sort out which, in an array of factors, have the greatest influence contributing to the observed outcome.

Theoretical approach

My theoretical approach takes its startpoint in the concepts of *common-pool resources* and *regimes*. Generally resources can be classified by whether they share the characteristics of *rivalry in consumption* and *difficulty of exclusion*. Common-pool resources (CPRs) are, like

public goods, not easily subject to exclusion among the group of users. On the other hand, their consumption is rival, similar to private goods. This constellation of attributes is a potential source of problems as prevention of overuse is non-trivial. For a renewable stock resource, long-term sustenance is dependent on the *appropriation rate* not exceeding the *regeneration rate,* at least on average. Potential CPR-problems can be divided into *harvest problems* which are connected with the flow of resource units out of the CPR (questions as, who is going to harvest the resource, how, and how much?) and *maintenance problems* connected with the provision of the resource stock.

The simplest possible representation of CPR situations can be achieved by noncooperative two-player games. There is a single position held by both players, and both players make a decision simultaneously and independent of the other. Each player has the choice between the strategies Cooperate or Defect. The values assigned to the pay-off parameters for the player will determine whether the outcome will be collectively rational as in the game of *Assurance,* producing a collective benefit given a collective contribution from both players, or collective irrational as in the game of *Prisoners Dilemma.*

Common-pool resources can be operated under various regimes, particularly as common-property or under *open access* which is non-property. In a simple fishery model an optimal individual strategy under open access, would be to increase fishing effort until the resource rent is dissipated at the point where total harvesting cost equals total revenue. For enforceable property rights, including *common property,* the effort level producing maximal profit is found at a point where the slope of total costs equals the tangent of total revenue.

In order to translate complex real world situations, with the variety of properties held by resources and regimes, into situations more accessible for analysis, we need tools. I have chosen to use the transdisciplinary *Instituitional Analysis and Development* (IAD) *framework.* Within this framework actors can be analyzed in action situations, as in a formal game. However, this game is constituted by different real world variables; both ecological factors and institutional variables. For analysis of the interrelations between changes within the production system and institutional change, I define the concepts *need* and *capacity of coordination.* Possible imbalance between them may create *deficit coordination capacity.* Further I define *capacity of transformation* as the society's ability to create new capacity of coordination when there is a deficit.

In applying the IAD framework perspective on reindeer management CPR problems I found a division between the *production* system the *institutional* system to be advantageous. The focal point of the production system have to be *the interaction of composite production factors,* e.g. pasture geography, pasture-herbivore interaction, and production technology. Elaborating on existing standard models I develop a mathematical *herbivore two-pasture model* as a basis for inference on how reindeer management may adapt to changes in herding and husbandry technology. Assuming that herders invest in new herding technology of reasons external to the model, I predict that they will have two alternatives for how to cover the increased costs. The one option is *herd increase,* while the other is *productivity increase* through new husbandry technology. We denote the first option as an *expansive strategy* as it requires extension of the available pasture , and the second as a *stabilizing strategy* as it focus thew structuring of the existing herd. Specifying externality theory for reindeer management I use the model derived and develop hypotheses on how different factors of nature geography and ecology may influence herder adaption strategies under technological change.

Further I introduce institutional factors considering how they may affect the basic CPR problems. These include the possible effects of missing markets, the traditional regimes of the CPRs. In particular I consider regulatory principles as common basic ideas governing thought and activity in so-called acepahalous societies. Moreover we consider the minority-state encounter and discuss the particular middleman relations which can develop and influence the people's ability to resolve CPR dilemmas.

Research design

The methodological approach chosen is a particular type of comparative analysis selecting observations with particularly high and low levels of the dependent variable for the chosen areas denoted North (West Finnmark) and South (North Trondelag and South Trondelag/Hedmark). The study is exploaratory where the main objective is to focus main patterns. The main part of the data used is already published material. Parts of the material are collected through the author's previous work in the public reindeer management administration. To fill holes in established knowledge specific field work is undertaken. The fieldwork encompass interviews with elderly herders, extension workers and file studies.

In the analysis we consider reindeer management as a system exposed to external influence, particularly that of technological change. In the comparative analysis we observe the outcome of dependent variables as pasture biomass and income and aim to discern how difference in response to similar external influence can be explained by systemspecific explanatory variables. These variables are the naturegeographic and instituional variables developed in the theoretical part.

The analysis is conducted in three stages. First, we set the stage by presenting elements of nature geography, cultural and political history for Sami and Norway up to around 1960. Second, we we focus the interrelations external influence, the CPR situation and the development of the production system by confronting the observed differences between the two regions studied. Third, we turn to the problem of explaining why North and South has adapted so differently to the similar external pressure, focusing the need and capacity of coordination and the full set of explanatory variables. That includes comparing each factor and testing every hypothesis against our empiric material. Comparing the effects of different factors we aim to discern possible differences of importance for the explanatory factors.

Empirical analysis

Sapmi, as a geographical area, is far more heterogeneous than most northern landscapes, and well suited for reindeer; particularly Finnmark with highly accessible lichen pastures at winter. The Sámi reindeer culture is ancient and has been through a number of transformations through the centuries, so also the type of reindeer management. The latest phase of reindeer pastoralism up to the 1960's also perform some regional variation. The institutions of the Sámi herding society can be described in terms of regulatory principles and rules-in-use and seem to be fairly well adapted to the requirements in the period up to the major technological shifts in the latest third of the 20th century. We found that the traditional position of the Sámi reindeer herder to be near to the one of a full co-owner as a de facto position.

From the latest part of the 19th century and to the period after the Second World War an ideology based on Social Darwinism dominated governmental policy towards the Sámi, as well in Norway as in Sweden. Reindeer management was considered inferior and imposed to give way for agricultural expansion by the neighboring peoples. *Contrasting the internal de facto position, Sami reindeer herders were de jure treated as nothing more than authorized users.* The Sami organized; and started to achieve some progress in the postwar period.

For the period from the 1960's on the South contrasts with the North in that it has stabilized pasture utilization and developed high income. External influence, public policy included, has mainly been the same for both the North and the South. We have inquired the development of the production systems in the two regions. Generally the snowmobile introduction started a fundamental change in herding technique which to a great extent solved the control problems of the postwar period, which had been most serious in the South. On the other hand, the technological development put reindeer management in a potential cost-price squeeze which led to two possible responses: (1) *herd expansion* or (2) *productivity increase.* If the first option were chosen, herd size would at some stage confront resource limitations, leading to an increased resource competition. If the second option were chosen, the full utilization of the potential would require a change in cooperation which to some extent would break down the traditional division between herding and husbandry practice.

Empirically we found a distinctly different development pattern in the North and South regions where the main choice of the North was *herd expansionism,* and the main one of the South was *productivity increase.* Further while the South situation seems to resemble the game of Assurance, the North situation seems nearer to that of Prisoners Dilemma. For the North an analysis of the internal development substantiates a complex CPR problem where herders having their summer pastures most adjacent to fall pastures were the winners in a competetive overgrazing of the lichen pastures.

In our analysis of the factors need and capacity of cooperation we found that the two regions seemed to have clearly different development paths, as *the South seemed have had a deficit capacity of coordination in the 1960's, while the North as a contrast seemed to have developed such a deficit during the following decades.* During this analysis we singled out a pair of physical features on the need side, summer pasture limitation and large scale commons in an open landscape. On the capacity side, three institutional factors, all connected to the functionality of the co-management system established. The presence of the two institutional factors; mutual trust herders-extension workers and appropriateness of the institutional system seem to be the outcome of societal use of capacity of transformation; which seem to have been used in the South. This seems to have contributed to a situation based on conditioned strategies. A third institutional factor; interest in the malfunction of the co-management system may have restricted the use of capacity of transformation in the North. Thus, while the South seems to have created new capacity of coordination, while the North has not, at least not in a sufficient degree. It may be the case that dominant strategies have made existing capacity of transformation more or less irrelevant.

The most important factors seem to have been *the physical features of the pastures, and the capacity for transformation and its use.* The natural conditions for adapting to the technological change seem to have been more in favor of stabilizing strategies in the South. Further the South Sámi were also better prepared than their fellows in the North. In addition; winners of the North pasture competition and the setting itself, might have influenced the remainder of the herding society not to take actions against overgrazing.

Sammendrag

Bakgrunn

Samene er anerkjent som urbefolkninga på Nordkalotten. Mens de en gang i tida var et selvstendig folk, er de nå en etnisk minoritet i fire nasjonalstater; Norge, Sverige, Finland og Russland. Dette er en studie av utviklinga innen reindrifta i den norske delen av *Sapmi*, Sameland. Samisk reindrift i Norge dekker det meste av landarealet til de nordnorske fylkene og Nord-Trøndelag, samt deler av Sør-Trøndelag og Hedmark. Reindrifta har et eiendomsregime hvor dyra er private, men beitet er felles.

Samene har levd av reinsdyr helt fra førhistorisk tid. I løpet av det hundreåret som nettopp er avslutta, har produksjonssystemet endra seg fra subsistensorientert pastoralisme til ei motorisert og markedsorientert næring. Mye av endringene er kommet i perioden 1960 til 1990 sammen med endringer i næringspolitikken. Mens lovverket som fremdeles gjaldt fra starten av perioden hadde som opprinnelig målsetting å avvikle hele næringa, ble det i løpet av perioden utvikla målsettinger om langsiktig ressursbruk og positiv utvikling. Samtidig med dette kom det samiske samfunnet inn under velferdsstatens ordninger med adgang til bedre skolegang, husvære, helsestell og sosiale forsikringsordninger. Politisk tok næringa skrittet fra et begrensa forvaltningsstyre til et medforvaltningssystem som ga næringas representanter innflytelse på sektorpolitikken.

I løpet av denne perioden har reindrifta blitt utsatt for både tekniske, økonomiske og politiske endringer. Markedsintegrasjon betydde både spesialisering på kjøttproduksjon og betydelig overgang til kjøp av både levnetsmidler og produksjonsmidler. Næringa utvikla seg vekk fra å være så godt som fullstendig avhengig av dyrs og menneskers muskelkraft til høg avhengighet av motoriserte hjelpemidler som snøskutere, biler og terrengkjøretøyer.

I løpet av 1980-åra viste det seg at utviklinga i næringa skulle bli ulik i landsdelene. Det er påfallende at de lavrike vinter- og høstbeitene på Finnamrksvidda er blitt alvorlig overbeita. Overbeitinga har sammenheng med en betydelig vekst i totalt reinantall. I tillegg kommer at reindrifta i Finnmark har gitt lågt driftsoverskudd. Til forskjell fra dette har den samiske reindrifta i Trøndelag stabilsert reinantallet og klart å holde et høgt og stabilt driftsoverskudd.

Målet med denne studien er å prøve å forklare hvorfor den store tekniske endringa kan knyttes til overbeiting og lågt utbytte i Vest-Finnmark. Toatalbildet er komplekst og andre undersøkelser har gitt forskjellige forklaringer. Generelt ser det ut til at det ikke er problemer med å finne variabler som i hvertfall har en viss forklaringskraft. Utfordringa er å finne hvilke av en rekke faktorer, som har størst innflytelse på det vi kan observere.

Teoretisk tilnærming

Teoretisk tar jeg utgangspunkt i begrepene *fellesressurser* og *regimer*. Generelt kan ressurser klassifiseres etter hvorvidt forbruk av dem er rivaliserende og om man kan eksludere andre fra bruken av dem. Fellesressurser er, som offentlige goder, ikke lette å ekskludere andre brukere fra. På den annen side er forbruket av dem rivaliserende; slik som for private goder. Denne koplingen av egenskaper kan være problematisk, da det ikke er lett å forbygge overforbruk. For en fornybar ressurs, er langsiktig bevaring av ressursen avhengig av at

ressursuttaket ikke er større enn ressurstilgangen, i hvert fall i gjennomsnitt. Potensielle fellesressursproblemer kan deles i høstingsproblemer og vedlikeholdsproblemer.

Den enklest mulige framstillinga av fellesressurssituasjoner kan vi få ved ikke-kooperativ spillteori for 2 spillere. Begge spillerne har samme posisjon og tar sin beslutning samtidig og uavhengig av hverandre. Begge spillere har valget mellom strategiene Samarbeide eller Svikte. Verdiene knyttet til hver av spillernes belønningsmatriser vil bestemme om utfallet blir kollektivt rasjonelt, som i Assuranse; som gir felles utbytte av et felles bidrag fra spillerne, eller kollektivt irrasjonelt, som i Fangens Dilemma.

Fellesressurser kan forvaltes av ulike regimer, særlig som *sameie* eller som *fri høsting*, som er ikke-eiendom. I en enkel fiskerimodell er en optimal individuell strategi under fri høsting å øke fangstinnsatsen inntil ressursrenta er uttømt ved det punktet totale fangstkostnader tilsvarer total fangstverdi. For effektive eiendomsregimer, som sameie, vil en finne den fangstinnsatsen som gir maksimal profitt, ved et punkt som hvor helningen på kostnadskurven tilsvarer tangenten på fangstverdien.

For å kunne oversette komplekse situasjoner fra den virkelige verden, med det mangfoldet av egenskaper ressurser og regimer har, til situasjoner som er mer tilgjengelige for analyse, trenger vi redskaper. Jeg har valgt å bruke det tverrfaglige "IAD framework". Innenfor denne rammen kan en analysere aktører i handlingssituasjoner, som i et formelt spill. Spillsituasjonen er imidlertid dannet av variabler fra den virkelige verden, både økologiske og institusjonelle. For analyse av sammenhengene mellom produksjonssystem og institusjonell endring har jeg definert begrepene *koordineringsbehov* og *–kapasitet*. Ubalanse mellom dem kan skape koordineringsmangel. Videre definerer jeg *omdanningskapasitet* som samfunnets evne til å skape ny koordineringskapasitet ved behov.

Ved å bruke dette perspektivet på reindriftas fellessressursproblemer, har jeg funnet det nyttig å dele mellom produksjonsystemet og institusjonene. Fokus for produksjonssystemet er sammenhengen mellom de sammensatte produksjonsfaktorene; beitegeografi, dyr-beite-sammenheng og produksjonsteknologi. Ved å videreutvikle eksisterende modeller har jeg satt sammen en planteeter-to-beitemodell som grunnlag for slutninger om hvordan reindrifta vil tilpasse seg endringer i gjete- og husdyrbruksteknologi. Under forutsetning av at reineierne investerer i ny gjeteteknikk på grunn av forhold som ligger utenfor modellen, kommer jeg til at de har to alternativer for å dekke kostnadsøkningen. Den ene er å øke flokkstørrelsen, mens den andre er å øke produktiviteten gjennom ny husdyrbruksteknologi. Vi kaller den første av dem en *ekspansiv strategi* siden den krever utvidelse av beitearealet og den andre en *stabiliserende strategi* siden den fokuserer på utnyttelse av eksisterende flokk. Ved å spesifisere eksternalitetsteori for reindrifta bruker jeg modellen til å utvikle hypoteser om hvordan ulike naturgrunnlagsfaktorer påvirker reineiernes tilpasningsstrategier under teknologisk endring.

Videre fører jeg inn institusjonelle faktorer og vurderer hvordan de påvirker fellesressursproblemer. Dette omfatter mulige effekter av fravær av markeder, og hvordan tradisjonelle regimer virker i forhold til fellesressurser; spesielt ser på jeg hvordan særegne reguleringsprinsipper styrer menneskenes tanker og handlinger i samfunn uten toppledelse. Videre ser jeg på møtet mellom minoriet og statssamfun og diskuterer hvordan mellommansroller kan utvikle og påvirke folks muligheter til å løse fellesressursproblemer.

Forskningsopplegg

Den metodiske tilnærminga en en spesiell type komparativ analyse som velger observasjoner ut fra høge og låge verdier på den avhengige variable i de valgte områdene Nord (Vest-Finnmark) og Sør (Nord-Trøndelag og Sør-Trøndelag/Hedmark). Studien er eksplorerende med mål å fokusere på hovedmønstre. Det meste av datatilfanget er allerede publisert materiale. Deler av det er samlet gjennom forfatterens tidligere arbeid i den offentlige reindriftsforvaltninga. For å fylle huller i eksisterende kunnskap er det gjort feltarbeid som omfatter intervjuer med eldre reindriftssamer samt arkivstudier.

I analysen ser vi på reindrifta som et system utsatt for ytre påvirkning, spesielt teknisk endring. I den komparative analysen ser vi på utfallet for de avhengige variable som biomasse av beite, samt inntekt og prøver å finne ut hvordan ulik respons på tilsvarende påvrikning kan bli forklart med systemspesifikke forklaringsvariable. Disse variablene er de naturgeografiske og institusjonelle variablene jeg utvikla i teoridelen.

Analysen gjennomføres i 3 deler. Først setter vi scenen med geografi og historie fram til 1960-åra. Så fokuserer vi sammenhengen mellom ekstern påvirkning, situasjonen vi kan se for fellesressursen, og utviklinga av produksjonssystemet, ved å se på forskjellene mellom de to områdene vi studerer. Til sist prøver vi å forklare hvorfor Nord og Sør har utvikla seg så forskjellig ved å fokusere på koordineringsbehov og kapasitet og hele settet av forklaringsvariable. Det innebærer at vi konfronterer hver faktor og hypotese med det empiriske materialet. Ved å sammenlikne virkningene av forskjellige faktorer prøver vi å forklare forskjeller i betydning for forklaringsvariablene.

Empirisk analyse

Sapmi er geografisk mer heterogent enn nordområder flest, og velegna for reinsdyr; spesielt Finnmark med sine rike og lett-tilgjengelige lavbeiter. Samisk kultur er gammel og har gått i gjennom mange forandringer – det har også reindrifta gjort. Opp mot 1960 var det en del variasjon innen reinnomadismen. De tradisjonelle institusjone var i hovedsak godt tilpassa til krava de ble stilt ovenfor, inntil siste tredel av det tjuende århundret. Vi kom til at reineierne var nært en *de facto* posisjon som sameiere.

Fra siste del av 1800-tallet til tida etter 2. Verdenskrig, hadde sosialdarwinistisk ideologi betydeleig innflytelse på myndighetenes samepolitikk i både Norge og Sverige. Reindrifta ble ansett mindreverdig og ble pålagt å vike for jordbrukets ekspansjon. I kontrast til sin faktiske eierrådighet ble reindrifta i lovverket bare tilgodesett med såkalt "tålt bruk". I etterkrigstida organiserte samene seg og begynte å gjøre visse framskritt.

For perioden fra 1960-åra, skiller Sør seg fra Nord med stabil beitetilpasning og høg inntekt, selv om den ytre påvirkninga i hovedtrekk har vært lik i begge områder. Snøskuteren innledet en revolusjon i gjeteteknikk. I sør løste den de problemene med kontroll over flokken, som hadde forkommet i etterkrigstida. I tillegg førte teknifiseringen til en kostandsøkning som enten kunne løses med flokkøkning eller produktivitetsvekst. Flokkøkning vil før eller siden møte ressursbeskrankning som da måtte føre til økt konkurranse. Det andre alternativet ville kreve økt samarbeid mellom reineierne.

Vi fant klar forskjell på Nord og Sør da hovedvalget i Nord var flokkøkning,mens det i Sør var produktivitetsvekst. Sør-situsjonen minner om spillet Assuranse, mens Nord-situasjonen minner mer om Fangens Dilemma. En analyse av den indre utviklinga i Nord viste en kompleks eksternalitet der vinnerne var de gruppene av reindriftssamer som var best plassert for å kunne "tjuvbeite" på de felles lavbeitene.

I analysen er vi kommet til at mens Sør så ut til å ha hatt mangelfull koordineringskapasitet i 1960-åra, så har Nord utvikla enn slik tilstand, de siste årtiene.

Gjennom analysen har vi funnet fram til et par fysiske faktorer på behovsida; sommerbeitebegrensing og forekomsten av store områder med åpent/grenseløst landskap, som særlig viktige. På kapasitetssida har vi funnet 3 institusjonelle faktorer, som alle har sammenheng med det nyetablerte styringssystemet. Tilstedeværelsen av 2 av disse; gjensidig tillit mellom reineierne og veiledningstjenesten samt at styringssystemet ble opplevd som hensiktsmessig, ser ut til å ha vært resultatet av at samfunnets transformasjonskapasitet ble brukt i Sør. Dette ser ut til å ha fremmet betingede strategier.

I Nord ser det ut til at en tredje institusjonell faktor; vinnerne i "kappbeitinga" har hatt egeninteresse av at styringsystemet ikke fungerte, kan ha begrensa bruken av samfunnets omdanningskapasitet i Nord. Bruk av dominate strategier kan defor ha gjort denne kapasiteten delvis irrelevant.

Totalt ser de viktigste faktorene ut til å være *den fysiske utforminga av beiteområdene, samfunnets transformasjonskapasitet og bruken av den.* Naturforholdene er bedre tilpassa stabiliserende strategier i Sør enn i Nord, samt at sørsamene var bedre forberedt. I tillegg har vinnerne i beitekonkuransen i Nord og selve konkurransesituasjonen kan også ha påvirka reindriftsamfunnet der til ikke å handle i forhold til overbeitinga.

Chapter 1
Introduction

This study is an attempt to explore a contemporary resource problem; semi-domestic reindeer overgrazing of vulnerable lichen pastures in the heartland of the subarctic tundra of Sapmi, Sámiland, on the territory of Finnmark, Norway. The overgrazing has taken place in the wake of a technological revolution, and an era of social reform, having its core period about 1960-1990. Though the Norwegian Government and the Association of Norwegian Reindeer Herding Sámi (NRL) have taken measures, and some progress is achieved, the situation is only partly under control; the resource base of a traditional industry may still be jeopardized. In this situation a thorough analysis of the background for the current crisis can be academically interesting and may also provide useful insights with policy implications. Before we explore the problem further we need some background about nature, people and history.

1.1 A Circumpolar and Historical Context of Reindeer and Sámi

What we in Fennoscandia know as Reindeer and in America as Caribou, are parts of the one species, *Rangifer tarandus*, which has a circumpolar extension in the North. The species belongs to the tundra and the taiga and has developed subspecies and races adapted to particular environments; altogether seven subspecies is described, cf. Figure 1.1. One of its most important properties is its ability to survive winter on lichens under snow cover (e.g. *Cladonia spp.* and *Cetraria spp.)* or tree-hanging lichens like, for example, *Alectoria sarmentosa* and *Bryoria fuscescens*. In Fennoscandia and the North of Russia we have the subspecies of *Rangifer tarandus tarandus*. The reindeer is the only native domestic animal of Fennoscandia; others have immigrated from the South with human support.

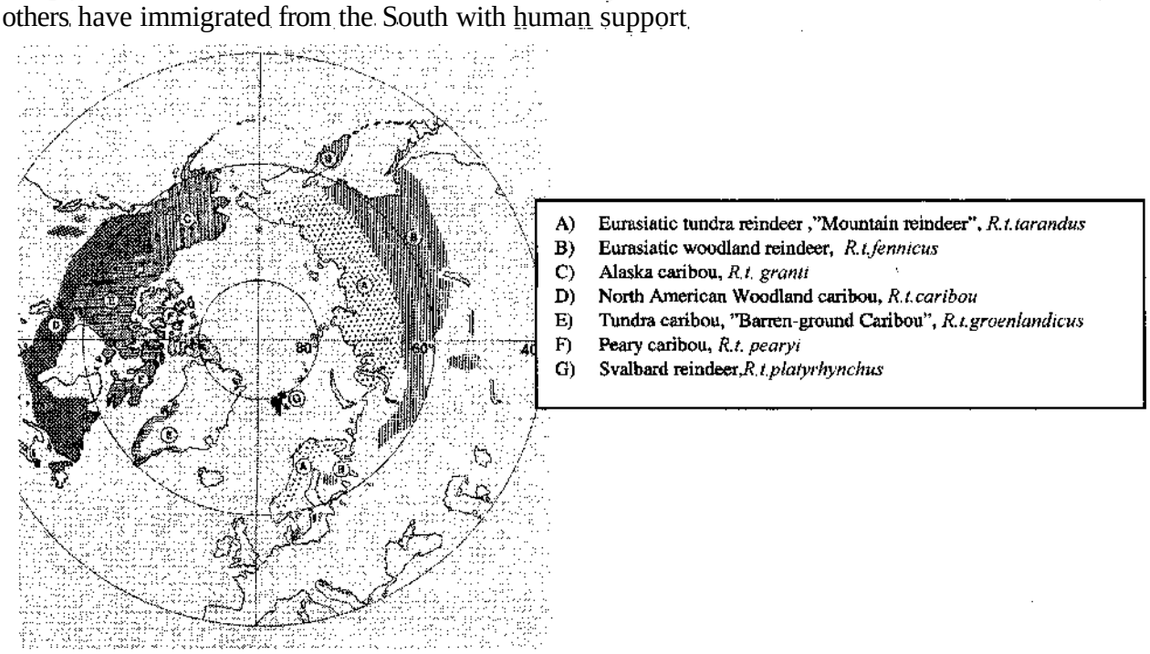
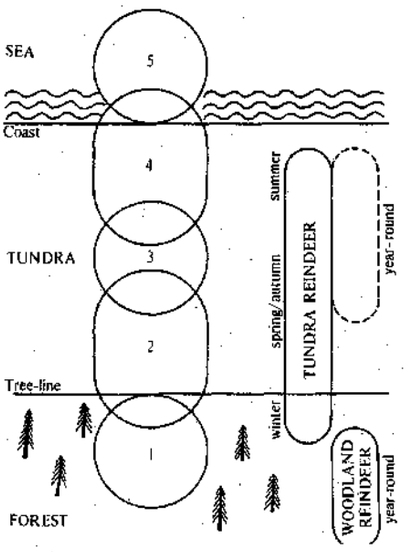


Figure 1.1. Circumpolar extension of Rangifer tarandus subspecies.
Source: Tyler and Røed, 1993:4.

Both in prehistoric, historic and current time, humans through hunting, pastoralism and as a modern industry utilize reindeer and caribou. Covering the ecological zones of arctic coast, tundra and forest Ingold (1980:12-15) has described a series of arctic and subarctic subsistence cycles, cf. Figure 1.2.



In relation to the major ecological zones of forest, tundra and arctic coast Ingold (1981:12-16) has identified 5 different *circumboreal reindeer subsistence cycles:* (1) a year-round woodland adaptation, (2) a forest- tundra adaptation, (3) an exclusive tundra adaptation, (4) a coast-tundra adaptation and (5) maritime settlements being a demographic reservoir for people in the interior. Note that altitude may be ecologically equivalent to latitude as migrating from a forested valley to naked mountains may be similar to a movement from tundra to taiga. Possible pastoral adaptations are depicted on the right-hand-side of the figure, all known in Fennoscandia (cf. Lenvik, 1978).

Figure 1.2. Arctic and subarctic subsistence cycles. Source: Ingold, 1980:13

Chiefly reindeer and caribou have been and still are a source of living for indigenous peoples, e.g. 26 peoples in Russia (Eidlitz, 1979). Most of these peoples still live a rather hard pre-industrial life, mainly subsisting on reindeer and harvesting nature with very limited access to, in western societies considered, goods of "modern civilization". The clearest exception from this is probably the Sámi people, having their homeland, Sapmi, in Fennoscandia and Kola Peninsula. The Sámi today, the Kola Sámi being an exception, is to a large extent an integrated part of the Nordic welfare societies sharing the modern living standard of the majority peoples. However, neither Sami history nor Sami present is free of problems. Traditional Sámiland two Milleniums ago probably covered most of Northern and Middle Scandinavia, whole Finland, Karelia and the whole Kola Peninsula, cf. Figure 1.3.

Figure 1.3. The extension of Sapmi 2000 years ago (left) and today (right).
Source: Jernsletten andSolbakk (1983:15)

The Sámi people, once autonomous, are currently an ethnic minority in all four nation states.

The Sámi is, however, officially recognized as the indigenous people of Northern Fennoscandia. Throughout the now closing Millenium Sapmi has gradually been colonized by the nation-states of the current Norway, Sweden, Finland and Russia and finally incorporated within the state borders established in the 18th and the 19th centuries (cf. Figure 1.3). During the eighteenth and nineteenth centuries, there were several waves of settlement expansion into Sámi areas. In the last decades of the nineteenth century, a new ideology (social Darwinism) achieved supremacy in the then twin kingdoms of Norway-Sweden. Sámi reindeer herd management was considered *inferior* to the majority peoples' expanding agriculture. Legislation from the last decades of the 19th century and the first decades of the 20th century had clear objectives of limiting the extent and rights of reindeer management. The offensive against reindeer management was a part of a general offensive towards Sámi culture and language, both in Norway and Sweden. It lasted down to the post-war era. In Norway the Act of Reindeer Herd Management of 1933, in force until 1979, was based upon a governmental attitude considering pastoralism as *a dying way of life*. It should be allowed to exist until vanishing, the presumption being that it would give way in conflict with agriculture (Indredepartementet, 1904).

1.2. Technological Change and Modernization

However, reindeer pastoralism proved to be very vital both in Sweden and in Norway. This was the case in spite of both negative governmental attitudes and resource pressure from agriculture. Moreover the herders life started to change, particularly after the Second World War, and more rapidly from the 1960's on. Modernization also reached the mountains of Sapmi. Particularly important, and interconnected, processes were (1) a gradual sedentarization, (2) a change from being a universal way of life towards becoming a mere occupation and (3) a growing motorization of the daily work operations. This was followed with more general societal processes as (4) extension of external markets for reindeer products, production inputs and consumption goods and (5) integration into the Nordic welfare societies with obligatory schooling, social welfare, industry subsidies and public labor markets.

Among these processes the technological change from full dependence of animal and human muscle to an increasingly higher dependence on motorized vehicles as snowmobiles, cars, and all terrain vehicles (ATVs) seems to have had a particular triggering effect speeding other economic and societal processes in the herding society. We may speak of a *technological revolution* in herder societies. This revolution started with the introduction of — and rapid switch to — the snowmobile and was widespread in the circumpolar North, having extensive impacts on as well Sámi as Inuit societies (Moran, 1979:132, cf. Pelto, 1973:151). However, the revolution followed different courses in different countries and regions.

Our topic is Sámi reindeer management within Norway. Gradual changes in governmental attitudes in the Postwar Era brought forward minor efforts providing some support to both reindeer management and to Sámi culture in a broader sense. This included, during the 1960's, support to the establishment of slaughterhouses, public establishment of as well research and extension services as a technical college. The changes in Norwegian public policy had become considerable at the end of the 1970's. The regulations intended for passive liquidation of reindeer pastoralism were gradually abolished. An extensive co-management reform evolved, partly in the 1960's but mainly during the 1970's, and implemented mainly

during the 1980's. The reform had two core elements; (1) a main agreement for the industry (Landbruksdepartementet, 1976), and (2) a new regulation act. The agreement was a result of negotiations and signed by the Ministry of Agriculture and the Association of Norwegian Reindeer Herding Sámi (NRL) in 1976 and approved by Stortinget (the parliament). Stortinget approved the act after public inquiry. The aims of the institutional reform included: (1) sustainable resource use, (2) safe income and living conditions for the herders, (3) ensuring herders' property rights, and (4) maintaining reindeer management as a part of the Sámi culture (Norges Lover, 1978, Landbruksdepartementet, 1976b).

The modernization continued the remainder of the 20th century. In the period 1960-1990 the Sámi reindeer industry in Norway experienced extensive *technological, economical and political* changes. Market integration included both specialized meat production and a high degree of purchase of both consumer goods and means of production. Politically the step was taken from a limited civil servant rule to integration into a co-management system giving industry representatives a considerable influence over public sector policy. Parallel to this, the Sámi society came under the "protection" of the modern welfare state giving the reindeer Sámi access to extended schooling, housing, health care and social security. The Act of Reindeer Management (Lov om reindrift) specifies property rights and a governance system with boards on several levels (Norges Lover, 1978). Administratively the area with recognized usufruct rights is divided into six Reindeer Pasture Areas, cf. Figure 1.4.

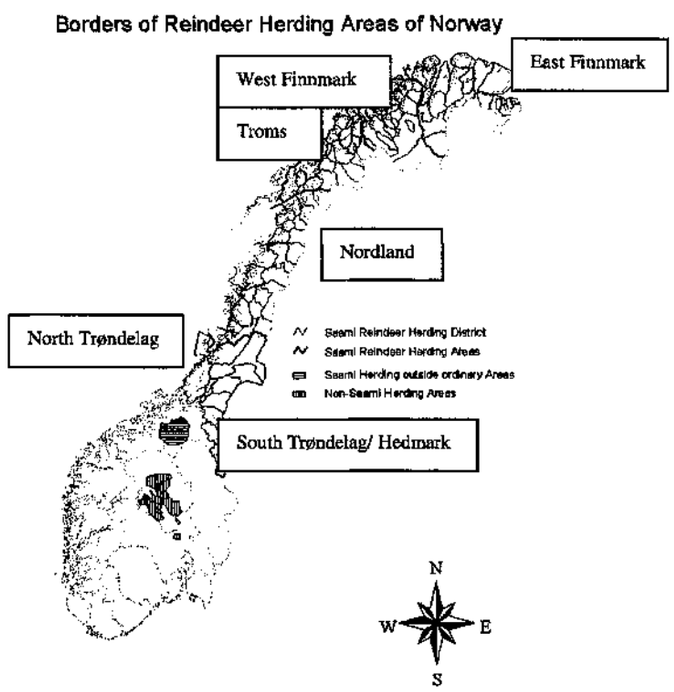


Figure 1.4.The area of Sámi Reindeer Pasture Rights divided into 6 Reindeer Pasture Areas. Source: Berge (1998:8).

Sámi reindeer management has usufruct rights over about 40 % of the Norwegian land surface, covering most of the four northernmost counties (Finnmark, Troms, Nordland, and North Tr0ndelag) and parts of two more (South Tr0ndelag and Hedmark). Contemporary Sámi reindeer management in Norway consists of approximately 3,300 persons who own about 210,000 reindeer (Reindriftsforvaltningen, 1998).

1.3 The Contemporary Finnmark Resource Problem

However, despite national reforms, the development of Sámi reindeer management has proved to be regionally very diverse. Clearly remarkable reindeer management in Finnmark, having about two thirds of the industry, during the 1980's, have not had the expected positive development. First, the lichen-rich winter and autumn pastures of Finnmarksvidda have become severely overgrazed; lichens are *slow-growing perennials,* which should not be grazed more than the annual increment to sustain their current pasture capacity. The registered overgrazing is connected with *a considerable growth in herd size.* Figure 1.5 depicts the total herd size for Finnmark 1950-1998 together with the results of a 1967 pasture capacity assessment.

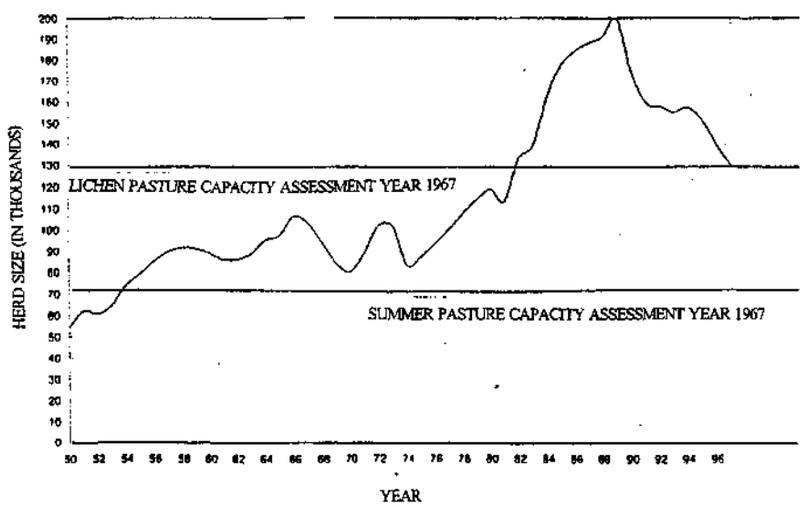


Figure 1.5. Finnmark reindeer herd size 1950-1998 compared to assessed pasture capacities. Source: Landbruksdepartementet (1998:13)

The aggregated herd size of Finnmark has: (1)more than doubled from the general level of the 1960's and the early 1970's to till 1990, (2)been greater then the summer pasture capacity for most of the period, (3)been greater than the lichen pasture capacity since 1982, and (4) been decreasing since 1990. Direct assessments substantiate a process of lichenbiomass reduction, cf. Table 1.1.

Table 1.1.State of lichen pastures at Finnmarksvidda 1973-1996.

	State of the Lichen Pastures		
Year	Fully intact[1)]	Overgrazed[2)]	Heavily overgrazed[3)]
1973	85%	15%	
1980	68%	32%	
1987/88	15%	56%	29%
1996	8%	42%	50%

[1)] Grazing has not reduced standing crop of lichen.
[2)] Grazing have reduced standing crop considerably and the lichen growth is clearly reduced
[3)] The standing crop is heavily reduced.
Definitions of [1)], [2)], and [3)] follow Lyftingsmo (1965) cf. Prestbakmo (1994:3-4).

Source: Landbruksdepartementet (1998), Johansen and Karlsen, 1998.

We note that the reduction is extensive, and that the numbers indicate an accelerating overgrazing during the 1980's. This is closely correlated to the herd size growth of the same decade. Studying the table we note that the overgrazing has continued also in the 1990's, even though total herd size is reduced considerably. The herd increase and overgrazing is remarkable insofar as herd size in other regions including North Tr0ndelag and South Tr0ndelag/Hedmark have been relatively stable.

Another feature of reindeer management in Finnmark is that the industry has produced a low and decreasing operating profit, which also is in clear contrast with the development in Tr0ndelag. Table l .2 compares operating profit per man-year for Finnmark and Trondelag.

Table 1.2. Operating profit[1] per man-year for Finnmark[2] and Trøndelag[3] 1980-1992. Numbers in 1000 NOK. 1 NOK ≈ $ 0.15. Fixed (1990) prices.

Operating profit	Finnmark	Trøndelag
1980	86.9	103.3
1982	36.8	140.7
1984	22.7	83
1986	16.9	88.3
1988	40.4	58.5
1990	-8.5	115.5
1992	15.5	95.3

[1] Operating profit = operating income – operating cost (fixed costs included).
[2] East Finnmark plus West Finnmark.
[3] North Trøndelag plus South Trøndelag/Hedmark

Source: Økonomisk Utvalg (1981- 1993).

We note that while operating profit per man-year in Tr0ndelag is rather stable at a relatively high level, in Finnmark the level is clearly lower and decreasing. For 1990 and 1992 the return to labor and equityper man-year is for Finnmark NOK 25,800 and 30,700 (in 1990-NOK) respectively. The corresponding numbers for Tr0ndelag are NOK 197,400 and 169,600. The leader of the Association of Norwegian Reindeer Herding Sámi (NRL), Odd Erling Smuk, described the situation, for West Finnmark and the adjacent part of East Finnmark (Karasjok), this way in 1988:

> "The reindeer management" ……. "is in the process of becoming a state-financed industry. The total operating profit of the industry in these regions is approaching zero, and the development the recent years has rapidly gone the wrong way. That is, the reindeer managing Sámi soon is living off state subsidies only" (Smuk, 1988, my translation; cf. Brox 1989:157).

The combined situation of a relatively dramatic overgrazing and low and decreasing yield in Finnmark is a puzzle. This area has namely from nature clearly the best living conditions for reindeer in Norway, with safe and stable lichen-rich winter pastures. Maybe it is the best within the whole traditional Sapmi. *Why is the best area exposed to the most serious problems while other areas seem to adapt far better to the same changes?*

The answer to this question seems to be essential in order to prevent future resource problems. The topic is highly disputed both publicly and between academicians. The answer is not obvious, but must be found in the interface between natural and social science. It is challenging to me both as an interdisciplinary researcher and as a Former State agent within the field of reindeer management. In fact it has bothered me over the years since I abandoned the service.

As a general problem of resource management it also seems to be relevant for a wider audience. Thus the aim of this study is to try to explain *why the technological revolution of reindeer management has been connected with overgrazing, resource depletion, and low yield in Finnmark* My focus will, however, be the area of *West Finnmark,* mainly because the development pattern there seems to be the clearest (cf. Chapter 5), but also as the statistics for this area is the most accessible.

1.4 Possible Explanations and the Chosen Theoretical Approach

In the academic, but also the public debate there are a variety of clearly expressed viewpoints on how the observed development should be explained. The social scientist Ottar Brox (1989, 1993) builds on the economic modeling of H. Scott Gordon (1954) to describe the herders' zero-sum game, which depletes the rent, through overgrazing. The anthropologist Robert Paine (1992, 1993, and 1994) asserts that problems are created by the political efforts undertaken to prevent the same problems and blames the state for removing responsibility from the herders.

The anthropologist Ivar Bjorklund (1990) maintains that the authorities neglect the mediator role of the Sámi siida institution, while the social scientists Ragnar Nilsen and Jens H. Mosli (1994) focus on the changing economic role of the household. The agroeconomist Marit Fjellheim (1986) calls attention to internal inconsistency of the regulation system, while the civil agronomists Ansgar Kosmo and Dag Lenvik (1985) hold that the design of the regulation system does not take into consideration the economic goals of the herders. All these authors seem to make good points, but one can ask whether they provide the whole story or what is most important. The challenge is to sort out which, in an array of interconnected factors, have the greatest influence contributing to the observed outcome.

In economics the *management regime* is often considered to be decisive for the adaptation of resource users. However, in practical analysis the challenge can be to find which regime is really in place. That means, how the regime function is not independent of neither features of the resource base or properties of both the community of resources users and the society more in general. This implies that such a complex problem hardly can be successfully analyzed within one single body of theory. We rather need to combine theories of different disciplinary origin and integrate use them to derive a set of hypotheses that can cover the main factors working. In order to include both ecological and institutional factors in my analysis, I have chosen to use the so-called Institutional Analysis and Development (IAD) framework (cf. Ostrom, Gardner and Walker, 1994) as my main approach. This approach is metatheoretical and allows for the combined use of both elements of ecology, resource economics and social sciences in the development of an interdisciplinary theory.

The dynamics of the resource base is essential; the real world interconnections are complex, but we need to search for basic conditions influencing animal - pasture stability and how this affects the whole set of production factors. Mathematical modeling can be a useful tool in this respect. The management regime is very important; reindeer management is governed by a peculiar regime; *mixes of individual and common property, where the animals are individual property but herding and pasture are communal*

Generally we know that common pool resources, like reindeer pastures, can be managed either by some kind of regulatory mechanism, a common property regime, or can be unregulated as

open access. When the flow of resource appropriation is lower than the regeneration rate, open access can be compatible with sustainable resource use. Each reindeer herder makes decisions of pasture appropriation individually, though they can affect the conditions for the others. A management regime includes some degree of collective coordination of individual choices. The regime combination of reindeer management represents a particular challenge insofar as individual and collective interests are confronted within the combination-regime. Moreover a regime does not exist in a social vacuum; we need to inquire how fundamental rules and values in the herder society provide standards for morally action and how these are influenced by the surrounding society, particularly when this influence is changing. Here general societal, technological as well as political changes should be considered.

Analyzing a situation where the resource adaptation at one point of time seems to be well balanced, and at another seems to be more or less out of control, requires notions that can reflect changes. I have chosen to consider the contemporary Finnmark situation as a lack of balance between the challenges to and the capacity of the management regime. Such an imbalance may have several possible origins. The emerging motorization increased human control ability over animals, and it is probable that the challenge to the regime increased during the period 1960-1990. The magnitude and development of the coordination capacity is more uncertain. The regime may have been (1) well functioning but lacking additional capacity, (2) disintegrating or (3) the society may have lacked sufficient capacity to transform as the transition from subsistence to a market orientation took place. The imbalance between need and capacity of coordination may have developed already before 1960. It is an entirely empiric matter to determine what the actual source of disproportion in the regime's coordination need and capacity for coordination really has been, whether it results from features of the traditional regime itself or external influences. This must be explored before we can illuminate our main question of explaining the resource development during the period under study.

To discern which factors are of importance, I have chosen to conduct *a comparative study*. This method is particularly suitable for examining differences and similarities over a moderate number of cases. We can thus infer which factors have explanatory power and which have not. For the comparison with West Finnmark the two South Sámi areas of North Trøndelag and South Trøndelag/Hedmark have been chosen. In this study we will thus go through a ladder of steps:

In Chapter 2 I present the general theoretical approach I base my analysis on. After a discussion of potential problems of common-pool resources, I present stylized game theoretical situations of cooperation and defection and introduce optimal individual strategies under different regimes. The main content of the chapter is a presentation of how the so-called IAD framework can be used as a tool to analyze concrete situations of resource use.

Chapter 3 is devoted to the development a specific theory of reindeer management production systems. The main content of the chapter is a discussion of mathematical herbivore pasture models; starting with a one-pasture model and continuing with a two-pasture model. The former is well-known, while the latter is developed here. Both are static equilibrium models. The two-pasture model is used a basis for the discussion *of how the use of the production factor labor is influenced by technological change*. The CPR resource problems from Chapter 2 are re-specified for reindeer management and the chapter ends up by suggesting hypotheses for under which conditions herders will tend to choose herd stabilizing and herd expansive strategies.

In Chapter 4 we study the institutional conditions of reindeer management. First we inquire distinctive properties of traditional herder societies, their resource dependence, relative market independence, and the lack of traditional top leadership. Secondly we consider the state – minority encounter and the institutional implications of the herder society being gradually integrated into external nation-state governance. We derive hypotheses for how institutional features are influenced.

The methodology, focusing comparative method, and the research design chosen for the empirical analysis are presented in Chapter 5. Chapter 6 provides information on the background factors nature geography, cultural and political history, mainly for the period to around 1960.

The direct empirical test of the hypothesis proposed, starts in Chapter 7, which focuses on performance in the period 1960-1990. The North and South CPR situations with respect to the state of the resource and income, are compared in relation to external influences and development of the production system. In Chapter 8 we proceed by comparing the hypotheses and the empirical evidence derived factor by factor. We draw conclusions for which hypotheses seem to have the major power of explanation. The final discussion and conclusion is presented in Chapter 9.

Chapter 2
Analyzing Common-Pool Resource Problems: A Theoretical Approach

In this chapter we will address the general class of problems associated with resources having multiple users. Our problem is about the dynamics between a *resource* and the *regime* that governs the utilization of the resource. To address complex problems, conceptual clarity is important. However, even outstanding theorists (cf. Berkes, 1989) use the confusing notion "common property resources." I follow Bromley (1992:4) in his statement: "There is no such thing as a common property *resource;* there are only resources controlled and managed by different *regimes."* In this chapter we will explore the connection between these concepts. We start out with clarifying some essential properties of the *resource-concept,* and continue emphasizing potential resource problems and how game theory and the IAD Framework can analyze them. As a part of this, we explore *regimes* within the broader concept of *institutions.*

2.1 Resources and Common-Pool Resource Problems

In economic terms, resources are scarce objects that are useful and valuable for humans, either directly or as input in a production process. The value of a resource will change due to changes in information, technology, and institutions, and new scarcities may turn formerly non-valuable goods into valuable resources. Resources are multi-attribute and have, for example, the dimensions of quantity, quality, time, and space (Randall, 1987:12).

The two obviously most important resources for reindeer management are the reindeer and the pastures. Both among the Sámi and other reindeer herding peoples, reindeer are dominantly private objects, while the pastures are usually held in common. However, we also know that other solutions are found in non-Sámi reindeer management — in Jotunheimen in South Norway, for example, both animals and pastures are held in common. Thus, *the regime governing the use of an idiosyncratic resource is not an attribute inherent to the resource itself.* Nevertheless, there is hardly random choice of regimes in reindeer herd management. On the contrary, there seems to be a connection between the physical characteristics of a resource and the regime, which is chosen to govern its use.

Generalizing from this example, we therefore assume *that physical attributes of the resources provide opportunities and constraints for what kind of a regime is possible or suitable.* Ostrom, Gardner and Walker (1994:6) focus on two such general attributes: (1) the *difficulty of excluding individuals from benefiting* from the good and (2) whether there is *rivalry in consumption*[1] or not. Exclusion of potential users can be accomplished either by physical or institutional means, or a combination, but the ease or cost of exclusion varies highly for different goods. E.g., controlling a single animal, or even a herd of reindeer, by herding can be done more easily than controlling the use of a pasture, insofar as that would include potential use by other persons.

[1] Ostrom et al 1994:6 use *degree of subtractability* in the same meaning.

The character of consumption of different goods is also highly variable. When a herder slaughters an animal, every single piece of meat cannot be consumed by more than one user. It is rivalry in consumption. The good of information about the landscape positioning of different herds can on the other hand be used by a number of fellow herders. Arranging these two general attributes in a simple matrix provide us with a very general classification of goods into four broad types: *private goods, public goods, toll* (club) *goods,* and *common-pool resources,* as in Table 2.1.

Table 2.1. A general classification of goods

		RIVALRY IN CONSUMPTION	
		Non-rival	Rival
EASE OF EXCLUSION	Difficult	**Public Goods** (Ex.: Information)	**Common-Pool Resources** (Ex.: Pastures)
	Easy	**Toll (club) Goods** (Ex.: Concerts)	**Private Goods** (Ex.: Reindeer, Snowmobiles)

Source: Ostrom et al., 1994:7

We note that private goods have the attributes of relative ease of exclusion of potential additional users and of non-rivalry in consumption. Public goods are the opposite of private goods in both respects: the consumption is non-rival while exclusion is difficult. *Common-pool resources* (CPRs) are, like public goods, not easily subject to exclusion among the group of users. On the other hand, their consumption is rival, similar to private goods. This constellation of attributes is a potential source of problems. Toll goods, which have the attributes of low rivalry of consumption and ease of exclusion, are not important for the type of problems we consider here.

This typology is not the only possible. Randall (1987:169) uses the concept of *congested goods.* Congested goods have the property of difficulty of exclusion, but can be either non-rival or rival in consumption depending upon the relative degree of utilization of the resources. That is, at low levels of resource utilization congested goods are like public goods, while they at high levels are like CPRs. Examples can be the traffic on a road or also the utilization of a pasture. However, for us the combined situation of rivalry in consumption and difficulty of exclusion involve interesting potential problems that can be analyzed within the CPR concept.

Much of the theoretical interest in common-pool resources (CPRs) is related to the potential problems of their management. CPR problems may appear as *overuse* of the resource or problems with the *maintenance* of the resource. To analyze such problems we need to focus their origin and their properties. Resources can be renewable or non-renewable, but in both cases we must distinguish between the *resource stock,* and *the flow* which can be harvested or appropriated. Exhaustible resources exist as given stocks, while renewable resources are or can be regenerated. Some renewable resources, like solar energy, wave, wind, and geothermal energy, *are flow resources,* for which the total size of the flow is unaffected by the amount of the flow that is harnessed at any point in time.

Biological resources and some other stock resources are *renewable* but *destructible* (cf. Randall,

1987:16); properties sometimes called being *conditioned renewable.* For a renewable stock resource, long-term sustenance is dependent on the *appropriation rate* not exceeding the *regeneration rate,* at least on average. The regeneration rate can be pure natural growth, as for biological systems, or dependent on human maintenance labor, as for example constructed physical systems like an irrigation facility. For humanly modified ecosystems, regeneration will often be partly dependent on natural conditions and partly on human efforts. For example, in cereal production, the harvest is dependent upon human action, like sowing and fertilization, and on nature's rain and sun.

Potential problems caused directly by the combined existence of *rivalry in consumption* and *difficulty of exclusion* are known as *externalities,* or external effects. They occur whenever *the production or consumption decisions of an actor affect the utility of another actor without compensation* (negative external effect) or payment (positive external effect) *corresponding to the transferred values* (cf. Perman, Ma and McGilvray, 1996:95). In a fishery, a negative externality can be one user's fishing reducing his co-user's potential for fishing. Using a metaphor from agriculture, we can say that for many biological resources, and also for some physical resources, sowing is as important as harvesting. For renewable stock resources, the need for regeneration can, in combination with the difficulty of exclusion, be the source of a related class of problems known *as free riding.* A free rider is someone who conceals his or her preferences for a good in order to *enjoy the benefits without paying for them* (Hanley, Shogren and White, 1997:43). The problem of free riding is known from the public goods literature (cf. Olson, 1965; Samuelson, 1954) and is usually applied for appropriating a resource. I have chosen to use the concept in an extended meaning including *shirking in maintenance activity,* that is; I will also consider persons enjoying the benefits of others maintenance activity without contributing as free riders. Both externalities and free riding can thus impose problems created by one user's actions or lack of action on his or her co-users.

To mirror the connection between different types of problems, let us imagine an irrigation system with a reservoir as an example of a conditioned renewable resource. The main attributes of interest are that the system has an *inflow* (or a source of water), an *outflow* (a sink), and contains a *stock* of water. We intend to use this example to classify different potential problems with respect to their origin and also the time perspective we use.

On basis of their source, one class of problems is related to the inflow, and another class associated with the outflow. The *inflow* class of the problems is related to the creation, maintenance, or improvement of the *resource stock,* that is, the cost of providing the services given by the resource. We denote problems related to the inflow as *maintenance problems*[2]. The source of the problems is individual incentives to be free riders on the maintenance activities of others. The general problem for the CPR user is to find the efficient level of his marginal costs of maintenance, equal to his marginal profit from use. Free riding of user A implies an increase in the costs or a reduction of total returns for user B. If B compensates by increasing his/her contribution, stock level is not affected, but the burden of labor and the outcome of the users can be highly skewed. For example, some users of a computer network may overload disk space but nevertheless be able to carry on if other users delete a greater part of their own files. In a time-independent perspective user A's free riding impose increased costs or reduced income on user

2 Ostrom et al. (1994:9) use the term provision problems.

B. We therefore denote this situation a *problem of skewed maintenance.*

Table 2.2. Potential CPR Problems

	IMPACT ON	
SOURCE	FLOW (Time-independent problems)	STOCK AND FLOW (Time-dependent problems)
INFLOW (Maintenance problems)	**Problem of skewed maintenance:** User A's free riding on User B's maintenance activity increases costs or reduces returns for User B	**Problem of insufficient maintenance:** Insufficient total level of maintenance due to free riding causes reduced stock level and reduced future harvest potential
OUTFLOW (Harvest problems)	**Harvesting externality:** The harvesting activity of User A imposes increased marginal costs or reduced marginal returns on User B thereby reducing his/her payoff.	**Over-harvesting externality:** Stock level reduced due to over-harvesting causing reduced regeneration and future payoff.

In a time-dependent perspective the implications are extended. If no one provides and maintains the structures that accumulate water into the reservoir, there is no water to use, for anybody. That is, the users face an environment in which the strategies they follow in one time period will affect the strategies open to them in later time periods. E.g., harvesting more than maximal growth in one period will contribute to stock reduction and thus lower possible harvest in the following periods. The problems become not only flow-connected but also *stock-connected.* Another example, modern reindeer management needs collective fence and corral systems to perform annual harvesting. Without these facilities, the herd is not gathered and under human control; that is, the outflow is conditioned on an inflow. All herders benefit from the fence once it has been erected - whether they have contributed or not. Who is going to take the responsibility of establishment and management? If the problem is not satisfactorily solved, the yield from the CPR may be reduced and the users face *the problem of insufficient maintenance*[3]. Ostrom et al. (1994:14) provide several descriptions from the literature how the capacity of an irrigation system can be reduced this way.

For most CPRs, the most apparent potential problems are, however, connected with the *outflow* aspect of the CPR and its allocation. These externalities may or may not have implications for the resource stock. They are associated with such basic questions as, *who is going to harvest the resource, how, and how much?* "The problems to be solved relate to excluding potential beneficiaries and allocating the subtractable flow" (Ostrom et al., 1994:9). In the irrigation system example, these problems are thus related to the use of water. The cluster of potential problems relating to withdrawal of resource units from the flow of resources provided by the CPR can be called *harvest problems.* This set of problems is related to the flow out from a resource stock or the output of a production process and can also encompass both time-

[3] Ostrom et al. (1994:14) denote this as a supply-side provision problem.

independent and time-dependent problems. The general problem for each user or appropriator is to find the efficient level of harvest equating his/her marginal costs with the corresponding marginal returns.

Here user A's increased harvest reduces the outcome for user B. If the harvest rate exceeds the regeneration rate (outflow is greater than inflow), the resource stock can be reduced. This happens when inflow and outflow are positively correlated and create *over-harvesting externalities*. A reduced regeneration rate and stock level will reduce the harvest potential for the future. A classic example is Hardin's (1968) imagined herder speculating whether he should increase his pasture exploitation with an additional animal or not. The outcome, known as the "Tragedy of the Commons," is an example of how individually rational users may create negative externalities by ignoring the impact of their actions on other's returns. This type of externality can be a stable situation or it can mean total resource depletion/extinction. The severity of the situation depends on both resource attributes and economic factors.

The typology introduced in Table 2.2 is inspired by, but deviates from, the one provided by Ostrom et al. (1994:8-15). I started out with the Ostrom et al. typology, but finding two weaknesses made me reformulate it: (1) most important, one class of problems (my type over-harvesting externality, cf. Table 2.2) falls into two of their types simultaneously ("appropriation externality" (ibid.:10) and "demand side provision problem"(ibid.:13), which I found confusing, and (2) it does not cover my problem type skewed maintenance (cf. Table 2.2).

The four types of Table 2.2 give the *general* typology. The harvesting problems can, following Ostrom et al. (1994:9-12), each be divided into two specific subtypes, including specific additional conditions. By assuming diverse production capabilities of the natural environment, we can localize the particular subtype, *assignment problems,* which mean potential competition for "hot spots". "Hot spots" are locations of higher productivity than the average, with the inherent possibility of inefficient use of the CPR (Ostrom et al., 1994:11, cf. Gordon, 1954:131-132). For example, the maximum sustainable yield derived from different parts of a pasture may differ. Situations where some users are better off than others due to differences in productivity are not externalities; an assignment problem emerges whenever the "hot spots" become overused and the "cold spots" underused and the overall outcome is reduced.

Harvesting problems can also be what Ostrom et al. (1994:12) call *technological externalities*[4], where use of one type of technology changes costs or productivity for users of other technologies. A rather dramatic example is the conversion to snowmobiles in the reindeer management of the East Sámi of Northern Finland, which led to the exclusion of a great number of herders and considerable social problems (Pelto, 1973). Assignment problems and technological externalities may reinforce existing harvest problems or be the direct reason for the emergence of new problems. We can also imagine that these two subtype problems can reinforce each other. For example, the introduction of new technology may promote hot-spot

[4] The notion *technological externalities* is in standard resource economics (cf. Baumol and Oates, 1988) used for externalities due to physical interconnections, as opposed to *pecuniary externalities,* externalities caused by financial matters. The two meanings of one term are a bit confusing. I have still chosen to use the concept here as my use is in accordance with the CPR-literature.

competition. In the subsequent chapter we will study combinations of different CPR-problems in some more detail.

To understand how the severity of CPR dilemmas can develop, game theory may give us some clues to the interpersonal dynamics working.

2.2 CPR dilemmas within a game theoretical framework

The simplest possible representation of CPR dilemmas can be achieved by non-cooperative, one-shot, two-player games. There is a single position held by both players, and both players make a decision simultaneously and independent of the other. Each player has the choice between two strategies. We denote the strategies *Cooperate* or *Defect* and a payoff matrix with the parameters α, β, ε, and ϕ, cf. Figure 2.1 for a general two-player matrix. The parameter values are determined by the transformation functions of the CPR. For a harvested biological resource, they are the outcome of the production function of the resource in question. What is essential is the diversity of possibilities created by various combinations of strategy choices. In the matrix of Figure 2.1, player 1 chooses between the two actions denoted by the two rows, and player 2 chooses between the two columns.

		PLAYER II			
		C		D	
PLAYER I	C	α	α	β	ε
	D	ε	β	ϕ	ϕ

Figure 2.1. A General two- player matrix where C= Cooperate, D= Defect. Payoff matrix parameter values α, β, ε, α, and ϕ.

The four cells of the matrix give the outcome function. The possible outcomes of player 1 are portrayed in the upper left-hand corner of each of the cells, while the lower right-hand corners correspond to the possible outcomes of player 2. The matrix also provides the set of information. The payoffs are given by the values of the parameters α, β, ε, and ϕ. By varying these values, the decision situation for the players, and thus the structure of the game, is changed. That is, the general matrix can provide a number of different games.

2.2.1 Dominant Strategy Games

Games can be classified with respect to their equilibria. In games with *dominant strategies* a rational player will always choose her best strategy given the opportunities available to her. If the parameter values are $\varepsilon>\alpha>\phi>\beta$ the game structure is *Prisoner's Dilemma*. Prisoner's Dilemma, if played once, typically has the *dominant strategy equilibrium* –Defect, Defect– and the Pareto inferior payoff (ϕ,ϕ). Pursuing individual rationality here produces collective

irrationality. One well-known example of this game is Hardin's (1968) hypothetical herder speculating whether to increase his herd or not. The logic of Prisoners Dilemma is per definition non-cooperative, and prevention of resource over-use can only be achieved by enforcement of an outside authority (Sen, 1967). This is consistent with a situation without an internal regime. Another game with dominant strategy equilibrium is Prisoner's Dream, defined by the parameter values $\alpha>\varepsilon$, $\beta>\phi$. Prisoner's Dream has the dominant strategy –Cooperate, Cooperate and the payoff is (α,α), which is a Pareto optimal solution. The logic of Prisoner's Dream may for example mirror a situation where there are resources in excess.

The logic in dominant strategy games do not change if they are extended to be *multi-person* and/or *iterated*, but this will make the resource overuse outcome of Hardin's allegory very clear as all herder repeat their decisions again and again.

2.2.2 Conditioned Strategy Games

Many games do not have dominant strategies, and a variety of alternative outcomes are possible. Conditioned strategies can produce solutions that are Nash-equilibria; combinations of strategies players are likely to choose where no player could do better by choosing a different strategy given the strategy chosen by the other — the strategy of each player being a best response to the strategy of the other (cf. Baird, Gertner and Picker, 1994:21). One example of a conditioned strategy is the game of *Assurance* defined by $\alpha>\varepsilon$ and $\alpha>\phi>\beta$. Assurance has two possible Nash equilibria –Defect, Defect– and –Cooperate, Cooperate– and the two associated payoff possibilities (α,α) and (ϕ,ϕ). That is, one player's contribution is not sufficient for gaining a collective benefit while two players' collective contribution will produce a joint benefit (Ostrom et al., 1994:56).

Generally, in a number of repeated games the so-called Folk Theorem (cf. Rasmusen, 1989) states that there are rich classes of games being Nash equilibria in the sense of sub-game perfections. These equilibria may be Pareto efficient or not. Runge (1992: 28-32) has described a multi-person and assurance game resting upon conditioned strategies. Describing a situation of two possible equilibria, one being Pareto inferior and the other Pareto superior, as in our description above, the author states that the condition to achieve the Pareto superior equilibrium is that *a minimum* (proportion) *of agents are assured that the others will cooperate*. That is, an inferior outcome is no longer inevitable; "if everyone is assured that a critical mass of others will obey a common property agreement, then it is in each person's individual interest to do likewise, since this outcome is preferred"(Runge, 1992:30). This is particularly relevant for the possibilities of establishing a regime.

Extending the setting to iterated games the situation can be made more realistic. One option is *spatial games*. Novak and May (1992) have incorporated an iterated multi-person game of Prisoner's Dilemma/Assurance into a cellular automaton in which the players are constrained to rectangular patches and interacting with their eight neighbors. As a simplification, the only strategies allowed are Always Cooperate and Always Defect. They establish the assumptions; $\alpha=1$, $\beta=\phi=0$, while ε are allowed to vary from run to run. In each round of the play patch owners interact with all eight adjacent players, and the sum of their payoffs is totaled. To begin the next round each patch is given to that individual among the previous owner and

adjacent neighbors who accumulated the largest payoff in the previous round. Their general finding is that, under a critical range of *the fraction* e/a, groups of cooperators will grow, while in a certain range, both cooperators and defectors will tend to have long-term co-existence, and over that range, clusters of defectors will tend to grow. These results[5] are relatively robust to changes in the details of the game.

Another type of conditioned strategies is *trigger strategies* where a player is, for example, committed to play Cooperate unless the other player plays Defect. One example of a trigger strategy is Tit-for-Tat (Axelrod, 1984). This strategy is *nice;* always starting with cooperating, it is *provocative* in that it at once retaliates against defection, but also *forgivable* insofar as it reciprocates renewed cooperation from the opponent (Alstad, 1994). Axelrod (op. cit.) conducted an experiment with computer programs representing different strategies that played infinitely repeated Prisoner's Dilemma games. The outcome was that Tit-for-Tat was the strategy giving the highest possibility for continued cooperation.

In a CPR perspective games with conditioned strategies seem to be the more challenging as basic models for CPR situations. We should note the role of *expectations of others' choices* in the conditioned strategies. In real world settings coordination norms (Schelling, 1960) will contribute to the assurance that others will not misuse common-pool resources and thus make it rational for the individual to respect them. Norms constitute a part of a regime contributing to the compliance to coordinated strategies. Turning this to a perspective on institutions, Ullman-Margalit (1977) states that the key element, which determines the success or failure of institutions is to which extent the institutions foster coordinated *expectations* in relation to a particular physical and social environment.

In the subsequent subchapter we will contrast individual strategies under two different institutional settings.

2.3 Optimal individual strategies under different institutional conditions

Using a simple static fishery model building on pure logistic growth as an illustration, we can consider the incentives that face individual resource harvesters exposed to different institutional settings: first unregulated (no institutions), that is no property or open access, and then in a fully regulated fishery, managed by an effective institution, a regime. In both cases, we assume that the linearly increasing harvesting costs are zero at maximum stock size K. We assume logistic growth, a fixed price for marketed harvest, and linearly increasing costs due to increasing harvesting cost when the stock size is lowered. Fixed costs, maintenance costs included, are assumed to be zero in this analysis. Change in stock size equals growth minus harvest while total profit II is total revenue TR minus total costs TC.

In the unregulated case, including the same assumptions as the game Prisoner's Dilemma, each user will exploit the fishery as far as there are opportunities of earning a profit, as there are no entry barriers. That is, each fisherman has an incentive to continue fishing until the total harvest reaches the point (NNIE) where the yield will just cover costs and the resource rent is driven to

[5] The results can be tried out by anybody by the computer program Populus (Alstad, 1994).

zero (cf. Figure 2.1). Although reducing the total catch would be in the collective interest, producing a positive profit, the rational fisherman has no incentive to do so. On the contrary, the fishermen's *aggregated effort in harvesting the common-pool resource will continue to increase until the resource rent is dissipated at the non-institutional equilibrium* N_{NIE}, *because the fishermen individually have earned profit by increasing their efforts up to this very point.*

The lack of a regime thus makes individual rationality collectively irrational. This is the classic Gordon-Schaefer model (Gordon 1954; Schaefer, 1957). The non-institutional (open access) equilibrium is a stable steady-state equilibrium, both in an economic equilibrium and a biological sense; the profit is zero and the resource stock is constant insofar as harvest equals growth. However with zero profit it is Pareto-inferior, and recalling Table 2.2, the combined stock and flow dependent problems could encompass this situation.

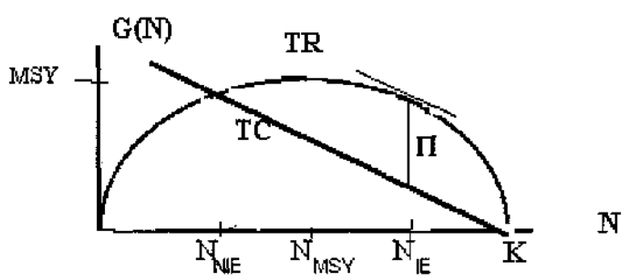


Figure 2.1. Fishery model. Non-institutional and effective institutional equilibria.

The second case is one of effective institutions. This can include as well private property as various forms of common property — I will go further into different regimes in the following subchapter. Though the cost and revenue function are the same as before, the incentive structure is different, so the rational fisherman starting out with maximum stock size, K, increases his harvesting effort to the point providing the maximum resource rent (N_{IE}). In Figure 2.1,the profit Π is the vertical difference between TR and TC. Basic microeconomic production theory states that maximizing Π with respect to N produces the first-order condition d(TC)/dN = d(TR)/dN, that is where the slope of TC equals the tangent of TR, found at the stock size N_{IE}. This is also a stable equilibrium point. The positive profits Π, is a pure surplus, or rent after all costs of fishing are paid. We should, however, note that this model does not include the costs of establishing and maintaining a regime. This costs, transaction costs, have to be smaller than Π for the regime to be effective.

We observe that harvesting costs introduce a trade-off between a lower total revenue and lower total costs due to denser stocks, implying that the point of maximum rent will be found at a higher stock level than that of maximum sustainable yield (MSY) (cf., Neher, 1990:25). This is often called the *stock effect*. Comparing with the non-institutional equilibrium, we find that *effective institutions would be an instrument of increasing total profit, from zero to a positive amount,* by reducing the resource exploitation by increasing stock size from a point below N_{MSY} to a point beyond N_{MSY}.

To analyze real world CPR situations we need tools that can translate the variety of properties

held by resources and regimes into situations like the ones mirrored by game theory. We have chosen the so-called IAD Framework to do that.

2.4 The IAD Framework

The research environment associated with The Workshop in Political Theory and Policy Analysis at Indiana University, Bloomington, USA, have during the last decades developed the so-called Institutional Analysis and Development (IAD) framework (cf. Berge, 1998; Oakerson, 1992; Ostrom, 1990; Ostrom, 1995; Ostrom, Gardner, and Walker, 1994, Thomson 1992, cf. Kieser and Ostrom, 1982) in various versions. The framework is meta-theoretical and can be used for organizing theories and explanations of different disciplinary origin.

2.4.1 The Action Arena

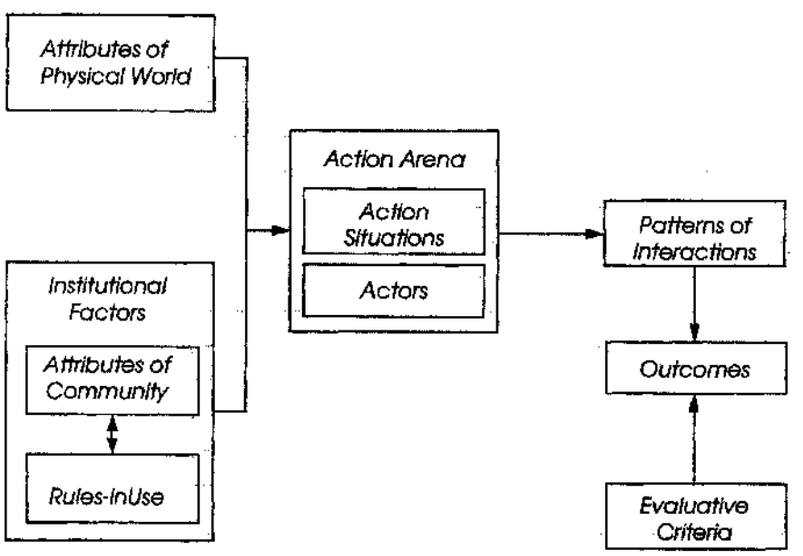


Figure 2.2. The IAD Framework
Source: Ostrom et al.1994: 37

The basic concept of the IAD framework[6] is the *action arena.* It includes the two main elements of *actors* and *action situations.* All three concepts are included in Figure 2.2. Action situations refer to the natural and social space where individuals interact and are to be defined from the purpose of analysis. All situations are viewed as being composed of the same set of elements

6 Here I basically follow Ostrom et al. (1994).

compatible with those of a formal game. The IAD framework is therefore a useful tool for analyzing a wide array of action situations, for example, those of legislatures, markets, and hierarchies as well as CPRs and other complex situations.

2.4.1.1 Elements of an action situation

The minimum elements of an action situation are:[7] (1) positions, (2) actions, (3) information, (4) a transformation function, (5) potential outcomes, and (6) costs/benefits assigned to actions and outcomes. *Positions* link actors with an authorized set of actions. Bosses, housewives, voters, farm workers, and judges are examples of positions. Positions are decisive for the action possibilities for the participants, which hold each specific position, but not by themselves. Analysis by IAD framework considers what action individuals holding defined positions are likely to take.

Actions are the possible set of actions for participants, in particular positions at a certain stage of a process. Some examples: to fish or not to fish, to increase the herd or not, to implement new technology or not, and to fight encroachment of competitors or not. The element of *information* is the set of available information for particular actors at a given point in time. It encompasses information about the physical parts of a CPR, preceding events, actions of other actors, and outcome. Information may be more or less complete and more and less asymmetrically distributed among the participants. *Transformation functions link actions and outcomes.* They can *be production functions* linking various inputs to diverse outputs of goods, deterministic or with a stochastic component. In some situations, uncertainty can be considerable, e.g., the long-term effects of a herd overgrazing. Transformation functions can also be *decision-making devices* like voting rules, for example, majority rule. *The potential outcomes* are the physical results of the participants'possible actions. Examples are the quantity of reindeer meat produced following a particular harvesting strategy, or the long-term effect on a pasture. *Costs and benefits* encompass the participants' valuation of the outcomes and the total payoffs for the actors.

2.4.1.2 Attributes of Actors

The minimum requirement of actors for using game theory is two players. Two-player games can be analyzed analytically. Multi-player games can be analyzed by computer simulation. Non-cooperative game theory is a powerful tool for predicting possible outcomes of standard rule games. Games of man against nature (one player) and fully competitive markets (an indefinite number of players) are cases where neoclassical theory is directly applicable. Assumptions about the behavior of the actors are often made for five types of variables: (1) preferences for actions and outcomes, (2) level of information (3) rationality, (4) selection criteria, and (5) individual resources. *Preferences* imply that individuals are assumed to be able to order actions or outcomes from the most to the least desirable. *Information* is a specification of the level of

[7] Ostrom et al. (1994:29) include an element denoted participants being actors placed in an action situation. I find this somewhat illogical insofar as this will tend to blur the distinction between the concepts actors and action situation.

information the actors possess when making a decision. In simple settings, assumptions of complete[8] or perfect[9] information can be made, while in more complex situations *bounded rationality* is a more reasonable assumption. We then presuppose that the amount of available information is greater than the processing capabilities of the individuals, and they therefore have to depend on various heuristics or shortcuts. Individual *selection criteria* will depend upon information level; with complete information actors can, for example, maximize utility or obey the mini-max criterion. Under bounded rationality, criteria like rules of thumb can be used to simplify the situation of decision. Monetary and time constraints are important characteristics of *individual resources,* limiting the feasible set of actions for the participants.

2.4.2. Constituting factors

The actors in an action situation make up the formal part of the IAD framework that can be analyzed as a game. However, this formal game is constituted by different real world variables. The set of variables shaping the action arenas and also the actors are grouped into two main factors (composite variables or vectors). These are the attributes of the *physical world,* and *institutional factors,* which can be divided further[10] into the attributes of the *community,* and *rules-in-use.* The interplay of these factors and the characteristics of the actors together compose the action arena.

2.4.2.1 Attributes of the Physical World[11]

The attributes of the physical world are fundamental. We cannot suspend the law of gravity. Further we have to adjust our action to our knowledge about this world. We have above, in 2.1, inquired the fundamental features of resource stocks and resource flows. For many renewable stock resources, the regeneration rate is a function of the size of the resource stock itself, known as *density dependent growth.* Further, our model in 2.3 was based on the *logistic growth function.* This model is widespread, as it appears to approximate very well the natural growth processes of a wide array of biological systems. It may also be used to mirror systems where human maintenance activity is a requirement for regeneration. The literature (cf. Edelstein-Keshet, 1988, Hanley et. al., 1997) provides many examples of modified or related models, but we will not explore such models in this chapter. In stead we will point to that within a CPR, there is a wide array of attributes affecting the prospects for resolution of common-pool resource problems. Two features have special importance: whether a CPR has *storage* facilities, like a

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8 The participants know the complete set of actions available for all actors at any time, possible outcomes of every possible action and all participants' preference ranking of possible outcomes (cf. Ostrom et al 1994:34).

9 Complete information plus that all actions been taken by participants are known to all others (Ostrom et al., 1994:34).

10 In Ostrom et al. (1994) "Attributes of Community" and "Rules-in-use" are treated as two sets of autonomous factors. This version underlines that the main difference is between physical and institutional factors.

11 This subsection draws heavily upon Ostrom et al 1994:Ch.l4.

dam for hydroelectric power, and whether the resource units are *mobile,* like fish. These physical constraints have considerable influence on which kinds of problems of harvest and maintenance are likely to emerge, as well as on the possibilities for solving them. We introduce a typology of CPRs based on these characteristics in Table 2.3.

By *stationarity* we mean that the resource units remain spatially limited prior to harvest or travel so slowly that they can be considered fixed for all practical short-term purposes. It is thus an attribute of the resource units yielded by a particular resource system and may vary continuously across physical environments. By *storage* we mean physical capacity of a resource to collect and hold resource units. The relation between storage and stationarity is obvious insofar as storage makes delayed appropriation of otherwise mobile resources possible. The appropriators can thus treat the stored resource units as capital in a bank and make withdrawals when the need or the profit is at its highest.

Table 2.3. A typology of CPRs.

		RESOURCE UNITS	
		Stationary	*Non-stationary*
STORAGE	*Available*	**Groundwater basins, Lichen pastures, Fish in a pond**	**Semi-domesticated commonly owned reindeer[1], irrigation canals with reservoirs**
	Not available	**Grazing lands, Wild berries, Fish in a lake**	**Migratory fish Wild reindeer[2], Run-of-the-river irrigation systems**

[1]Semi-domesticated reindeer is usually (Sámi type) private property . Exceptions are present in non-sámi reindeer management in Finland and South of Norway, which are owned collectively by a group of individuals. Human control makes it a storable resource.

[2]Wild reindeer is a CPR-resource. Because of lack of human control it cannot be considered storable

Source: Ostrom et al. (1994:309)

Of the different types of potential CPR problems introduced in 2.2, *harvesting problems* are most apparent for stationary resource units because of their relatively higher availability. They can, however, be more acute for non-stationary resources. They have a higher degree of uncertainty about the abundance of the resource. Excessive appropriation creates both increased harvesting costs and resource depletion over time. CPR users harvesting stationary resource units have the advantage of having better possibilities for planning their appropriation. There is, for instance, a great difference in risk between the Eskimo (Inuit) hunters of Labrador, Canada, and the pastoral villages of India. The former group depends on the migrating herds of wild caribou for their annual hunt, and faces the uncertainty of the herds' appearance (cf. Kleivan, 1966). The latter group has their herds under control, and is therefore able to create systems with annual quotas of fodder extraction (cf. Agrawal, 1992).

As stationarity implies relatively lower uncertainty and better control possibilities than non-stationarity, stationary resource units make it possible to solve technological externalities and assignment problems by spatial allocations. As for *maintenance problems*, appropriators are also less likely to engage in provision activities when the resource units are non-stationary. The

attribute of *storage* can alleviate some appropriation problems for CPRs with non-stationary flows, insofar as it both can lessen uncertainty and smooth flow variations. Appropriators will therefore be more reluctant to accept allocation schemes when their resource facility lacks storage.

As a whole, in CPRs without storage capabilities and with mobile resource units, it will be more difficult and costly both to acquire adequate information about the resource system and its flow of products and to reach agreements about appropriation and contribution to development and maintenance. Obviously size and complexity are also important general factors influencing the governability of a CPR. Other factors, including renewability, fragility, generation interval, and spatial distribution, can also be important, depending on the character of the resource system. The relative importance of physical attributes compared to institutions varies considerably for different action arenas, but these are, of course, very important for CPRs being natural resources.

2.4.2.2 Institutional factors

Returning to Figure 2.2 and descending from attributes of the physical world we come to institutional factors. The literature in this field may appear as not fully homogenous. It seems as if different authors are stressing various aspects differently, thereby creating concepts that may overlap to some extent. Bromley (1989:39) defines institutions as *"rules and conventions that define choice sets from which individuals, firms, households, and other decision-making units choose courses of action."* [12] More accurately, institutions can be considered as having two dimensions, "consensual arrangements or agreed-upon patterns of behavior that comprise -- conventions, or as rules and entitlements that define -- with both clarity and obvious sanction individual and group choice sets (Bromley, 1989:77-78)."

We note that institutions constitute opportunities for and constraints on action. Especially in natural resource management, it is obvious that the physical world must work together with rules and conventions to compose human's choice set. CPR users thus face successive layers of structuring. Physical constraints are absolute, while *institutional statements* like norms and rules, can be followed, but are also breakable. According to Crawford and Ostrom (1995:584-586), the institutional statements can be grouped into:

(1) *shared strategies,* which include the terms telling who, what, and where/when (for example, reindeer herders might state: "We usually slaughter 3-year-old bucks");
(2) *norms,* which are a strategy plus a deontic (may, must or must not), (for example, "We must slaughter mainly 3-year-old bucks"), and:
(3) *rules,* which consist of a norm plus a sanction (for example, "We must slaughter mainly 3-year-old-bucks, or else we shame ourselves."

More precisely, rules can be seen as *"generally agreed-upon and enforced prescriptions that*

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[12] In everyday and administrative language institution can also be organizations like hospitals, schools etc. We exclude this use of the notion.

require, forbid, or permit specific actions for more than a single individual" (Ostrom, 1986). Rules can be under grouped into *rules-in-use*[13], which are enforced and usually followed, and *rules-in-form*, which is nothing but words on a paper (Sproule-Jones, 1993:266). The precondition for a rule becoming a rule-in-use is the existence of a shared meaning (Ostrom et al. 1994:40) or a *community of understanding*; acknowledged beliefs existing within any governance system about the basic logic of its rule configurations (Sproule-Jones, 1993:268). Shared meaning is not, however, sufficient to create *compliance* to norms and rules. No rules are ever self-enforcing. Somehow, user performance needs to be *monitored* so that defection can be sanctioned.

Conventional wisdom is that sustaining CPRs relies on external enforcement (cf. Hardin, 1968). I will advance an approach exploring the potential that internal enforcement is the basic. In practical settings, more compliance can be observed than selective incentives as coercion, side payments, and esteem can explain. Levi (1990:408-409) asserts that the most effective institutions incorporate a normative system of informal and internalized rules. More precisely, she characterizes this as *contingent consent*[14], more concretely thought of as *the norm of fairness*. "If current arrangements represent an acceptable bargain, and if others are doing what they can reasonably be expected to do to uphold the bargain, the institution can be considered 'fair'" (ibid.: 409).

In the IAD framework terminology institutions are divided into the two clusters of variables: attributes related to community and those related to rules-in-use.

Attributes of the Community

Returning to Figure 2.2 the attributes of community is a part of institutional factors. In its broadest meaning, community includes all individuals affected by the decision situation. More specifically, it encompasses what we usually call *culture,* which rather uncontroversial may be defined as the ideas, values, rules, and norms a human takes over from the preceding generation and pursues — as a rule, somewhat altered —in the next generation (Klausen, 1970). The concept may also be defined more broadly to include *ways of life* and *material goods* created and valued by the group in question (cf. Giddens, 1993:31). In our context, a precise definition is not required, but what we need to consider is *the relation between culture and institutions*. Obviously the concepts overlap to some extent, but culture is both a wider concept and more deeply rooted in the human mind, implying that parts of culture may be viewed as relatively stable basic institutions or meta-institutions. Rules-in-use can thus be considered the more designable part of the institutions. That is, culture heavily influences which rules become rules-in-use.

Ostrom et al. (1994:45) focus on features of culture like (1) generally accepted *norms of behavior*, (2) the level of *common understanding* about action arenas, (3) the extent to which

13 Cf. working rules (Commons, 1957).

14 The author (Levi, 1988) also use the notion "quasi-voluntary compliance" to describe in essence the same mechanism.

preferences are homogenous, and (4) the distribution of *resources* among members. A wide array of institutions can be considered an integral part of a society's culture and thus an important basis for institutional development. Cornell and Kalt (1990:22) attribute two relevant roles to culture in development processes: to *specify preferences* and to be a *strategic guide* to action encompassing a repertoire of individual and collective responses to given circumstances. Providing shared preferences and perceived options that dampen incentives to free-ride, culture serves as a set of what they call "implicit contracts," and thus is a classic public good (ibid: 37). Culture provides standards for evaluating and developing the more directly operative parts of a society's institutions. The general level of trust or distrust in a community connected with the role of social capital is an important cultural attribute. Many of the factors determining changes in the capacity for institutional transformation thus belong to the sphere of culture or the variable of community.

Rules-in-use

Recalling the understanding of rules and *rules-in-use*, we now consider the upper layer of action-structuring devices and the more directly operative part of the institutions. All rules are outcomes of human efforts to create order and predictability by authorizing required, permitted, and forbidden actions for defined positions (Ostrom, 1986). Rules are characterized by being contextual, prescriptive, and followable (Shimanoff, 1980). They are *contextual* in the sense that they only may be applied in the situations stipulated. They are *prescriptive* in the sense that those knowledgeable of a rule are held accountable when they break the rule (op.cit: 41). They are *followable* because actors may choose whether to follow a certain rule or not. This attribute distinguishes actions arising from institutional devices such as rules and norms from those, where choice is physically impossible.

Over time, rule following can become habitual and thus a more or less subconscious *convention*. For example, in most countries cars drive on the right-hand side of the road. This is more than a traffic regulation; the practice is so habitual that many individuals feel uneasy when in Britain and driving on the left. The often-subconscious character of operational rules-in-use can be a problem in empirical institutional analysis (Ostrom et al., 1994:40), insofar as CPR users can comply to rules almost as a spinal reflex. The outsider analyst may not observe that there is a rule working and thus may misinterpret the observed action. The rule may become apparent only when broken. The stability of rule-ordered actions is dependent upon shared meaning, leading to similar interpretation. However, the meaning of a rule can change if the action situation changes considerably and thus erodes the applicability of the rule (V. Ostrom, 1980:312).

In institutional analysis, it is therefore necessary to consider rules in their dynamic interaction with all parts of an action arena. Most social realities are composed of a multiple of interconnected arenas. The IAD framework allows for analysis at multiple levels. Rules-in-use are usually nested or stacked by scope of authority. Ostrom et al. (1994:46) specify rules at 3 successive levels;

(1) *operational rules* for everyday decisions,
(2) *collective-choice rules*, which are rules about who may change operational rules and under which conditions (rules of competence and procedure), and

(3) *constitutional-choice rules,* which define how collective-choice rules, in their turn, can be changed. A typical example of a constitutional choice rule is the formal procedure of lawmaking in a legislature. However, acts of constitutional choice do not need to be rule-ordered, e.g., when a new organization is established, other that they can be subsumed under a society's freedom of organization.[15] To extend this example, the new organization often will have as one of its first formal acts to write its own by- laws, which will usually include all three levels.

This can be achieved as sketched in Figure 2.3.

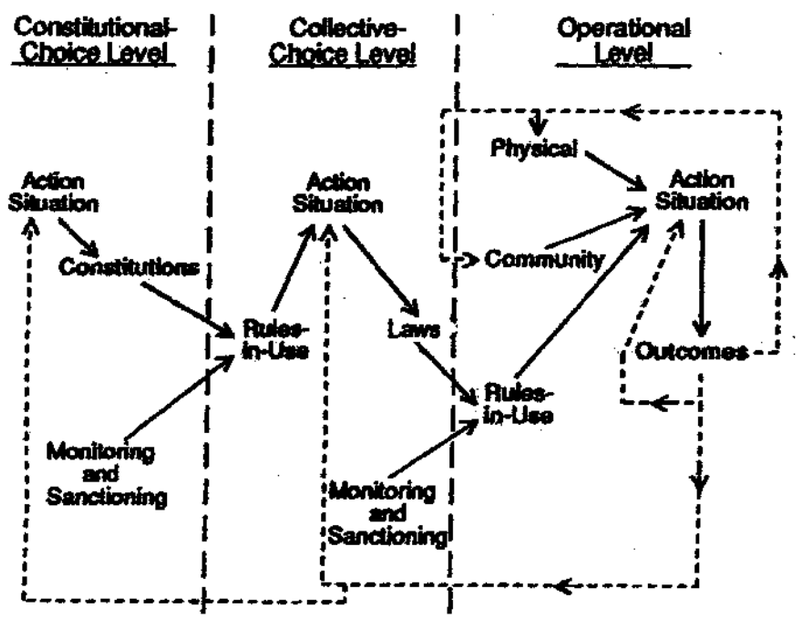


Figure 2.3. Linking levels of analysis.
From Ostrom et al.(1994:47)

To understand Figure 2.3, we may imagine that the operational level (1) is a local CPR and that the collective-choice level (2) is a regional combined legislature and governing body with the full responsibility for the rule-supply and enforcement of the CPR. Further the constitutional-choice level (3) is a central combined legislature and governing body with the ultimate responsibility for the supply and enforcement of competence and procedure rules in the regional body. We note that the level 1-compliance to laws produced on level 2 needs to be monitored and sanctioned by level 2 to become rules-in-use at level 1. In the same way, the level 2-compliance to constitutions produced on level 3 needs to be monitored and sanctioned by level 3 to become rules-in-use at level 2. This is because compliance to operational rules is a second-order dilemma, which cannot be resolved within the confines of the operational level. In the same way, compliance to collective-choice rules is a third-order dilemma. The compliance at level 1 is nested in compliance at level 2. The levels of analysis are not necessarily reflected in a

15 Which, however, often is a part of its constitution.

similar organizational hierarchy. Whether collective-choice and constitutional-choice activities are performed by special bodies or, by all CPR-users in common, is fully an empirical question.

To understand how rules work, we often need to understand their origin and history. The sources of rules in everyday life are diverse, covering everything from formal legislatures to informal small groups, but insofar as rules are meant for groups of individuals, they also need to be made or at least receive their meaning in some collective process. In IAD framework, this is reflected by the concept of *collective-choice arenas*, where operation rules are decided (Ostrom et. al., 1994:39). The collective of rule-users can be their own collective-choice arena, but a rule may also be created in another action arena than the one where it is supposed to work as an *operational rule*. Recalling the concepts, *community of understanding* and *shared meaning*, we note the need for dialogue between the rule-making body and the rule users for rules to acquire everyday use as rules-in-use. Making a rule into a rule-in-use is a collective process of acceptance, while to break a rule-in-use is an individual process of choice. There is, however, dialectic between the two processes. While following a rule contributes to its legitimacy in becoming a rule-in-use, breaking the rule contributes to its erosion as a rule-in-use.

Regimes

The rules-in-use constitute *regimes* that can govern the use of the resources in question. Common-pool resources can be managed by different resource management or property regimes. Bromley (1991:22) 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. Property regimes include property rights. *Property* is a claim to a benefit stream and a *property right* is such a claim protected through assignment of duties to others, which may interfere with the benefit stream (Bromley, 1992:4). Property relations between individuals and groups imply correspondence between the right of one party and the duty of one other party's duty to protect the former party's interests. This means that property, instead of being an object such as land, rather is a *social relation* defining the property holder with respect to something of value against all others. Property is thus a triadic social relation involving benefit streams, right holders, and duty bearers (ibid.).

We note that, for a CPR, a user's right is linked not to a resource stock, but to the resource (out)flow. It is, in other words, primarily a harvest right.[16] This right *"is only as secure as the duty of all others to respect the conditions that protect that stream"*(Bromley, 1991:22). We notice that others' respect for property rights can affect both maintenance and harvesting in a CPR setting. Bromley (ibid.) emphasizes that *compliance protected and reinforced by an authority system*, the state or other social arrangements, is a necessary condition for the viability of any property regime. The authority system includes decision-making arrangements that specify *who* decides *what* in relation to *whom* (Oakerson, 1992:46). The essence of control over resources is that there exist socially acknowledged rules and conventions making it clear who is the "owner," or the primary decision unit, for the resource in question. The main difference between changing types of property regimes is the *scope* of this unit (Bromley, 1991:141).

16 Other corresponding duties and rights can of course be connected with the maintenance side of the resource.

Finding four types of resource management and property regimes sufficient for most purposes, Bromley (1989:205) lists the essence of them:

1) Private property	Individuals have a right to undertake socially acceptable uses, and have a duty to refrain from socially unacceptable uses. Others (called "non-owners") have a duty to refrain from preventing socially acceptable uses, and have a right to expect that only socially acceptable types of use will occur.
2) Common property	The management group (the "owners") has a right to exclude non-members, and non-members have a duty to abide by exclusion. Individual members of the management group (the "co-owners") have both rights and duties with respect to use rates and maintenance of the thing owned.
3) State property	Individuals have a duty to observe use/access rules determined by a controlling/managing agency. Agencies have a right to determine use/access rules.
4) Non-property	There is no defined group of users or "owners" and so the benefit stream is available to anyone. Individuals have both privilege and no right with respect to user rates and maintenance of the asset. The asset is an "open-access resource."

A rent gradient can be constructed, assuming that *the economic value of a resource is the value of the benefit stream it produces* and that each of the different property regimes is connected to a particular structure of administrative and *transaction costs*[17]. Bromley (1991:142-143) offers a tentative model for choice of management regimes over land and related natural resources. The core of it is that *societies will define property rights and connected control regimes in accordance with the value of the actual resources.* Assuming that both resource rent and transaction costs follow the same gradient, the different regimes in sequence 1-4, above, will be used for resources of diminishing relative value. This suggests that *the most valuable land assets tend to be administered under the regime of private property, while the least valuable resources are left as open access.* Common-pool resources can be managed by any of the last three, as private property is assumed to be associated with higher exclusion costs and correspondingly higher returns.

Non-property, or *open access,* is thus connected with resources producing a benefit stream too low to pay for the establishment and operation of any real regime, meaning that *a resource under open access will belong to the party first to exercise physical control over it.* The social relation of property cannot exist when physical capture is a condition for effective control. When guarding a captured object is necessary, it is because the social acknowledgment which gives property its content is lacking (Bromley, 1991:32), or at least insufficient.

Common-property regimes are characterized by (1) being private property for a group of co-owners, implying exclusion of non-owners, (2) rights and duties for the individual co-owners,

17 cf. Williamson (1985)

and (3) social units with definite membership and boundaries, common cultural norms, and endogenous authority systems (Bromley, 1991:26). Common property "owners" have the same freedom of management as owners of other private property, with the condition that the use of the property is considered socially useful by the society. The protected right of excluding outsiders is indeed a powerful device for both owners of private property and common-property co-owners. The internal structure of individual rights and duties in such a regime can vary considerably with the attributes of the resource and its users. What is important is that viable common-property regimes have "a built-in structure of economic and non-economic incentives that encourages compliance with existing conventions and institutions" (Bromley, 1991:27-28). Conformity with group norms is an important part of this structure. The possession entitlements, the core of the property regime, also encompass an array of *management tools,* including a management subsystem with authority instruments. The well-balanced operation of the regime is dependent upon its authority mechanisms being able to enforce the requirements of system maintenance (ibid.).

Common-pool resources can also be managed by *state property regimes.* We should observe that this would be a kind of minimum regime, as for natural or forest parks. The resource may be managed directly through government agencies, or user groups may be given usufruct rights without title and long-term security of tenure (Bromley, 1991:23). This type of regime is different from the situation when the state carries out active ownership as a private owner. That would typically be the case for more valuable resources.

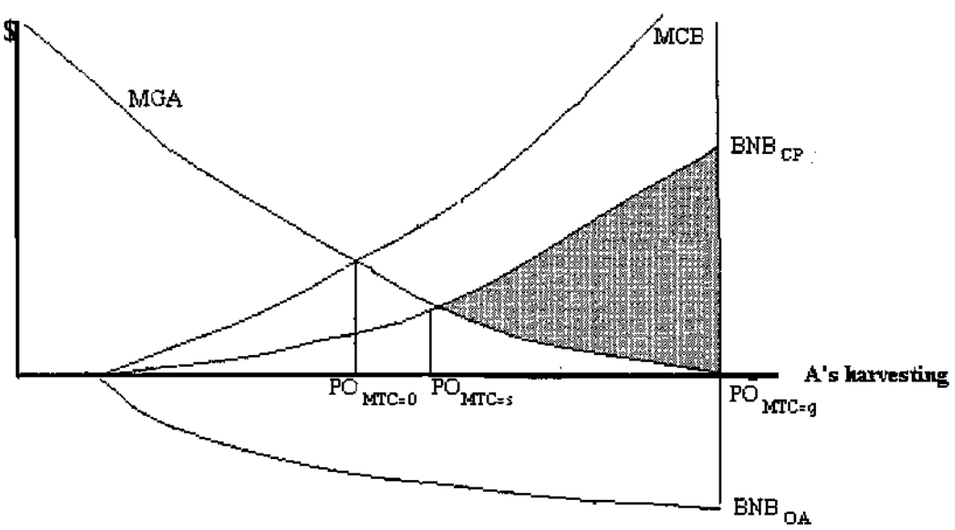
Open access will result "from the absence, or the breakdown, of a management and authority system whose very purpose was to introduce and enforce a set of norms of behavior among participants with respect to that particular resource" (Bromley, 1991:30). In principle, such a breakdown can take place in any of the other regimes in question. Bromley (1991:22) also points to that the allegory Hardin's (1968) "Tragedy of the Commons" has confused both scholars and others, giving *common property* a misplaced responsibility for resource degradation that properly belongs to a situation of *open access.* The metaphor deflects attention away from the social arrangements, which can make common property regimes viable and overcome resource degradation.

The Role of Transaction Costs

Focusing the relation between transaction cost and regimes, we can explore the relation between regimes and *efficiency* in a CPR context. So far we have used the standard economic Pareto criterion without any questioning. Let us start with the well-known Coase(1960) statement that, on the condition of *zero transaction costs and no income or rights effects, bargaining among involved parties will eliminate all Pareto-relevant externalities,* independent of the initial specification of property rights. Recalling the features of CPRs as goods in Table 2.1, *"difficulty of exclusion" is connected with high transaction costs.* That is, solving the problem is not only associated with loss and gain in resource exploitation, but also costs of bargaining and regulation. It seems fruitful to assume *positive transaction costs* for CPR problems. Bromley (1991:76-78, cf. his figure 4.2) compares the situations of positive vs. zero transaction costs for a classic externality situation, finding that the initial legal structure will move the equilibrium emission level in a direction which is advantageous to the party protected by the initial

institutional setup.

In Figure 2.4 we define a CPR situation with User A as an "offender" and User B as a "victim." Recalling Table 2.2 we consider an outflow (harvest) problem. Whether it is flow-related or both stock and flow-related does not influence this particular discussion. On the horizontal axis we depict A's level of harvest, suggesting that increased harvest will be consistent with decreasing marginal gain for User A and, beyond some level, increasing marginal costs for User B. Let us start with a standard situation of zero transaction cost. Here we find a Pareto optimum at the intersection of the curves of marginal gain for User A (MGA) and marginal loss for User B (MCB). Pareto relevant externalities will thus be adaptations to the right of $PO_{MTC}=0$, and Pareto irrelevant ones will be to the left.



User A is an "offender" while User B is a "victim". User B's net bid curves, BNB_{OA} for open access and BNB_{CP} for a common property regime, depend on the relative size of the marginal transaction costs (MTC). The Pareto optima are given by $PO_{MTC=g}$ for open access and $PO_{MTC=s}$ for a common property regime.

Figure 2.4. CPR problems and efficiency

In a situation of an emerging externality, we assume that User B has no legal protection and needs to take initiative to bargain for a solution. We shall see how the relative size of positive transaction costs influences the results. Imagine the existence of two possible regime situations: 1*) open access* and 2) some type of a *common property regime*. Following Bromley (op.cit.), we recognize that User B's willingness to pay will be diminished to the extent transaction costs fall on User B. In the figure, this is depicted by net bid curves (BNB). Given each regime, we only consider marginal transaction costs.

For the case of open access (1), the costs of bargaining solutions will probably be considerable. In the figure we have depicted a situation where User B's net bid curve is negative due to the high transaction costs. The optimal solution in this setting is to do nothing, and the externality will thus persist at the level optimal for User A, i.e., $PO_{MTC=g}$. The great marginal transaction

costs have thus changed what seemed a Pareto-relevant externality into a Pareto-optimal situation. Without a common property regime the situation cannot be changed. For such a regime (2), we have depicted a situation with smaller marginal transaction costs. This is consistent with that the regime having established rules for resource use, conflict resolution, etc. In this case we achieve a Pareto optimum at POMTC=S > POMTC=O. *The gray shaded area between the curves of BNBCP and MGA gives the total gain at this point, compared to an open access adaptation.*

We should remember, however, that fixed costs are not included in this figure. *If the setup costs of a regime are greater than the total gain operating the regime* (cf. "the gray area"), *the regime will not be established,* and we thus end up with open access anyway. Generally we note that both cases have Pareto-optimal solutions, and that the relative size of the transaction costs is the factor deciding the extension of the persisting CPR-problem.

Regimes and strength

Returning to IAD framework, we can use its tools to describe regimes of varying strengths. Schlager and Ostrom (1993:14-24) have classified property rights arraying property-right regimes, distinguishing between more and less extensive common property regimes. The bundles of rights include both operational rules and collective-choice rules. The most relevant rules, which are components of common property regimes, are defined in Table 2.4 (ibid.: 14-15).

Table 2.4. The most relevant property rights in CPRs

Operation level property rights:	
Access (entry)	The right to enter a defined physical property.
Withdrawal	The right to appropriate (harvest) the product flow of a resource.
Collective-choice level property rights:	
Management	The right to regulate internal use patterns, and to transform the resource by making improvements.
Exclusion	The right to determine who will have an access right, and how that right may be transferred.
Transferability[1]	The right to sell or lease either or both of the above collective-choice rights.

[1] The authors use the term "alienation"

Source: Schlager and Ostrom (1993:14-15)

The rights defined in Table 2.4 may be considered basic rights, which together constitute the bundle of rights of full ownership as a co-owner in a CPR. We can note that Bromley (1989:205) in his listing of the essence of regime types, uses quotation marks naming the management "owners" and "co-owner," thus indicating that their bundle of rights need not be

that of full ownership. Schlager and Ostrom progress by using the elements of Table 2.4 to define bundles of rights constituting *positions* in a cumulative manner, cf. Table 2.5. The positions thus vary from full co-ownership to authorized user, which is the position nearest to no-property.

De Alessi (1980:42) argues that "differences in the structures of rights to use resources affect behavior systematically and predictably." Schlager and Ostrom (1993:24) predict theoretically that CPR users would be more inclined to invest in institutions governing their entry and harvest if they have a more complete bundle of property rights. By inspecting a number (30) of cases involving fishermen and containing both a CPR dilemma and well-documented rules-in-use, the authors found a clear connection between *the extension of the bundle of property rights* and the fishermen's *ability to resolve common-pool resource dilemmas.* That means that if the CPR users in Table 2.5 are "owners," they are much more inclined to solve common problems than "authorized users."

Table 2.5. Bundles of rights associated with positions

	OWNER	PROPRIETOR	CLAIMANT	AUTHORIZED USER
Access and withdrawal	X	X	X	X
Management	X	X	X	
Exclusion	X	X		
Transferability	X			

Source: Schlager and Ostrom (1993:16)

Introducing this classification of the extension of property rights refines our analytic tools, but one more distinction is necessary to define more precisely the coordination potential of actual regimes. Sources of property rights are often diverse. The juridical notions *de facto* and *de jure* rights define different sets of rights, which may overlap, complement, or be in conflict with each other. As rules-in-use, *de facto rights*[18] are defined and enforced by the collective of the users themselves, while *de jure rights* are defined and given lawful recognition by government authorities (Schlager and Ostrom, 1993:19). De jure and de facto rights can be considered as two realms or communities of understanding (and enforcement) that may or may not happen to intersect. I would presume the situation of a partial intersection to be the usual.

One implication of this is that a user group may have different positions in the two rule systems. For example, fishermen, who are recognized only as authorized users by the government and thus having the *de jure* rights of access and withdrawal, may themselves execute *de facto* rights of management and exclusion as *de facto* proprietors. With this they may be perceived as fully legitimate within the local community (ibid: 19, cf. Berkes, 1989). *De facto* property rights are important for several reasons. A striking feature is that what are *apparently unregulated commons* (open access) for outsiders *can be effectively regulated with* de facto *regimes*. Failures to recognize this may be fatal in certain cases, as governmental regulations may be created which destroy well-functioning systems. *De facto* regimes are often closely matched to the

[18] De facto rights can also be described in terms as customary rights, folk law or people's law.

physical and economic conditions of a CPR, implying low regulation costs for the users.

2.5 Institutional capacity in change

Recalling Figure 2.3, there is a dialectic motion between the operational and the higher levels of analysis. Institutional transactions (Bromley, 1989:128), activity to change the rules of the game, belong to the class of collective-choice activity. To study how the action situation on operational level interplays with the action situation on collective-choice level, I will use two additional pairs of concepts; *need vs. capacity of coordination* (on operational level) and *need vs. capacity of transformation* (on collective-choice level).

2.5.1 Need and capacity of coordination

The action situation for a given common-pool resource includes a basic dynamics between the resource base and its users. The character of this interplay will define the *need of coordination*[19] by institutional arrangements. Changes in this basic dynamics may change the call for coordination. What will be critical for a resource management regime is its institutional *capacity to create compliance.* Long-term viability of common-property institutions will presuppose a balance (a system equilibrium[20]) between, on the one hand, a *need of coordination* and, on the other hand, a *capacity of coordination.*

Starting with the need side, this may encompass as well biological, technological as socio-economic properties. Biological growth rates and growth patterns can be fundamental. For example, large whales with low growth rates are vulnerable to extinction. This fact will thus contribute to the increase of the need of coordination for a CPR based on whaling. Generally uncertainty about factors like minimum threshold population, actual stock size, harvest rates, and the existence of random factors may promote over-harvest to exhaustion (cf. Perman et. al., 1996:181) and will conduce to an adding need. Among the social factors, the number of potential users is of course fundamental for the need of coordination. Runge (1992:19-21) points to relative poverty, critical dependence of natural resources, and uncertainty with respect to income streams as stylized characteristics of village life in less-developed countries. These are all factors that may increase the need of coordination. Further many resources are or have been well safeguarded by nature itself, i.e., through the size, location, inaccessibility or volatility of the CPR in relation to the technological possibilities of its appropriation. This setting would be typical for what Howe (1979:62) defines as frontier economies. A good illustration of this is the fisheries of northern Norway, which did not become a threatened resource until the new technological opportunities of the era after the Second World War appeared (Brox, 1990:231).

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19 This concept is related to "demand for institutional service" used by some authors (e.g. Lin and Nugent, 1995: 2319, cf. 2325). Because "need for coordination" involves an objective of sustaining a resource, even though the resource value is low I prefer to avoid directly market-related concepts as "demand", and "supply" of institutions.

20 An institutional equilibrium would be a situation where none of the actors would find it advantageous to devote resources to pursue institutional change (cf. North, 1990:86).

The capacity of coordination is a feature of the user group and the regime they have established. We would expect the number and the *homogeneity* of the appropriators to affect the capacity of coordination. The smaller and more homogenous the user groups are, the tighter the social relations and level of shared strategies will tend to be, and thus the lower the need will be of coordination through a set of enforced rules (cf. the concept of the local commons, Seabright, 1993). The capacity of the institutional system is generally dependent upon clarity in defining users/owners, their rights and duties, and the corresponding duties of non-owners. The set of rules also needs to be adapted to the physical attributes of the resource and the actual harvest and production technology. A prerequisite for an efficient coordination of actions is that compliance to the rules is monitored and enforced through sanctioning of rule breakers (cf. Ostrom 1990:90). The lower is the costs of running the regime compared to profits for the users, the better. Limited group size is a factor promoting mutual and low-cost monitoring.

Imbalance between coordination need and coordination capacity may have both external and internal sources. Ostrom (1998:41) points to rapid exogenous changes, including technological, factor availability, and heterogeneity of participants, as possible threats to the continuance of any self-organized system. Ostrom (1998:42-43) also calls attention to *transmission failures* □□rapid changes of population or culture leading to "a circumstance in which the general principles involved in the effective community-governed institutions are not transmitted from one generation to another." This can undermine the community of understanding, on which the interpretation of formal rules ultimately rests and create opportunity for opportunistic interpretation and behavior promoting institutional erosion, thus reducing the capacity for coordination. In Sámi societies, the governmentally imposed duty of sending children to school has, at least some places, this kind of effect (Nergård, 1996).

Bromley (1991:28) provides an illustrative description of how a common property regime can be undermined by external pressure:

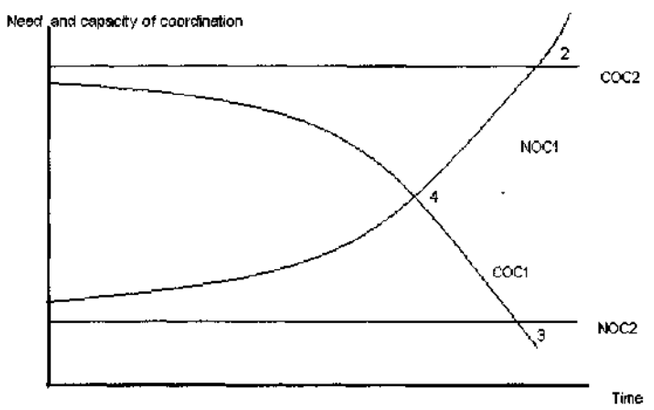
> *"If the modern state holds common property in low esteem...then external threats to common property will not receive the same governmental response as would a threat to private property. ...If pastoralists are regarded as politically marginal... then the property regimes central to pastoralism will be only indifferently protected against threat from others. If those threatening pastoralist property regimes - sedentary agriculturalists for example - happen to enjoy more favor from the state, then the protection of grasslands under common property against encroachments will be haphazard at best."*

This example could be extended, by including possible threats from other property regimes. State property regimes can encompass a wide variety of public objectives, which advance public goods, ranging from military defense to nature conservancy and outdoor recreation. Focussing on the latter type, we should observe that common property regimes are not only jeopardized by regimes and activities causing physical encroachments and direct loss of land, but also by regulations intended to preserve land and nature. The extension of state property regimes in modern time can diminish the space for common property regimes, both physically and by becoming institutional competitors. That is, state property regimes remove control from common property users by strengthening the influence of different state agencies. If this happens parallel to expansion of private property, common property regimes can be squeezed between private property and state property, promoting a development towards open access.

A combined effect of increasing need and reduced capacity is the impact of population growth on a common property rangeland, forestry, or fishery. Insofar as all members of the user group have the same nominal use of harvesting the resource, the aggregated need will ultimately exceed the natural rate of regeneration. "Failure to deal appropriately with the change of the size of the group affects the equilibrium and integrity of the system" (Bromley, 1991:32). Accordingly, the influence of population growth is twofold; processes of erosion are initiated both for the renewable resource base and the regime. The processes will be mutually reinforcing, and if they are not ceased - one way or another - the terminal outcome is, logical, "Because of the decline of effective social conventions and institutions to regulate total use, *a common property regime for the group becomes an open access regime for those within the group* (ibid., my italics, JÅR)".

In our typology of CPR problems, the transition from affecting flow to also affecting stock (cf. Table 2.2) will tend to be relatively imperceptible for most users. Over time, however, an increasing portion of the users will experience diminishing returns. The more serious the effects are, the more probable it is that users will recognize that they have a problem and start a search for solutions.

On observing an empirical CPR problem, first we usually really observe a deficit of institutional coordination. To explore the problem we need to examine the relation between need and capacity. Figure 2.5 depicts possible major development patterns leading to imbalance between these factors.



NOC_1 and NOC_2 are alternative curves for need of coordination, while COC_1 and COC_2 are alternative curves for capacity of coordination. The numbers 2, 3 and 4 mark the COC/NOC intersections where imbalance of coordination may emerge.

Figure 2.5. Need and capacity of coordination as functions of time

The figure leaves us with four possible situations:

(1) No Problem ($COC_2 > NOC_2$)
(2) Problem because of increased need ($NOC_1 > COC_2$)
(3) Problem because of decreased capacity ($COC_1 < NOC_2$)
(4) Problem because of both ($COC_1 < NOC_1$)

The problem situations emerge at the COC/NOC intersections and are marked with their relevant numbers in the figure. As the need curve usually is connected with observable physical factors, at least to some extent, changes in need would be the easiest to observe; that is we would probably observe a change of the NOC_1-type, for example the introduction and spread of new technology. Due to the difficulties of observing the capacity of coordination, a pure institutional factor, it would often be hard to distinguish between situation 2 and 4. We have to ask whether the deficit of capacity in relation to need also involves decline of capacity. Situation 3 could be either a transmission failure or the result of a undermining external pressure. For as well situations 3 as situation 4 we may need to examine the institutional history to find answers and choose possibilities at different points in time. Our ability to find answers depends on whether there is reliable data that may give us a picture of past coordination capacity of the institutions involved.

2.5.2 Need and capacity of transformation (institutional change)

Whenever a deficit of coordination capacity emerges, a process of regime breakdown may be initiated. Another possibility is through collective *action* to adjust the regime. In the following section we will consider some basic conditions for institutional change.

Whether the emerging imbalance has an external or internal origin, the challenge will be to increase the institutional capacity of creating compliance by strengthening established institutions, developing new institutions, or a combination of the two. Thus there is a need of transformation (of the institutions). We will label the ability to increase the institutional capacity (of creating compliance) *capacity of transformation.* The design and adoption of new institutions to solve CPR problems are difficult tasks in any setting, but situational variables are important. Ostrom (1990:211) lists, approximately in order of importance, factors positively related to rule improvements. They are: (1) a common judgement among most appropriators of *being harmed* if rules are not changed, (2) *similar impact* of new rules on most appropriators, (3) *low discount rates* for most appropriators, (4) relatively *low* information, transformation, and enforcement *costs*, (5) presence of initial *social capital* in the shape of shared generalized norms of reciprocity and trust, and (6) a relatively small and stable *size* of the appropriator group.

Insofar as institutions represent a social bargain, compliance must give a return to the individuals and also reflect a particular distribution of power resources. The institutions will thus have a propensity to change when the balance of power changes and some parties thus see new opportunities for gains. Institutional changes can be *discontinuous,* as in the cases of conquest and revolution, but most of them are *incremental.* Discontinuous changes imply radical changes in the set of formal rules, but informal constraints like customs, norms and conventions, which often have deep cultural roots, will have a tendency to survive and thus have a modifying effect. Incremental changes can take place continuously when new bargains and compromises between the actors are possible (North, 1990:89-91).

However, intentions for institutional change are one thing, and achieving the changes pursued is quite another. The outcome of institutional transactions is generally limited by past events. North (1990:104) calls this *path dependence* of institutional change. Past events provide

opportunities and impose constraints, including or precluding possibilities for changes in the future. Thus history matters a lot - to understand the choices of today we need to trace the incremental evolution of institutions. The impact of identical institutional changes can also be very different when imposed on different societies. A historic example of that is the adoption of the US Constitution in Latin American countries (ibid: 100-101).

Turning to the problem of *rebuilding transformation capacity,* we consider the examination of the prerequisites for creating sustainable economic development on contemporary American Indian reservations (Cornell and Kalt, 1990). In short, when basic preconditions like resource base, human capital ~ in the sense of skill and expertise — and market opportunities were fulfilled, the institutional challenges were summed up to be the achievements of: (1) sovereignty,[21] which more generally can be interpreted as autonomy, (2) leaders serving their people as a whole rather than their personal or subgroup interests,[22]and (3) effective governance, i.e., implementation, and incentive systems by means of formal and informal mechanisms which accord with the *people's cultural feeling of what is appropriate.* What seems to be crucial is the cultural part; reliable leaders and a strong political position externally are inadequate if the new authority system does not obtain a hearing with the cultural repertoire of the people. This means that culture serves as "collective templates that describe how they can and should organize themselves and respond to the political, economic and social conditions they encounter" (ibid: 37).

Seeking to reveal the conditions for sustainability of common-pool resources, Ostrom (1990:90) has made an analysis of resource regimes which are self-organized and self-governed and have proven to be long-enduring. She suggests the following *design principles*[23] for long-enduring CPR institutions:

1) Clearly defined boundaries both of the CPR itself and who has appropriation rights.
2) Congruence between appropriation and provision rules and local conditions
3) Collective choice arrangement - participation of affected individuals in rule change
4) Monitoring - self-monitoring or monitors that are accountable to the appropriators
5) Graduated sanctions - from appropriators/their officials to those who violate the rules
6) Conflict resolution mechanisms — with access to rapid, low-cost local arenas
7) Rights to organize users' own institutions not challenged by external governmental authorities
8) Nested enterprises - multiple layer organization when part of larger systems.

We note that first two principles are about core operational rules and their relation to the physical domain; clear external boundaries and access rights and other operational rules that are adjusted to the physical attributes of the resource. Principle 2 directly focus what we have called balance between need and capacity of coordination. Principles 3-7 all are concerned with various aspects of creating an *internal autonomous collective level* under the ultimate control of

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21 Liberation from federal dominance.

22 Avoid rent - seeking from leaders.

23 Conditions accounting for the success of institutions in sustaining the CPRs and achieving compliance to the rules-in-use from an array of successive generations of appropriators.

the appropriators themselves, including an *authority system* and mechanisms of rule change. There is a clear connection between principles 2 and 3, as tailoring of rules to local circumstances can be made at low cost for the users. Principle 5 is of particular interest, since monitoring and sanctioning are also costly for the enforcer (cf. Elster, 1989:41), and it gives the rule-breaker new opportunities to rebuild his loss of reputation. Principle 8 is specific for more complex CPRs, but in line with the more basic principles. We also note that the constitutional level is not directly addressed in the principles, but may be indirectly important via principle 3.

In this chapter we have explored the general character of CPRs and CPR problems and how their dynamics can be analyzed by means of the IAD Framework. In the following chapter we will explore the more specific resource base dilemmas for reindeer management.

Chapter 3
Reindeer Management Production Systems

The core production factors of reindeer management are *pasture, herd* and *labor*. However, while pasture is intimately connected to *natural geography*, labor is dependent upon *technology*. To study the production system of reindeer management we therefore need to include the impact of these factors as well. The three core factors are mutually substitutable within certain limits and may also be set under pressure from external forces. The *pasture* is a common pool resource normally administered under some form of a common property regime. The *herd* is consisting of animals, which usually are herded communally by groups of households, but privately owned by household units, which are the basic production units. Thus we have *a mixed management regime* where the resource regulated by common property produces one of the inputs in the production functions of the individual owners. In addition the institutional surroundings created by the influence of the state make the governing of reindeer management a complex affair.

In applying the IAD framework perspective on reindeer management CPR problems a division between the *production* system (this chapter) and the *institutional* system (the subsequent chapter), seems advantageous. When studying the production system, we realize that our focal points have to be *the interaction of composite production factors*, e.g. pasture geography, pasture-herbivore interaction, and production technology. These are elaborated in subsequent subchapters. We proceed by studying specific CPR-problems and end up with hypotheses for how different production factors may influence choice of adaptation strategys to technolgical change.

3.1 Pasture Geography

Natural geography is constituted out of a long array of factors, being basic long-time stable constituents of the ecosystems in question. In our context geology and climate seem to be the most important. Geology shapes the landscape both animals and humans live and move in. Bedrock is also the basic source of nutrition for the plant cover the animals live off, while climatic factors influence accessibility and energetic cost of pasturing and movement. How variation in nutrition and snow-cover influence plant growth, and in turn, herd dynamics will be included in our modeling in the subchapter 3.2. Here we will inquire the impact of *landscape structure*. The landscape provides *use areas,* which are areas that reindeer management is dependent on both for grazing, calf-marking, rutting, airing mountains (to avoid mosquito harassment) and migration routes. Reindeer herd management is founded upon regional migratory patterns, which are relatively constant over the years. The animals thus have requirements determined by sequence of as many as eight seasons (Sara, 1996, cf. Manker, 1963). While the availability of the use areas mainly are a function of the landscape, the contemporary main threats to these areas are encroachments due to physical constructions (e.g. roads, hydroelectric power plants and mines) and disturbances caused by the increase in outdoor recreation by urban people. The exact land use pattern of a region also depends on variation in property rights and local tradition. In the following subsection we will make landscape the object of a closer contemplation. We should, however, pay attention to the role of geology and climate as ultimate sources of a considerable part of the variation observed.

The implications of landscape tend to be scale-dependent. At a *macro* (e.g., > 1000 km^2) scale a flat landscape will be different from a mountainous landscape. This can easily be seen, studying a map over the major vegetation ecological zones of Scandinavia. The distance between different ecological zones is much greater in rather flat Sweden than mountainous Norway south of Finnmark. For adaptations utilizing several ecological zones, the migrations between the seasonal pastures will thus tend to be the longer, in a flatter large-scale landscape. Thus *we would expect to find the most fully developed nomadism with the longest migrations in the flattest macro-landscape*. One implication of this is that a very flat landscape will tend to promote high energetic and operation costs due to the long migrations. Another is that an elongated shape of the total pasture and use areas will increase the total circumference per unit area i.e., reduce the interior/edge ratio (cf. Forman and Godron, 1986:111) thus increasing the potential for internal competition[1] or external disturbance. The edge effect of external disturbance (the distance inwards in an area where pasturing animals are significantly influenced by a disturbance source on the border), e.g. by tourist facilities for hikers, have proven to be 5-10 km (Nellemann, 1997b).

On a medium scale (e.g., from about 1 km^2 to about 1000 km^2), the presence or absence of *natural borders* is an important feature in the configuration of pasture and use areas. Mountain ridges, steep valleys, and major rivers constitute barriers in the landscape. In Sámi language, here Lule Sámi, there are terms distinguishing between *oaggas eatnan* ("landscape with natural borders") and *luomokis eatnan* ("landscape without natural borders"). Natural borders support the herding work, and lack of natural borders may contribute to insufficient human control. The late Sámi scholar Israel Ruong (1982:69) thus states very clearly "Herding form is a function of landscape." *Landscape without natural borders requires more intensive herding*, and extensive herding in this type of landscape may lead to loss of control and productivity.

The landscape term *njarga*, North Sámi for peninsula, is commonly used for *a pasture area, which is surrounded by natural borders at three sides*. Generally peninsulas are considered to have a funnel effect (Forman and Gordon, 1986:113) and are therefore considered to be of great importance in practical reindeer herding. In a broken landscape, each *local common* (Seabright, 1993) will tend to be used by only a few households. Open landscapes will thus tend to have larger CPRs used by more 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. We may denote this type of common as a *second order common*. In other words we would expect a connection between landscape factors and the need for coordination. Recalling our considerations above in 2.5.2 this should also include the *capacity of transformation* as we would except the transaction costs of a regime to increase with the size and complexity of the social organization.

On a micro scale (e.g., <1 km^2) high variation in altitude will provide a high diversity of ecological conditions per unit area and - opposite of what we generally would believe - thus imply a higher carrying capacity than a flatter area (cf. Nelleman, 1997a). The reindeer's physiological requirements and the requirements of reindeer husbandry both follow an annual cycle, that is, each season or sub-season has its particular requirement for the landscape (Sara, 1997). Generally a varied landscape will produce a high abundance of pasture and other use areas. This effect is found to outnumber the counter effect of steepness. Thus we hold that a varied micro-landscape will tend to increase pasture capacity.

[1] For one group competing with other groups.

3.2 Pasture-Herbivore Interaction

In this subchapter we will explore the implications of physical and economic mechanisms governing pasture use. The reindeer (*Rangifer tarandus tarandus*) is a semi-domesticated ungulate. Compared with full-domestic ungulates as e.g. cattle, goat and sheep, *the semi-domestic reindeer occupy a particular ecological niche insofar as it is independent of supplementary feeding for winter survival*. This fact also provides reindeer herd management with comparative advantages of low-cost feeding (cf. Oksanen, 1992:4). Alternatively the cost of total feeding of reindeer on food concentrate for 3 winter months would equal the value of the contemporary average annual production of reindeer in Norway (Lenvik, 1989:11). That means extensive supplementary feeding for reindeer will bring the animal out of its niche and make it compete with more effective alternatives, as sheep, in their respective niches thereby spoiling the reindeer's comparative advantage.

A main division of *pasture* areas for reindeer is between the green pastures (mainly herbs and grasses) of summer time and the more or less snow-covered lichen pastures of winter. Fall and spring pastures have a composition in-between these extremes, but for our model purposes bisection is sufficient. For the reindeer the green-pasture season is an anabolic phase which means a physiological building-up of protein reserves, while winter is a catabolic phase where food-intake is reduced and the animals to a considerable extent survive on the accumulated reserves from summer. The animals' energy requirement is about 5 times higher in summer than in winter (Rehbinder and Nikander, 1999). While protein reserves are stored from summer to winter, lichen pastures are stored from year to year (cf. Table 2.3, availability of *storage* facilities). Grasses and herbs not being grazed are wilting by the end of the growing season, while lichens not grazed can live for many years. This corresponds with fundamental differences in both growth pattern and resilience, which we will inquire below. The implications of the different features, and their interconnections, are not easy to survey without formal modeling. In the following, we will therefore discuss models of the dynamics between reindeer and pasture. We start with a simple pasture-herbivore model, which is well known from the literature, and proceed by developing a new two-pasture-herbivore model.

3.2.1 A pasture-herbivore model

Ecological models as a rule describe systems of two, and sometimes three, trophic levels[2]. The sustenance of the system in question is dependent upon balance in growth and exploitation between all levels modeled. Modeling is accomplished by means of a set of differential[3] or difference[4] equations. Each equation describes one trophic level (Maynard Smith, 1973, Rosenzweig, 1973). In the context of difference equations *a steady state solution,* x_{bar}, can, following Edelstein-Keshet (1988:40-44), be defined to be a value satisfying the relation:

$$x_{n+1} = x_n = x_{bar}; \qquad \text{(Eq. 3.1)}$$

[2] nutrional levels as producers, herbivores and predators.

[3] continuous case

[4] discrete case

implying no change from generation n to generation n+1 so that x_{bar} is a fixed point for a function f (x). A steady-state solution can be stable or not. It is *stable* if neighboring states are attracted to it, and *unstable* if the converse is true. A small perturbation of the steady-state situation will distinguish between stable and unstable states. As an example a ball at rest in the bottom of a valley will return to its former position if kicked slightly or even strongly, while the slightest disturbance will cause a ball resting at the top of hill to run away towards one of the adjoining valleys. Generally spoken. Under what conditions will plant and herbivore populations be mutually regulating? Will there be stable steady-state solutions for plant-herbivore interaction?

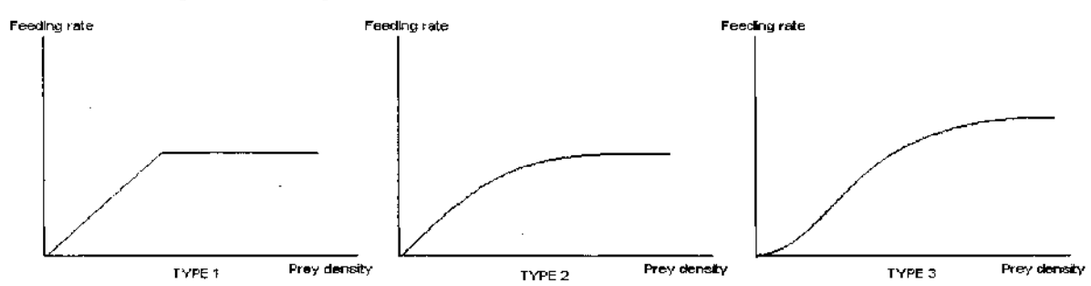
3.2.1.1 Models of two interacting populations

The simplest model for systems of two interacting populations as e.g. a predator-prey system — here notated as a plant-herbivore system, is the classic Lotka -Volterra equations:

$$dV/dt = gV - cVH \qquad \text{(Eq. 3.2)}$$
$$dH/dt = -mH + rVH \qquad \text{(Eq. 3.3)}$$

where V is vegetation biomass, g is vegetation growth rate, c is herbivore consumption rate, H is herbivore biomass, m is herbivore mortality rate and r is herbivore growth rate.

When a predator-prey type, the prey population, *V(t)*, has a potential for unbounded exponential growth, *gV*, which is limited by predation measured by the so-called *functional response* term, *cVH*. The predator population, *H(t)*, has a total mortality, *-mH*, and a total growth called *numerical response* term depending on prey abundance as *rVH*. This system, having all constant rates, is *oscillating* with a period determined by the parameters of the model and amplitude determined by the initial conditions (May, 1981). A hare-lynx system may be described broadly similar to this model. By modifying the terms we can develop models covering a wide variety of interaction patterns. Standard modifications are the inclusion of density dependence and saturation effects. Holling (1965) defines three types of the functional response, cf. Figure 3.1.



Feeding rate is c . Prey density is V.

Figure 3.1. Three Types of Functional Response
Source: Holling, 1965 (cf. Begon,Harper and Townsend, 1996:346-350)

Type 1, which has a linear rise and a plateau, is not so frequently observed (Begon et al., 1996:349), but there are examples of linear rise for herbivores (Crawley, 1983). For the most customary observed functional response (type 2) consumption gradually increases with prey

density, but decelerates until a plateau of constant consumption. The last type (type 3) is sigmoid with an accelerating consumption at low prey densities and similar to type 2 at higher densities.

Grazing systems is a special type of predator-prey systems, where the predator is a herbivore and the preys are plants. Monro (1967) makes a primary division of grazing systems between those in which the herbivores influence the food growth and those systems where they do not. The former type is called *interactive* systems and the latter *non-interactive* systems. Caughley and Lawton (1981) make subdivisions classifying non-interactive systems into *reactive* systems where the growth rate of the herbivores reacts to the regeneration rate of the vegetation and *non-reactive* systems in which the herbivores increase largely independent of plant growth. The interactive systems are divided into *laissez-faire* systems in which the herbivores do not interfere with each other's feeding activities and *inferential* systems in which an animal may reduce the potential food ability for others.

3.2.1.2 Model development

We assume that the system we study is a pasture-herbivore system of the inferential type. A more generalform , allowing for rate variations, of the equations 3.2 and 3.3 is:

$$dV/dt = g(V)V-c(V)VH; \qquad \text{(Eq. 3.2.a)}$$
$$dH/dt = -m(H)H + r\,(V,H)VH; \qquad \text{(Eq. 3.3.a)}$$

Equation (3.2.a) can also be written dV/dt=G-C, where G is total vegetation growth and C is herbivore plant consumption (functional response). Including density dependence in the plant growth term is usually obtained by the logistic equation, which can be written:

$$dV/dt= gV(1-V/K); \qquad \text{(Eq. 3.4)}$$

where $K>0$ is the vegetation carrying capacity and $g>0$ the intrinsic growth rate of the vegetation. Inserting into equartion (3.2.a), we have for the net change in vegetation when grazed (total vegetation growth minus consumption):

$$dV/dt=gV(1-V/K)-c(V)VH \qquad \text{(Eq. 3.5)}$$

Specifying the effect of grazing as a type-2 functional response the *vegetation equation of motion* can be:

$$dV/dt = gV(1-V/K)-c[V/(V+D)]H \qquad \text{(Eq. 3.6)}$$

Here c, consumption per herbivore, is a positive constant and $D>0$ is a *self-saturation coefficient*, a characteristic density of vegetation at which the herbivore functional response starts to saturate (May, 1981); being inversely proportional to grazing efficiency at low plant density. Maynard Smith (1974) interprets the coefficient to be an expression for the time-span from biological consumption to biological growth. These two interpretations are not necessarily contradictory, and D could be considered as encompassing both effects.

Turning our attention to the herbivore equation (3.3.a) we assume herbivore mortality being a constant, $m<1$. Further we assume the numerical response, rVH, to be saturating similarly to

the type 2 functional response. Here $r>0$ is the herbivore intrinsic growth rate. For the net change of herbivores, the *herbivore equation of motion*, we have:

$$dH/dt = - mH + rHV/(V+D) \quad = H\,[rV/(V+D)-m] \qquad \text{(Eq.3.7)}$$

The equations (3.6, 3.7) are established as system of equations of motion for vegetation and herbivores as described both by Rosenzweig and MacArthur (1963) and Brekke and Stenseth (1994). Skonhoft (1998) and Øye (1996) use the same model discussing reindeer management.

Let us now consider this model as a standard model for ungulates (cf. Caughley and Lawton, 1981) and inquire its stability properties. Our first step is to derive the *zero-isoclines* for each trophic level. Zero-isoclines are *demarcation curves indicating exactly constant biomass for the trophic level in question* (cf. Begon, Harper and Townsend, 1996:275). Starting with the vegetation, we insert $dV/dt = 0$ into the vegetation equation of motion (Eq. 3.6), and produce the *vegetation zero-isocline*:

$$H = g/c\,(1-V/K)(V+D); \qquad \text{(Eq.3.8)}$$

which represents *the herd size exactly removing the regrowth of vegetation.* Herd sizes higher than the vegetation zero-isocline will reduce the standing crop of vegetation biomass (*overgrazing*), while herd sizes under it will make the vegetation biomass increase (*undergrazing*). The vegetation zero-isocline is depicted in Figure 3.2 with vegetation on the horizontal axis and herbivores on the vertical. The vertical arrows indicate the direction of movement for vegetation biomass over and under the isocline.

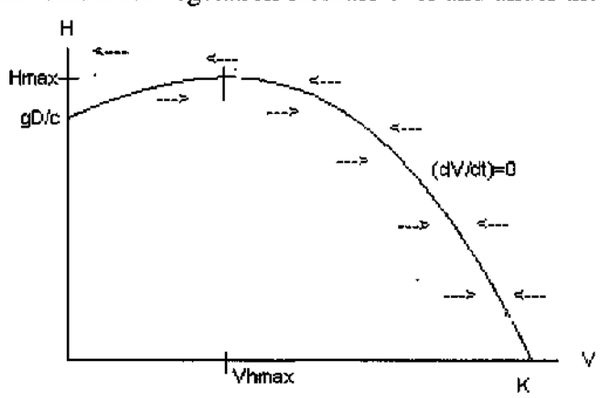


Figure 3.2. The vegetation zero-isocline.
Arrows represent direction of movement for vegetation biomass

Considering the isocline further, we insert $V=0$ into equation 3.8, which yields $H=gD/c$; being the isoclines intersection at the H-axis. Likewise; inserting $H=0$ yields $V=K$; being the isocline intersection at the V-axis.

Differentiation provides:

$$dH/dV = -g/c\,[2V/K+D/K-1)] \qquad \text{(Eq. 3.9)}$$

Inserting (into eq. 3.9) $dH/dV = 0$ implies; $V = (K-D)/2$; which is an extreme point. Differentiating once more (from eq. 3.9) yields;

$d^2H/dV^2 = -2g/Kc < 0;$ (Eq. 3.10)

We can sum up that *the vegetation zero-isocline is concave with a maximum point,* for $V = V_{Hmax} = (K-D)/2$. Inserting for V into eq. 3.8 yields;

$H_{MAX} = g[(K+D)/2]^2/cK$ (Eq. 3.11)

Interpreting the vegetation zero-isocline, the intersection of the V-axis, K, is the vegetation *carrying capacity*. At this point the vegetation produce no regrowth and the herbivores thus would be extinct. The intersection of the H-axis means that *the vegetation can be grazed down completely*. How can we interpret that the herbivores constitute a positive number H=gD/c when V=0? The expression tells us that there is a positive plant biomass growth consumed by a number of herbivores. I suggest the interpretation that the growth gD is sprouting from plant roots, that means V must be interpreted as the accessible over-ground level vegetation, which would be compatible for the growth pattern of perennials. That is, *the herbivores will not be extinct even though the standing crop of grazeable vegetation becomes zeroed*[5] (conditioned that the herbivores have a positive net growth rate, see below).

Turning our .attention to the herbivores we insert dH/dt=0 into the equation of motion (eq.3.7) and the *herbivore zero-isocline* becomes:

$V = mD/(r-m);$ (Eq. 3.12)

and represents *the vegetation biomass exactly sufficient to sustain a stable herd size*. All parameters being positive numbers; V is positive when r>m. The graph of this isocline, made up of parameters all being constants, can be depicted as vertical straight line from one value at the V-axis. The system of the zero-isoclines, the equations (3.8, 3.12), is depicted in Figure 3.3.

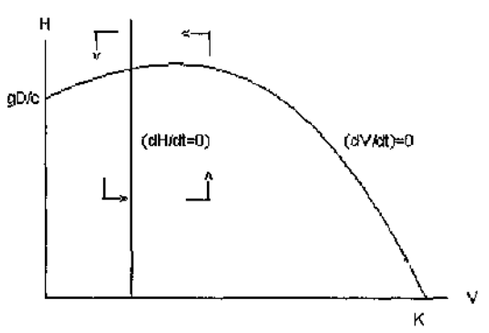


Figure 3.3 The Zero-Isoclines of Vegetation and Herbivores.
The arrows indicate movement directions

Vegetation levels to the right of the herbivore zero-isocline imply an increase in herd size,while vegetation levels to the left of the herbivore zero-isocline lead to reduction in herd size. Depending on the magnitude of V in equation (3.12) the intersection between the two zero-isoclines can be placed between V=0 and V_{max}, as in the the figure, or at an other point

[5] If we compare with a situation where there is an inaccessible vegetation refuge, the isocline would intersect the V-axis at a point R > 0 and both the standing crop and the annual growth would be inaccessible.

of the graph of dV/dt (eq. 3.8). The arrows in the figure represent the direction of movement for both trophic levels. The two zero-isoclines create four sectors with particular movements each. The intersection of the two zero-isoclines represents the adaptation where both plant and herbivore biomass are sustained.

Stability properties

Initially in this subsection we introduced stability and steady state solutions. Studying stability we generally explore, which changes in equations or systems challenge stability and which do not. For equations parameters can need to be within critical values (bifurcation values), e.g. the logistic equation (eq. 3.4) goes from stability to stable oscillations when our parameter g pass the value of 3 from below (May, 1976). For systems the stability conditions can be solved algebraically or graphically; where how zero-isoclines intersect can be critical.

The stability of our system depends of where the intersection of the zero-isoclines is placed in relation to V_{MSY}. If the dH/dt=0 crosses the dV/dt=0 curve to the left of V_{MSY}, both species in the system will perform temporary oscillations with constant amplitude. That is, V and H will exhibit a pattern both fluctuating over time. If the equilibrium is to the right of the maximum point the system will perform dampened oscillations and the number of both species will stabilize over time (Maynard Smith, 1974). Considering the growth rates, we note that increasing g will lift the vegetation zero-isocline, but not influence VMSY- Increasing the herbivore intrinsic growth rate, r, will move the herbivore zero-isocline over to the left and be synonymous with increased instability. Increasing the mortality, m, will on the contrary have a stabilizing effect by moving the herbivore zero-isocline to the right. That is, increasing the herbivore net growth rate, r-m, will have a destabilizing effect on the system.

Studying the effect of varying the magnitude of D in the herbivore zero-isocline, we note that low D-values[6] are consistent with animals being efficient grazers. These will have a less stabile adaptation than *inefficient grazers* (high D-values). Increasing the value of the self-saturation coefficient D in an existing system, will both shift the H-isocline to the right and also the level of V_{MSY} to the left, thereby stabilizing the system performance (cf. Oye, 1996). Inquiring the effects of changing the size of K, we observe that increasing K will shift the level of V_{MSY} to the right and thereby contribute to system destabilization. This is what Rosenzweig (1971) named *the enrichment paradox.* Obviously the paradox is that increasing accessible pasture capacity increases instability. Studying D and K simultaneously we note that increasing the relation K/D, which is a measure of accessible pasture, means lowered stability. Adding our knowledge about herbivore growth rates, we can sum up that for an existing system in initial balance: *(1) high relations between the parameters K/D and (2) a high herbivore net growth rate (r-m),* by themselves and in combination, *have the potential of implying system destabilization.*

Discussing the real world implications of instability in models with respect to ungulates, Caughley (1971:211-215) asserts that no cycling ungulate population has ever been recorded, neither has oscillations of increasing amplitudes been reported for herbivores of any area.

[6] We should note that in model where we defined D=0 as a possible value this would be compatible with a situation where all plant parts, roots included, would be removed. Thus there would be no regrowth and the herbivores would extinct. This is possible to imagine for efficient grazers as e.g. goats.

Including an investigation of the well-known example of reindeer population eruption and crash at St. Matthew Island (Klein, 1968) he concludes that though limit cycles and unstable equilibria are theoretically possible, they are not a feature of ungulate population dynamics. Metzgar and Boyd (1988) do not consider stability a general feature of ungulate-forage relations and expect catastrophic vegetation instability in relative simple environments where vegetation is particularly vulnerable to herbivores. They therefore find that persistence of such systems will depend on *herbivore migration.* I will not inquire further the implications of differences in the views of Caughley vs. Metzgar and Boyd, but state that the distinct features of seasonal pastures is an argument for two-pasture-modeling for populations of reindeer. Before we proceed to the two-pasture model, we will however inquire the effects of harvesting, which is equivalent with hunting or reindeer management, within our one-pasture model.

A model including harvesting

Since we now are applying the general model on reindeer we will interchangeably use for H *herd size* (of a standard average reindeer) and *herbivore biomass.*

Both reindeer management and hunting of wild reindeer are based on harvesting reindeer. Harvest means adding a humanly directed mortality to the natural one. Starting with the herbivore (herd) zero-isocline from above (eq. 3.12), we may therefore add harvest as an an extra term to the mortality term. We aim to find *the harvest rate rate exactly keeping the herd size in accordance with the herbivore zero-isocline.* Denoting this term *the balance harvest rate,* x, the herbivore zero-isocline performs this version:

$$V = (m+x)D/ r-(m+x); \qquad \text{(Eq. 3.12.b)}$$

V is still a straight line in the V-H plane. Solving for x, produces an alternative expression for the herbivore zero-isocline. The balance harvest rate, becomes:

$$x = (rV/V+D) - m \qquad \text{(Eq. 3.13)}$$

Differentiating with respect to V produces:

$$dx/dV = rD /(V+D)^2 \quad \text{which is } > 0 \text{ all positive V.} \qquad \text{(Eq. 3.14)}$$

Differentiating once more yields:

$$d^2x/dV^2 = - 2rD/(V+D)^3 \quad \text{which is } < 0 \text{ for all positive V.} \qquad \text{(Eq. 3.15)}$$

The balance harvest rate, x=0 for V=mD/(r-m); which is the original herbivore zero-isocline (eq. 3.12).

For V<mD/(r-m) the balance harvest a steady population of H cannot be sustained. Observing Figure 3.3 adaptations to the left of the herbivore zero-isocline means reduced herd size, but increased vegetation biomass when herd size is under the vegetation zero-isocline (cf. lower left quadrant).

For V>mD/(r-m), the balance harvest rate x is increasing at a decreasing rate approaching r-m asymptotically when V increases towards infinity, cf. Figure 3.4. We can imagine the graph of the balance harvest rate in the third dimention by placing the graph of Figure 3.4 vertically on the paper plane with the graph for x intersecting the V-axis at the same point as the herbivore zero-isocline.

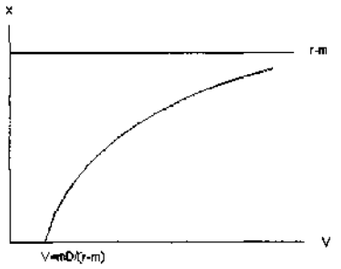


Figure 3.4. Harvest rate as a function of vegetation biomass

Defining output (yield), Y, as total sustainable harvest, that would be herd size, H, times the balance harvest rate, x. We insert from the two zero-isoclines (eq. 3.8, 3.13);

$$\begin{aligned} Y &= Hx \\ &= (g/c)(1-V/K)(V+D)[(rV/V+D)-m] \\ &= (g/c)(r-m-D)V(1-V/K) \end{aligned} \qquad \text{(Eq.3.16)}$$

The output is zero when x is zero; for V=mD/(r-m).
Differentiating with respect to V produces;

$$\begin{aligned} dY/dV &= (g/c)(r-m-D)d[V(1-V/K)]/dV \\ &= (g/c)(r-m-D)(1-2V/K) \end{aligned} \qquad \text{(Eq. 3.17)}$$

Inserting zero for the derivative identifies V=K/2 as an extreme point.
Differentiating once more yields;

$$d^2Y/dV^2 = -2(gK/c)(r-m-D); \qquad \text{(Eq. 3.18)}$$

which is a straight line, always negative, implying over-all concavity for the output function. We conclude that *the output function is increasing at a decreasing rate with a maximum,* at V_{MSY}=K/2. The output function is depicted in Figure 3.5.

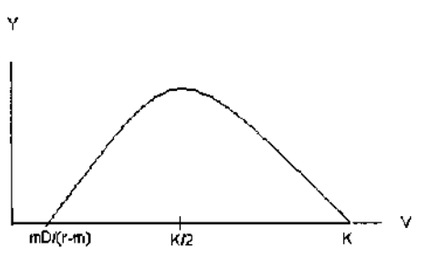


Figure 3.5. Output as a function of vegetation biomass

Output is a function of both herd size and harvest rate. Herd size and harvest rate are in turn functions of vegetation biomass; that is Y=Y(H(V), x (V)). We can also depict how output vary with herd size taking the variation in harvest rate into account (given that both herd size and harvest rate vary in accordance with the zero-isoclines), cf. Figure 3.6.

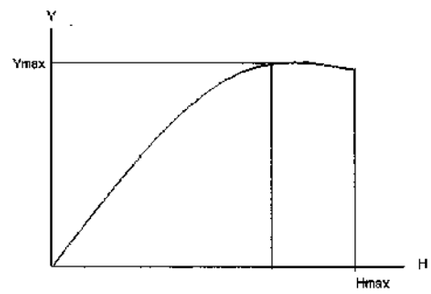


Figure 3.6. Output varying with herd size

We note that output increase with increasing herd size to a maximum, reflecting V= K/2 (eq. 3.17, cf. Figure 3.5), and then decrease until maximum herd size is reached at HMAX= $g[(K+D)/2]^2/cK$ (eq.3.11, cf. Figure 3.2) and the output curve drops to zero. The sudden drop in output means that there at *herd sizes higher than* HMAX *is no output on the zero-isoclines.* Any H> HMAX will thus imply overgrazing (cf. comments to eq. 3.8).

Recalling the stability considerations in the previous section, the extension of the one-pasture model to include harvesting does not affect the vegetation zero-isocline. As for the herd zero-isocline, harvesting by adding human-decided mortality to that of nature decreases the net growth rate and thereby increases stability. As a corollary *harvesting,* conditioned that the humans pursue a strategy implying an adaptation in correspondence with the herbivore zero-isocline, *provides an opportunity of eliminating herd regrowth as a source of instability,* leaving us with the enrichment paradox (a high K/D relation) as the only feature promoting destabilization. However, if the humans choose a management strategy including a harvest rate lower than the the balance harvest rate, x, instability may persist.

In the following section we extend our modeling to include two pastures.

3.2.2 A Two Pasture-Reindeer Model

The one-pasture model above is general and does not include what is peculiar for reindeer, as already stated, the character of winter food. The main diet during winter is lichens (Cladonia spp.), which have their optimal growth when grazing is limited, while most summer feeding plants (herbs and grasses) can be relatively heavily grazed one year without this affecting the pasture capacity of subsequent years. Grazing on average more than the annual growth of lichens will reduce standing crop and may thus reduce long term system stability. This dissimilarity implies different dynamics between pastures and herd for different seasons. In addition, different seasonal pastures also have specific ecological roles. *For northern ungulates the capacity of the winter pastures are considered to limit herd size while the potential of green pastures (summer) decides the exploitation of the growth and production potential of the herd via each animal* (Klein, 1968). This is known as *the Klein hypothesis.*

On this background I find that, though general models of the Rosenschweig-MacArthur-type provide important basic knowledge, there is a need to extend the reasoning to a two-pasture setting. I have not found any theoretical work on this subject, andt I therefore challenged myself to make an attempt. Thus my intention in this subchapter is to construct a reindeer two-pasture model reflecting both intra and interseasonal realtions. The model has analytic purposes aiming to capture essential features without a need of advanced mathematical skills. The general model above is used as a point of departure for the summer season. To ease computation we define K=1. We also add subscripts for summer, *su*, when necessary. This creates the adjusted *summer vegetation equation of motion* (cf. eq. 3.5) and the adjusted *summer pasture zero-isocline* (cf. eq. 3.8):

$$dV_{Su}/dt = g_{Su}V(1-V) - c_{Su}[V/(V + D)]H_{Su} \qquad \text{(Eq. 3.5.b)}$$

$$H_{Su}=(g_{Su}/c_{Su})(1-V)(V+D) \qquad \text{(Eq. 3.8.b)}$$

We should remark that V and D receive no subscripts. The reason is that we will introduce an other letter for winter pasture vegetation and that we have no direct parallel to the selfsaturation coefficient, D, for our winter pasture model (see below).

In the one-pasture model we discussed the self-saturation coefficient D as a characteristic influenced by vegetation and herbivore properties. Summer pastures mainly consist of *grasses* and *herbs*. Being rapid growing; grasses and some herbs are perennials[7], sprouting from their roots while most herbs are annuals, germinating from seeds, however, as groups they share *a relatively high level of robustness towards physical erosion*. Reindeer are known as picky feeders and as such less efficient grazers than e.g. sheep and goats, in particular at summer pastures. Thus, we can sustain the interpretation given of the relation between D and V given above. However, as humans can manipulate both animals and pasture, we may imagine that humans can manipulate D. Focusing grazing efficiency, we assume that human direction via herding can increase grazing efficiency and thus lower D.

The summer pasture share the features of the vegetation for one-pasture model, e.g. maximum herd size on summer pasture will be:

$$H_{Su(MAX)}= g_{Su}/c_{Su}[(1+D)/2]^2 \qquad \text{(Eq.3.11.b)}$$

We proceed by developing (1) a model for the reindeer lichen dynamics, (2) a reindeer herd model using the Klein hypothesis as a starting point, and (3) combining them into a herd and two-pasture model. The remainder of section 3.2.2 is mainly mathematical construction and analysis of this very model.

3.2.2.1 Lichen growth and consumption

Contrasting grasses and herbs, lichens[8] grow slowly, about 10 percent annualy (Gaare, 1998) and are fragile too, especially under dry conditions as in summer, while they in winter are

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7 Generally the proportion of annual and biannual plants decrease with increasing altitude and latitude (cf. Heide, 1997)

8 A symbiosis between fungi and algae into a thallus mainly consists of the fungi component. The most important group for reindeer is erected, and on the ground growing shrub lichens, especially the genera Cladonia and Cetraria, but in some arens also the tree hanging "beard" lichens are very important, e.g. Swedish continental forests.

protected by a snow-cover, which limits accessibility. Carpet forming lichens have a peculiar growth pattern. Andreyev (1977:298) defines three stages; (1)Podetium (fruticosae thallus) formation and growth (8-14 years), (2)podetium renovation, i.e., simultaneous growth and decay (from below) with positive net growth, and (3) podetium dying off when the rate of dying off exceeds the creation. Connecting this to our general equation of change in plant biomass (eq. 3.2.a) this concerns the first term, total vegetation growth — also denoted G. In Andreyev's phases (1) and (2) $G>0$, while in his phase (3) $G<0$. In our context phase (3) have no interest. We denote total lichen biomass, L, maximum lichen biomass as K_L, and total lichen growth G_L. We focus the phases with a positive G_L and $L< K_L$.

Andreyev (1977:298-302) provides observations of relative growth rates in his phases (1) and (2). Kärenlampi (1973), cf. Virtala (1992:244) has measured net growth at different levels of lichen standing biomass. Converting these data to a common form show good correspondence between the two authors' observations. The basic growth pattern seems to be sigmoid at low L, having a maximum point G_{Max} at about $K_L/3$ and be decreasing at a somewhat increasing rate for $L > L_{GMax}$), cf. Figure 3.7. The relative lichen growth, G_L/L, varied from near zero to 14 percent when L varied from near zero to $L_{G(Lmax)}$.

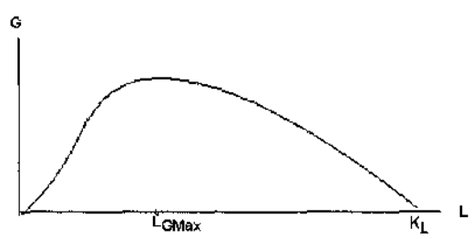

Figure 3.7. Observed lichen growth pattern

This is a growth pattern performing clear deviation from logistic growth. However, to limit complexity in functional form[9], I have chosen the well-known logistic function L(1-L) to represent lichen growth in our modelling. Denoting lichen growth rate g_L (a positive constant) we have:

$$G_L = g_L L(1-L); \qquad \text{(Eq. 3.19)}$$

which is zero for L=0 and L=1 and positive for $0<L<1$. From general knowledge about the the logistic fuction[10] we know that G_L is thus increasing at a decreasing rate up to a maximum at L =1/2 and decreasing to zero at L=1.The growth function may be represented by Figure 3.8.

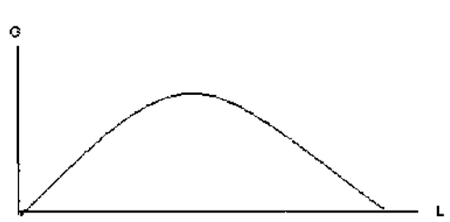

Figure 3.8. Lichen growth model (logistic function)

9 More complex functional forms did not improve the model enough to defend the more inconvenient computation.

10 or cf. the reasoning around Figure 3.5 for a related but little more complex functional form

Gaare and Skogland (1980:49) have inquired and modelled lichen consumpion for wild reindeer. Here two elements of their model will be used. Firstly, a *residual biomass* R is defined. *R is a minor portion of L that normally is not grazed due to energetic cost.* Gaare and Skogland (op. cit.) use a R-value of 2,7% in their model. As lichens at winter is under snow-cover, the lower is L, the higher is the energetic cost on searching and digging for lichen. When this cost exceeds the income of the lichen food intake the reindeer will shift from grazing lichen to subsistence on vascular litter and bryophytes — which is inferior feeding but may be possible to survive on. The shift is a hunger drive, and it also is common herder knowledge that grazing herds scatter when there is a lack of lichen on winter pasture. This mechanism can be an explanation that Malthusian catastrophes might be avoided (cf. Beach, 1981:46-47, Ingold, 1976:31-32). *Thus lichen biomass is never grazed to zero when there is a normal snow-cover.*

Secondly, they find a functional response of Holling's type 1 (cf. Figure 3.1) to be the most appropriate. A major explanation is that the magnitude of wastage[11] increases about 5 times from low to high L-levels. We here choose to model consumption as linearly increasing with lichen biomass[12]. We denote total lichen consumption C_L (cf. comments to eq. 3.2.a) lichen consumption per average animal lichen consumption c_L (cf. eq. 3.2.a). In defining R as a minor part of L, we have chosen to use a magnitude of R ranging from zero up to R=0,1 in our modelling. Further we denote winter herd size, H_W. Total lichen consumption (cf. eq. 3.2.a, second term) can be represented by the equation:

$$C_L = H_W c_L (L-R); \qquad \text{(Eq. 3.20)}$$

Combining with the lichen growth expression (eq. 3.19), we construct (cf. eq. 3.2.a) *the lichen biomass equation of motion*:

$$\begin{aligned} dL/dt &= G_L - C_L \\ &= g_L L(1-L) - H_W c_L (L-R) \end{aligned} \qquad \text{(Eq. 3.21)}$$

Constant lichen biomass, that is inserting (into eq. 3.21) dL/dt=0 and solving for H_W, produces *the lichen zero-isocline*:

$$H_W = (g_L/c_L)\, L(1-L)/(L-R) \qquad \text{(Eq. 3.22)}$$

Per definition H_W is the winter herd size that exactly graze the total lichen growth keeping lichen biomass constant, for every L. Inspecting the equation, we find that H_W is undefined for L=R and zero for L=0 and L=1. H_W is negative for 0<L<R and positive for R<L<1. We interpret negative herd size as no grazing on lichen. The break in the curve at R means *that the curve section between 0 and R is without practical interest as R per definition is the lower limit for L biomass being an object for grazing.* We assume that nutrion from litter and bryophytes (see above) is of minor significance to our modelling. We will come back to R below.

Differentiating (eq. 3.22) makes the equation:

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11 Lichen affected but not eaten

12 Assuming that the Holling plateau level of unchanged consumption is reached at levels so near K=1, that it isinsignificant for our purposes.

$$dH_W/dL = (g_L/c_L)[-L^2+2RL-R]/(L-R)^2] \qquad \text{(Eq. 3.23)}$$

which also is undefined for L=R. Insofar as the denominator is always positive when the function is defined, the sign of the derivative is determined by the nominator, which is a parabolic. The nominator has the roots; $L=1-/+\sqrt{[(R-1)/R]}$; which has no solution for when R is defined. That is; dH_W/dL is always negative, meaning that *when the lichen zero-isocline is defined* H_W *is an always-decreasing function* in the area $0<L<1$ (Of practical interest; the area $R<L<1$).

Differentiating once more (eq. 3.23) produces the expression:

$$d^2H_W/dL^2=2Rg_L/c_L \; [L^2+(1-3R)L+R^2]/ (L-R)^4; \qquad \text{(Eq. 3.24)}$$

which also is undefined for L=R. The denominator is always positive when the function is defined. The nominator is parabolic having roots given by the expression: $L=\{(3R-1)+/\sqrt{(1-6R+5R^2)}\}/2$; which has no solution for defined values of R. That is; d^2H_W/dL^2 is always positive and *the lichen zero-isocline is convex.* Lichen zero-isoclines with different R-values ,R=0,1 to R=0, are plotted in Figure 3.9.

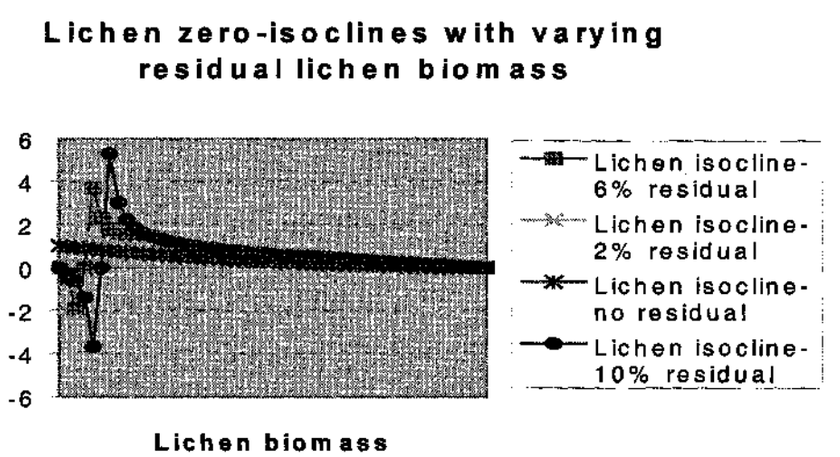


Figure 3.9. Lichen zero-isoclines for different residual lichen biomass levels R is where the curves break the H-axis.

Inquiring further the effect of changing magnitude of R, we differentiate the lichen zero-isocline with respect to R:

$$dH_W/dR= (g_L/c_L)d[L(1-L)/(L-R)]/dR \; = (g_L/c_L) \; [L(1-L)/(L-R)^2]; \qquad \text{(Eq. 3.25)}$$

which also is undefined for L=R and zero for L=0 and L=1. All terms being positive for other $0<L<1$, makes the partial derivative for the residual positive in the whole range. That is, the higher is the residual biomass, the higher is the lichen pasture zero-isocline. The practical meaning is *that the higher is R, the higher can winter herd size be without overgrazing.* The magnitude of R will be a function of the accessibility of the remaining L, the *magnitude and packing of the snow-cover* being the most important factor. That is, the lower is accessibility, the higher is R. Inspecting equation 3.22 we find that when R is approaching zero, H_W will approach $H_{W,R=0}=g_L(1-L)/c_L$, which exists in the whole range $0<=L<=1$ being a straight decreasing line

intersecting the H-axis at 1 and the L-axis at 1. *At R=0 there is no shift away from lichen grazing at low L, and lichen biomass is grazed down to L=0, which in this model means extinction of both lichen and reindeer* (sustaining our given assumption of litter and bryophytes is of minor significance). The practical implication of this is *that snow–cover is of major importance for sustaining lichen pastures, and reindeer.*

3.2.2.2 Herd interaction

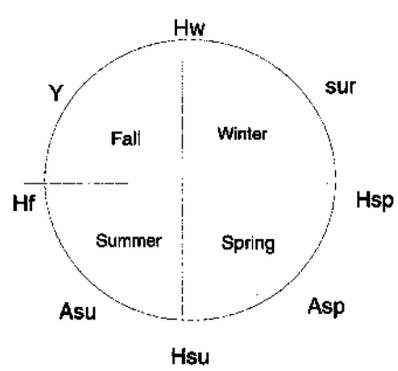
To understand the basics of herd dynamics we start by dividing the year into four main seasons which each has their main events: winter: survival (winter mortality); spring: calving; summer: physiological growth; and fall: harvest. We assume no mortality in other seasons than winter, and that physiological growth takes place only at summer[13]. We also assume that all slaughter is performed during fall. We define interseasonal connections in Table 3.1.

The basic connections are:
-winter herd(H_W) times survival rate (sur) is spring herd (H_{Sp})
-spring herd times spring accumulation rate (A_{Sp}) is summer herd (H_{Su})
-summer herd times summer accumulation rate (A_{Su}) is fall herd
-fall herd (H_F) minus harvest (Y) is winter herd.

Table 3.1. Seasonal herd concepts and events

SEASON	*HERD*	*EVENT*
Winter	Winter herd (H_W)	Survival rate (sur)
Spring	Spring herd (H_{Sp})	Spring accumulation rate (A_{Sp})
Summer	Summer herd (H_{Su})	Summer accumulation rate (A_{Su})
Fall	Fall herd (H_F)	Harvest (Y)

A sketch of the annual cycle, indicating the connections of the events, is presented in Figure 3.10.



Hw=winter herd, Hsp=spring herd, Hsu=summer herd, and Hf=fall herd.
sur=survival rate, Asp=spring accumulation, Asu=summer accumulation and Y=Yield

Figure 3.10. An annual cycle of herd dynamics
Inspired by Virtala (1992:236)

13 Recalling the Klein hypothesis introduced above, we here have extended the assumptions of the hypothesis by connecting both mortality and natality to winter pasture, while we have sustained the assumption of the connection between summer pasture and individual physiological growth.

Using the concepts of Table 3.1, and given a steady state winter herd ($dH_W/dt=0$) we can when observing the connections of Figure 3.10, establish two links between winter herd and summer herd:

(1)The *spring* connection; $H_{Su}= H_{Sp}A_{Sp}= H_W surA_{Sp}$ (Eq 3.26)
(2)and the *fall* connection; $H_{Su}A_{Su}-Y= H_F-Y = H_W$ (Eq. 3.27)

Combining them and solving for Y, produces our *herd zero-isocline;*

$$Y= H_W(surA_{Sp}A_{Su}-1); \quad \text{(Eq. 3.28)}$$

where the parenthesis expresses *the net growth rate* on annual basis. We note that this rate is positive when the product of the factors is greater than one. The herd zero-isocline will also be the basic *output* function (note the parallel to eq. 3.16). H_W is already defined in our previous subchapter. For establishing connections to pastures the herd-zero-isocline needs specification.

3.2.2.3 Herd and pasture interrelations

Using the annual cycle in Figure 3.10 as a startpoint, here we will specify the interseasonal relations and next connect them to derive a specified herd zero-isocline.

We specify the spring herd, $H_{Sp}= H_W sur$ (cf. eq. 3.26) by assuming[14] the *survival rate*, sur, to be decreasing with increasing lichen biomass as a hyperbolic function, and define:

$$sur=1- m/L; \quad \text{(eq. 3.29)}$$

where *m* is mortality rate. Inserting into the equation 3.26 we establish:

$$H_{Sp}= H_W(1- m/L); \quad \text{(eq. 3.30)}$$

Recalling that the winter herd was determined by the lichen pasture zero-isocline (eq. 3.22), by insertion into equation 3..30, we obtain for the surviving spring herd:

$$H_{Sp} = (g_L/c_L)L\ (1-L)/(L-R)(1- m/L) = (g_L/c_L)L\ (1-L)/(L-R)(L-m)/L]$$
$$= (g_L/c_L)(1-L)(L-m)/(L-R) \quad \text{(Eq. 3.31)}$$

Summer herd, H_{Su}, is herd size including the calves of this year, and for the factor of accumulation through birth, spring accumulation, A_{Sp}, we have in equation 3.26 established the connection $H_{Su}= H_{Sp}A_{Sp}$. Assuming[15] that maximum birth rate, *natality*, is *n*, and that the realized birth rate is a function of lichen biomass, increasing, first accelerating and then decelerating via a turning point, a polynomial of the degree 3 with the coeffisients α, β, χ and δ can describe such a development[16]. That is:

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14 We also assume that winter mortality is independent of summer pasture capacity, which is a clear simplification as protein deposits built up at summer pastures is an important factor for winter survival (Rehbinder and Nikander, 1999:25)

15 We do not include in our model that good summer pastures is important for achieving a high pregnancy rate.

16 For our modeling we have chosen a=-2,b=3,c=0 and d=1 as a non-extreme example.

$$A_{Sp} = (1+n)(\alpha L^3+\beta L^2+\chi L+\delta) \qquad \text{(Eq.3.32)}$$

An example of a possible pattern of spring accumulation is depicted in Figure 3.11.

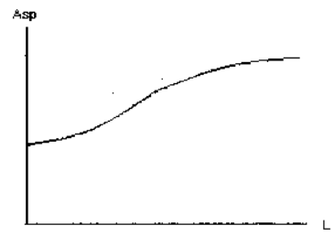

Figure 3.11. Spring accumulation as a function of lichen biomass

By inserting (eq. 3.32 into the connection from 3.26) we establish:

$$H_{Su} = H_{Sp}(1+n)(\alpha L^3+\beta L^2+\chi L+\delta) \qquad \text{(Eq. 3.33)}$$

Inserting for spring herd (eq. 3.31), we receive:

$$\begin{aligned} H_{Su} &= [(g_L/c_L)(1-L)(L-m)/(L-R)][(1+n)(\alpha L^3+\beta L^2+\chi L+\delta)] \\ &= (g_L/\, c_L\,)(\alpha L^3+\beta L^2+\chi L+\delta)(1-L)(L-m)(1+n)/\, L-R) \end{aligned} \qquad \text{(Eq. 3.34)}$$

The three curves for winter herd, spring herd, and summer herd, are compared in Figure 3.12.

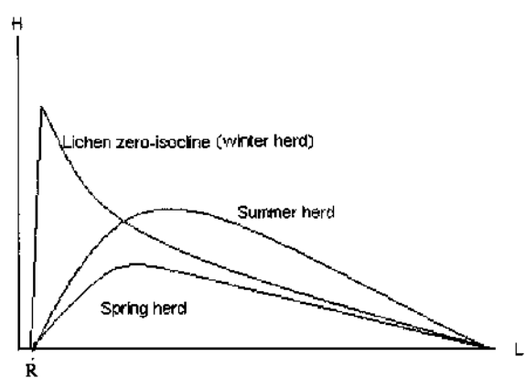

Figure 3.12. Winter, spring and summer herds as functions of lichen biomass

Moreover we assume that all herbivore biomass increase take place at summer pasture. *Fall herd*, H_F, is herd biomass before harvest, and for the factor of biomass accumulation at summer pasture, *summer accumulation*, A_{Su}, we establish (cf. eq. 3.27):

$$H_F = H_{Su}A_{Su} \qquad \text{(Eq. 3.27.b)}$$

We specify the summer accumulation similar to the one-pasture model. We use *regrowth* with a subscript for summer, r_{Su}, for increase in herbivore biomass and define:

$$A_{Su} = 1+[r_{Su}V/(V+D)] \qquad \text{(Eq. 3.35)}$$

Inserting into equation 3.27.b we establish for fall herd:

$$H_F = H_{Su}(1+r_{Su}V/V+D)$$
$$= (g_L/c_L)(\alpha L^3+\beta L^2+\chi L+\delta)(1-L)(L-m)(1+n)[1+(r_{Su}V/V+D)]/(L-R) \qquad \text{(Eq. 3.36)}$$

We have now specified all our assumptions for the annual herd cycle and sum them up in Table 3.2.

Table 3.2. The events of the herd year connected and specified

SEASON	*HERD*	*EVENT*	*PARAMETER*	*CONNECTION*
Winter	Winter herd (H_W)	Survival (sur)	Mortality (m)	$H_{Sp}= H_w(1- m/L)$
Spring	Spring herd (H_{Sp})	Spring accumulation (A_{Sp})	Natality(n)	$H_{Su}=H_{Sp}(1+n)(aL^3+bL^2+cL+d)$
Summer	Summer herd (H_{Su})	Summer accumulation (A_{Su})	Regrowth (r)	$H_F= H_{Su}(1+(rV/V+D))$
Fall	Fall herd (H_F)	Harvest (Y)	Harvest rate(x)	$Y= H_wx= H_F - H_w$

As all rates now are specified, we can depict the herd zero-isocline as Figure 3.13, which has a three-axes-system. The rates constituting the herd growth rate are depicted as functions of pasture biomass on the vertical axis. We have two horizontal axes, the one for winter pasture is on the right-hand side, while the one for summer pasture is on the left-hand side. The left-hand-side is seen in reverse.

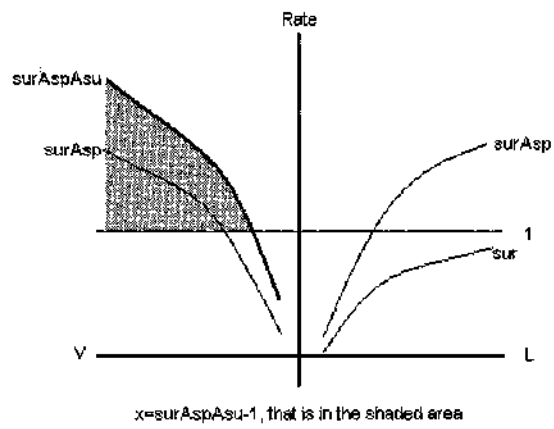

Figure 3.13. The herd zero-isocline specified

We note that the intersection of unity and the vertical axis is drawn as a help-line marking the level of zero net growth. On the right-hand-axis, representing winter pasture biomass, the curves for survival and spring accumulation times survival are depicted. We note that survival increase at a decreasing rate from zero at low lichen biomass approaching 1-m at high L-values. The other curve ($surA_{Sp}$) represents the combined effect of winter mortality and natality.

On the left hand axis, representing summer pasture biomass, the curve for spring accumulation times survival is copied over from the right-hand-side as a mirror image. The summer accumulation is depicted as the product of summer accumulation, and the other curve establishes the gross accumulation ($surA_{Sp}A_{Su}$). The distance between this curve and the line of unity establish the net growth $x = (surA_{Sp}A_{Su}-1)$. In the figure x is depicted as a function of V. Observe that for the two-pasture model we in equations 3.5b and 3.8b have defined V without a subscript as summer vegetation.

Output

Having derived the herd zero-isocline, which is equivalent with the output from balanced harvest, we here need to anlayse the variation of the output function with the factors V and L. We develop the full expression for the herd zero-isocline by inserting (cf. Table 3.2) into the basic output function (eq.3.28):

$$Y = H_w(surA_{Sp}A_{Su}-1)$$
$$Y=[(g_L/c_L)L(1-L)/(L-R)]\{[(L-m)/L](1+n)(\alpha L^3+\beta L^2+\chi L+\delta)[1+(rV/(V+D))]-1\}; \qquad \text{(Eq. 3.37)}$$

which also is undefined for L=R, L=0. It is zero for L=1. For positive parameters and factors its sign is decided by the expression in {brackets}, the other elements being always non-negative when defined. Differentiating with respect to the factors V and L, we explore further the variation of Y. First we explore the influence of change in summer vegetation capacity by differentiating (eq. 3.37):

$$dY/dV= [g_L L(1-L)/c_L(L-R)]\{[(L-m)/L](1+n)\ (\alpha L^3+\beta L^2+\chi L+\delta)r\ \ d[V/(V+D)]/dV$$
$$=\{[g_L L(1-L)/c_L(L-R)]\{[(L-m)/L](1+n)\ (\alpha L^3+\beta L^2+\chi L+\delta)\}\ rD/(V+D)^2; \qquad \text{(Eq. 3.38)}$$

which is undefined for L=R and L=0, zero for L=m and L=1, and *positive* for all other values of L and V in the range zero to unity. That means that *the output function is increasing for increasing values of V.* The higher is the summer pasture biomass, the higher is the harvest. Varying the parameters r and D imply increasing output with increasing r and decreasing output with increasing D.

Differentiating once more (eq. 3.38) with respect to V makes:

$$d^2Y/dV^2= -[2\ D/(V+D)^3][g_L(\alpha L^3+\beta L^2+\chi L+\delta)(1-L)(L-m)(1+n)r/c_L(L-R)]; \qquad \text{(Eq. 3.39)}$$

which also is undefined for L=R, zero for L=m, and L=1, but *negative* for all other of values of L and V between 0 and 1. That means that the output function is *concave*, the increase is at a decreasing rate, and Y will, given L, approach asymptotically to a value determined by L and the parameters. Output is depicted as a function of summer vegetation biomass in Figure 3.14.

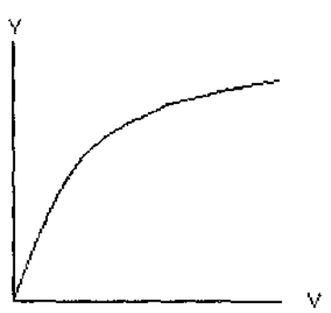

Figure 3.14. Output as a function of summer vegetation biomass

We note that output increase with V, at a decreasing rate, approaching asymptotically a value given by L and the parameters. That means there is no interior maximum point. Thus m*aximum output is reached at maximum summer vegetation biomass*. Comparing the figure with Figures

3.4 and 3.5, we observe that the curve for output as a function of summer biomass is of the same type as the one for harvest rate in the one-pasture-model. Comparing the equations, we find that the explanation is that *in the two-pasture model summer pasture capacity does not influence herd size, but balance harvest rate only.*

Turning our attention towards the other factor, L, the computation becomes a bit complicated. For the ease of understanding, we again start with the basic output function (eq. 3.28), $Y= H_w(surA_{Sp}A_{Su}-1)$. Differentiation gives:

$$dY/dL=Hw\ d/dL\ [surAspAsu] + dHw/dL\ (surAspAsu-1) \qquad \text{(Eq. 3.40)}$$

Insertion gives:

$$dY/dL=(g_L/c_L)\ [L(1-L)/(L-R)][(1+n)(1+rV)/(V+D)]\ \{d[(L-m)\ (\alpha L^3+\beta L^2+\chi L+\delta)/L)/dL\}$$
$$+ (g_L/c_L)\{[-L^2+2RL-R]/(L-R)^2]\ \{[(L-m)/L](1+n)(\alpha L^3+\beta L^2+\chi L+\delta)[1+rV/(V+D)]-1\}$$

$$= [g_L/c_L(L-R)]\ \{[(1+n)(1+rV)/(V+D)][3\alpha L^4-2m\alpha L^3+(\chi-m\beta)L^2+m\beta][L(1-L)]$$
$$+\{[-L^2+2RL-R]/(L-R)]\{[(L-m)/L](1+n)(\alpha L^3+\beta L^2+\chi L+\delta)[1+rV/(V+D)]-1\}\} \text{ (Eq. 3.40.a)}$$

The expression consists of one short bracket and one long bracket. The long bracket consists of two terms; one on the first line and the second on the second line. Examining the sign; the short bracket is psoitive for all L>R. The *first term* of the long bracket consists of all non-negative factors, except for the *polynomial* reflecting changes in survival and natality. Simulation after insertion of our chosen coefficients (cf. footnote before eq.3.32), gives that *the polynomial will change from positive via zero to negative.* As a corallary so will the first term.

For *the second term* the first parenthesis, which is the derivative of the winter herd zero-isocline, is non-positive when defined. The sign of the long bracket in this term, which is the net growth rate, is determined by the size of the product of expressions in the brackets. When the product is greater than unity, the whole content of the brackets is positive. The expressions for survival increasing from zero and asymptotically towards 1-m and summer accumulation being held at a constant rate between zero and unity, the sign is determined by the polynomial for natality. When the effect of the polynomial outweighs the effect of the two other factors, the product will be greater than unity and the sign of the brackets will change from negative to positive at a turning point for the polynomial[17]. That is; *term 2 will change from positive via zero to negative.* We thus have two terms with a similar pattern of sign.

The overall sign for the partial derivative for the lichen biomass will be determined by the sum of the two terms. When both terms are positive, the partial derivative will become positive. When both are negative, the partial derivative will become negative. When they have opposite signs, the overall sign will be determined by the absolute value of the terms.

With the chosen coefficients, *the sign will change from positive via indeterminate to become negative.* We have not explored how robust this conclusion is for all possible variation in the coefficients[18], so we assume that we have coefficients supporting this pattern.*The output function*

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17 at 6aL +2b, in our case at L=0,5

18 That would be a question of how narrowly the parameters had to be specified.

will thus be increasing to a maximum, $Y(L)_{Max}$, *and then decrease with increasing lichen biomass*, cf. Figure 3.15.

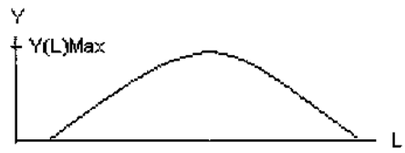


Figure 3.15. Output as a function of lichen biomass

The partials for the output function indicate *a marked difference between the two seasonal pastures*. While the output function increases at a decreasing rate for increasing summer pasture without an internal maximum, it has an internal maximum for winter pasture capacity. Output is a function of both winter herd size and harvest rate. The explanation is obvious when considering the output function. *Herd size is a function of winter vegetation biomass, while harvest rate is a function of pasture biomass for both the seasonal pastures.* The basic output equation can be written;

$$Y=H_w x=H_w(surA_{Sp}A_{Su}-1)=[H_w(L)][(sur(L)A_{Sp}(L)A_{Su}(V)-1)] \qquad \text{(Eq. 3.28.a)}$$

In Figure 3.16 we have depicted how output vary with winter herd size; this being the inverse curve of the winter herd curve in Figure 3.12.

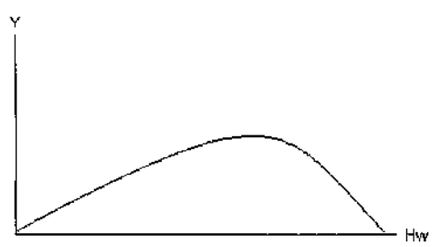


Figure 3.16. Output varying with winter herd size

Output increases, rather slowly, with increasing winter herd up to a maximum. This maximum is $H_{W(Y(L)Max)}$, and then decreases, relatively fast, for increasing winter herd size until output becomes zero at the maximum herd size, H_{WMax}. For the decending part of the curve, considering Figures 3.12 and 3.13 might add some valuable insights. We note that the curves (Figure 3.12) for spring herd and summer herd have their maxima at higher L-values than the winter herd curve (lichen zero-isocline), which have its maximum near R. Further the composite balance harvest rate becomes zero some distances out on the V-axis (Figure 3.13). All elements of this rate have a gradual descend. This also give indications to that the curve in Figure 3.16 does not drop directly to zero. Further the exact form of the whole curve depends on the relations between the three components of the harvest rate.

Summing up our findings we have that to maximize output a manager should (1) adapt winter herd size to the level $H_{W(Y(L)Max)}$ given by the lichen biomass $L_{(dY/dL=0)}$ and (2)have as abundant summer pastures as possible. In practice; let herd size be decided by winterpasture capacity.

Next we will consider the effect of putting constarints on seasonal pasture capacities.

Stability properties

Taking our start point in a stable system, the actual adaptation is in correspondence with all three zero-isoclines. Recalling from the herbivore-one-pasture model our conclusion that in systems including harvesting herd regrowth may be eliminated as a source of system destabilization, we here focus sources of instability connected with the pasture zero-isoclines. We should also note the real world argument that ungulate-forage systems are dependent upon migration. In this model the connection between herbivores and pastures are split between summer and winter pastures implying different types of plant-herbivore dynamics for each season. This feature influences the stability conditions. Considering stability in a two-pasture-context we should note that the production factors V and L are to some extent substitutable, but limited by the interseasonal connection of the herd (cf. Table 3.2). The direct biological connection is through the size of the summer herd. The summer herd entering summer pasture, is determined by winter pasture capacity (winter pasture zero-isocline), survival and spring accumulation. The adaptation of the entering herd depends upon herd size in relation to the summer herd zero-isocline.

Following the enrichment paradox logic we can ask *how the balance between the capacities of the two seasonal pastures affects stability.* This is a relevant question insofar as empirical pasture situations often involve imbalance in seasonal pasture capacities. In principle we can have three different balance situations. (1) We denote the situation where both season pastures and the herd size are stable as a *situation of perfect summer and winter pasture balance* and use this situation as our standard reference situation. Deviations can be situations where either summer pasture or winter pasture are in minimum; we denote them situations of (2) *summer pasture limitation* and (3) *winter pasture limitation,* respectively. In defining the situation we chose to compare the *entering summer herd* resulting from an optimal adaptation to winter pasture capacity, $H_{SU}(Y(L)Max)$ (Insert for dY/dL =0 into eq.3.34) with the *maximum summer herd on summer pasture,* $H_{SU}(Max)$, (cf. eq. 3.1 l.b). Table 3.3 define the three situations:

Table 3.3. Situations of seasonal pasture capacity relations

	Entering summer herd	Summer pasture capacity
Perfect summer and winter pasture balance	$H_{Su(Y(L)Max)}$ =	$H_{S(Max)}$
Summer pasture limitation	$H_{Su(Y(L)Max)}$ >	$H_{S(Max)}$
Winter pasture limitation	$H_{Su(Y(L)Max)}$ <	$H_{S(Max)}$

We might possibly had defined the situations differently, as $Hw(Max)$ vs. $H_{SU}(Max)$ Or $H_{SU}((Y(L)Max)$ vs. $H_{SU}(dY(v)Max)$. The first option is not recommended as $Hw(Max)$ deviates from the herd zero-isocline. For the second option the point $H_{SU}(dY(V)Max)$ does not exist, an approximation would be at a V-value so near K=l (maximum summer pasture capacity) that the level of pasture utilization would be unrealistically low for any practical purpose. The chosen points for the definitions are both well defined, on the zero-isoclines and also seem to be in reasonable correspondence with established use in reindeer management (cf. Mel0y, 1996, Reinbeitekommisjonen, 1967).

Situations with three zero-isoclines are more difficult to present graphically than situations with two. The equilibrium point will be the intersection between both pasture zero-isoclines and the herd zero-isoclines. I have chosen to break up the problem. The herd zero-isocline is already presented above (cf. Figure 3.13). We will now present the overall vegetation zero-isocline in a

series of three-axes-systems, cf. Figures 3.17-3.19. Herd size is depicted on the vertical axis. On the two horizontal axes, winter pasture biomass is depicted on the right-hand-side, while summer pasture biomass is depicted on the left-hand-side. The left-hand-side is seen in reverse, like above in Figure 3.13. First we will inquire the situation of perfect pasture balance and thereafter the deviations.

The situation of perfect summer and winter pasture balance is depicted in Figure 3.17.

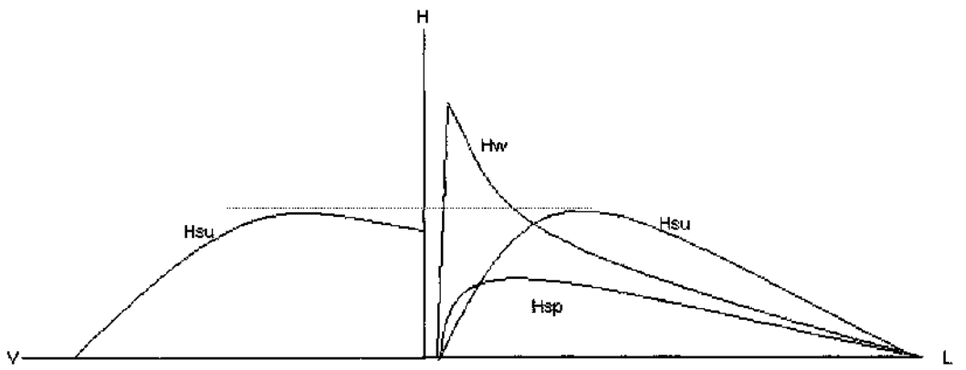


Figure 3.17. The situation of perfect summer and winter pasture balance

The right-hand-side has three curves, the ones for winter herd, spring herd, and summer herd. The latter is the crucial one, representing herd size entering summer pasture. When this herd size equals the summer vegetation zero-isocline on the left-hand-side, the pasture capacity of each season pasture fits the herd dynamic requirements exactly. That is; the summer herd on the right-hand-side $H_{su}(Y(L)Max)$ equals the summer herd $H_{su}(Max)$ on the left-hand-side. This is marked by the summer herd-line in the figure. *The adaptation is stable.*

Next we consider the situations where one of the seasonal pastures is in minimum and thus is a constraint upon possible herd size. That is, adaptations outside one of the three zero-isoclines. Let us first consider the situation of summer-pasture limitation, cf. Figure 3.18.

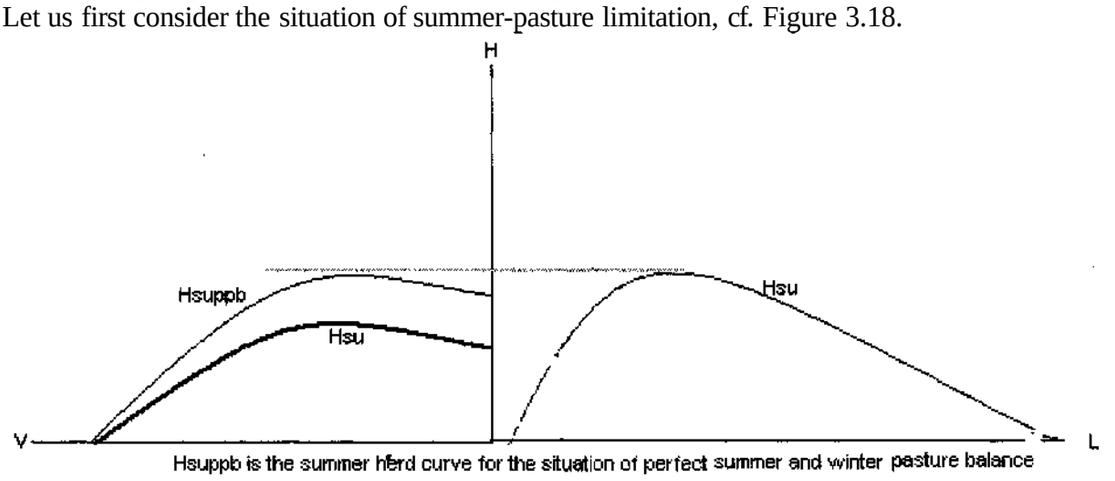
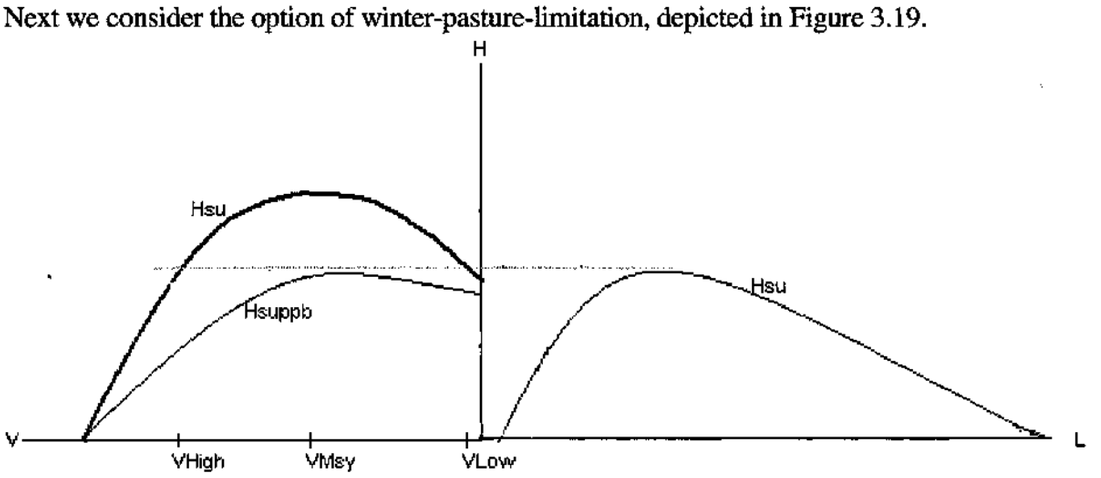


Figure 3.18. The situation of summer-pasture limitation

Focusing the left-hand side, comparing with perfect-pasture limitation in Figure 3.17, we note that the summer-pasture zero-isocline is lower than the entering summer herd. That means that

standing crop of summer vegetation will be reduced if herd size is not lowered down to a level on the summer pasture zero-isocline. If overgrazing of summer pastures is chosen, this implies *instability and temporary oscillations in V and herd size*. This instability is not dampened by winter pasture capacity since it is higher than summer pasture capacity. The situation of inadequate summer pasturage may, in settings where this is possible, lead to *grazing out of season* in winter pastures, which may lead to winter pasture overgrazing (this will depend on how much winter pastures are utilized). If, on the contrary, herd size is lowered, a stabilizing effect may be obtained.

Next we consider the option of winter-pasture-limitation, depicted in Figure 3.19.



Hsuppb is the summer herd curve for the situation of perfect summer and winter pasture balance

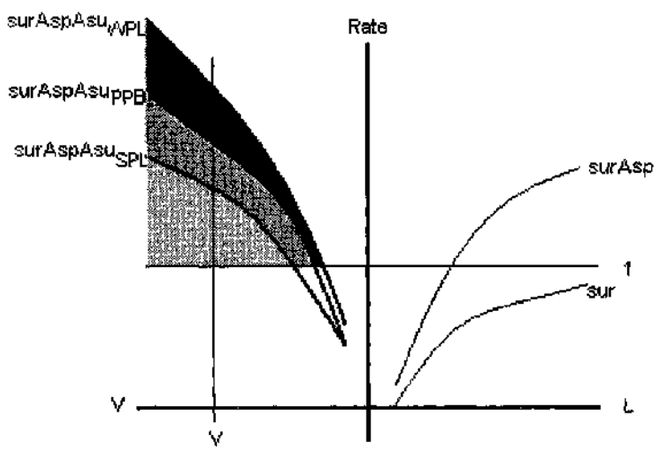
Figure 3.19.The situation of winter-pasture limitation

We focus the left-hand-side. Winter-pasture-limitation is equivalent with increased summer-pasture capacity. Observing the summer herd-line we note that it crosses the summer-pasture zero-isocline at two points correspnding to the vegatation biomass values, $V_{High}>V_{MSY}$ and $V_{Low}<V_{MSY}$, meaning two possible adaptations. Recalling the stability properties of the one-pasture model; the option $V_{High}>V_{MSY}$ in that model imply dampened oscillations and stability, while $V_{Low}<V_{MSY}$ imply temporary oscillations and instability. In this model the combined effect of winter mortality (cf. eq. 3.29) and natality through spring accumulation (cf. eq. 3.32) will dampen the oscillations also for the $V_{Low}<V_{MSY}$ option, meaning that *winter pasture limitation is a balanced situation* (independent of whteher the actual adaptation is to the right or to the left of V_{MSY}).

Turning our attention to output for the deviating situations Figure 3.20 compares the harvest rates of winter-pasture-limitation and summer-pasture limitation with the standard situation of perfect summer and winter pasture balance.

We use the subscripts PPB for perfect (summer and winter) pasture balance, SPL for summer pasture limitation and WPL for winter pasture limitation. The figure is of the same type as Figure 3.13, and demonstrates that the balance harvest rates; $x_{WPL}>x_{PPB}>x_{SPL}$ compared for the same value of V. Assuming taht winter herd, H_W, is the same in all three situations, this implies that $Y_{WPL}>Y_{PPB}>Y_{SPL}$, when compared for *the same value of V. The reason for this is that the relatively higher $H_{Su(Max)}$ is, compared to $H_{Su(Y(L)Max)}$, the higher becomes V*, when staying on the summer pasture zero-isocline, *and thus harvest rate and output*. For summer pasture limitation

we may have a more favorable outcome if the limitation set by the summer pasture is made effective and winter herd size, H_W, is kept lower than for perfect pasture balance. Such a reduction can imply an increased harvest rate via improved winter survival and spring accumulation. As a result the difference between summer pasture limitation and perfect pasture balance can be reduced.

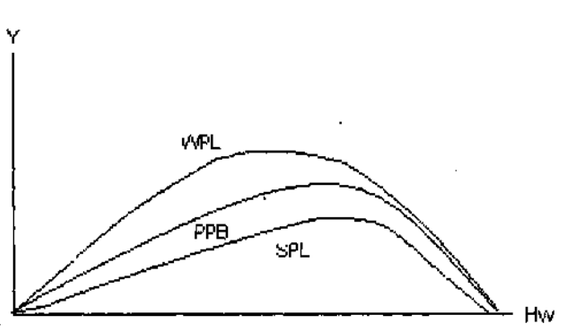


$surAspAsu_{WPL}$ is total growth rate for the situation of winter pasture limitation
$surAspAsu_{PPB}$ is total growth rate for the situation of perfect pasture balance
$surAspAsu_{SPL}$ is total growth rate for the situation of summer pasture limitation

The harvest rates for any optional value of summer vegetation biomass V are x=surAspAsu-1; which is the fraction of the vertical line from V passing through the light grey area for summer pasture limitation, the light grey plus the dark grey area for perfect pasture balance and both these areas and the black area for winter pasture limitation

Figure 3.20. Harvest rates, x, as functions of summer pasture capacity, V, for the situations of perfect (summer and winter) pasture balance (PPB), summer pasture limitation (SPL), and winter pasture limitation (WPL), when winter herd is given

Considering output as a function of winter herd size, we have depicted various functional forms for all three pasture-balance situations in Figure 3.21.



WPL is winter pasture limitation, PPB is perfect pasture balance, SPL is summer pasture limitation

Figure 3.21. Output as a function of winter herd size for various pasture-balance situations

For the situation of winter pasture limitation *the output is consistently higher than the output for the standard situation* (perfect summer and winter pasture balance). A CPR with winter-pasture

limitation also has its output maximum at a lower herd size than the standard situation. The stronger is the winter pasture limitation, the clearer are these features. Thus a winter pasture limited CPR can support a *smaller* herd than the standard situation, but *each animal will be more productive.*

The situation of *summer-pasture limitation will,* on the contrary, *tend to have a lower output than the standard situation for all herd sizes.* The maximum output is also found for a relatively higher herd size than the standard situation. Thus a summer pasture limited CPR can support a *large herd, but with low productivity per animal.*

Recalling the stability properties of the one-pasture model we may include some of them in the pasture balance perspective. We still use the situation of perfect pasture balance as our standard situation of reference. Pasture growth rate, which had a zero effect in the one pasture model, here is split by season.

Starting with the *summer pasture growth rate,* gs_u, we note by regarding the summer pasture zero-isocline (eq. 3.8.b), that increasing the growth rate means lifting the isocline. This is compatible with a development towards summer pasture limitation, and means increased stability and output. Turning to the *winter pasture growth rate,* gL, we note by considering the winter pasture zero-isocline (eq. 3.22); that an increase in this rate will lift the isocline. This is parallel to evolving summer pasture limitation, and is consistent with reduced stability.

The herbivore intrinsic growth rate, r, from the one-pasture model is in this model split into *natality,* n and *regrowth,* r_{Su}. Natality influences entering summer herd (cf. eq. 3.34); that is increasing natality lifts the summer herd line, which is parallel to summer-pasture-limitation and increased instability. The regrowth parameter, r_{Su}, influences the herd isocline only (cf. Table 3.2 and eq. 3.37); requiring that an increased rs_u, is compensated for by increasing the balance harvest rate, x.

The *mortality* parameter, m, will in this setting influence spring herd and herd entering summer pasture. For the latter (cf. eq 3.37) we find that increasing mortality reduces entering summer herd. This is equivalent with a movement towards winter pasture limitation, which is a stabilizing pattern.

As for the measures of accessible pasture capacity, we have for simplicity defined K=1. For summer pastures we still have D, while for winter pastures we have included the *residual lichen vegetation parameter* R. Above we found that increasing R (letting more lichen remain ungrazed) means lifting the winter pasture zero-isocline; increasing actual winter pasture capacity. This is parallel to a development towards summer pasture limitation, which is destabilizing. The *summer pasture self-saturation coefficient,* D influences the summer pasture zero-isocline (cf. eq. 3.8.b) by lifting the isocline when increasing D. This is compatible with an evolving winter pasture limitation, which we above found to be a stabile adaptation.

So far about the implications of change in pasture balance and each of the parameters, which for both models are summed up in Tables 3.4 and 3.5 below.

First we will, however, establish some connections back to pasture geography.

3.2.3 Pasture geography and stability

Recalling our subchapter 3.1 on pasture geography we will now consider how geology, climate, and landscape structure can influence the herd-pasture dynamics described above.

3.2.3.1 Geology

Geology affects vegetation via plant nutrition. Degradable rock types rich of nutrients, as e.g. cambro-silurian, give origin to soils providing opportunity for high biomass of summer pastures, while acidic and little degradable bedrock provides meager conditions for summer pastures. That means, *the more nutritious soils, the higher will the summer pasture-isocline tend to be.* Remembering our evaluation of winter-pasture limitation above, we find that a situation of winter-pasture limitation and rich summer pastures is optimal.

Regarding winter pastures we have that lichens are favored by oligotrophic and little degradable bedrock as the competition from vascular plants then is limited. Typically good lichen pastures can be found at granites and sandstones (cf. Lenvik, 1978).

3.2.3.2 Climate

Climate influence both summer and winter pastures. Precipitation is a precondition for the growth of vascular plants, and generally the higher it is, the better summer pastures. The most crucial influence of climate is, however, on winter pastures. They are affected both (1) indirectly via accessibility for through snow-cover and packing, and (2) directly via annual precipitation (competition with vascular plants).

Starting with the indirect effect, we recall our winter pasture model and Figure 3.9. The residual lichen biomass, R, is a function of winter pasture accessibility. *As R is strongly influenced by the energetic cost of searching and digging for lichen, the thinner and looser the snow-cover is, the lower is R and the more accessible are the winter pastures.* Precipitation as annual millimeters of snowfall may be used as an indication of the magnitude of R (cf. Kosmo, 1998). An increase in R will mean a lift in the winter-pasture zero-isocline and also the summer-herd line, and thus be positive on output.

On the other hand, *if R becomes too low, the vulnerable winter pastures will loose protection against overgrazing and trampling.* Our stability discussion above indicated the possibility of overgrazing winter pastures (by grazing out of season) in situations of summer pasture limitation. That would imply *grazing lichen pastures when R being zeroed, and could thus involve lichen biomass depletion.*

Some writers (e.g. Bj0rklund, 1990; Fox, 1995) have questioned the use of equilibrium models for reindeer-pasture systems provided that winter mortality due to random climatic factors have a greater effect than herd-pasture dynamics. We may address this problem by a comparison with the tropics. Broadly spoken, in the tropics equilibrium models are applicable when annual precipitation is abundant, and on the contrary not in draught areas. Then the duration of the draught is more decisive for animal survival and growth than pasture capacity (Behnke, 1999). Remarkably enough the connection between stability and annual precipitation tends to be quite

opposite in the Sub-Arctic, at least in Fennoscandia. This have two reasons; (1) the winter pastures determines survival (Klein hypothesis), and (2) lichens, the main winter diet, in addition to oligotrophy are favored by relatively low total annual precipitation. In relatively arid areas lichens tend to oust vascular plants (Gaare, 1997). Thus low annual precipitation will tend to lift the winter pasture zero-isocline due to a higher total lichen growth. These areas will tend to have a higher winter pasture capacity than more humid areas.

Seeing both the direct and the indirect effects of climate on winter pastures in common we have that (1) low level of total annual precipitation will tend to increase the winter pasture zero-isocline, while (2) low annual precipitation as snow means low R and lowering the same isocline. *For winter pasture capacity it thus would be optimal with low annual precipitation promoting lichen growth and a relatively high proportion of the annual amount of precipitation falling as snow safeguarding that R does not become too low and the pastures too exposed for overgrazing.*

3.2.3.3 Landscape structure

In the discussion above we found that the situation of summer pasture limitation could promote grazing out of season and lichen pasture overgrazing to depletion. Whether this is feasible, depends on landscape structure. Recalling our passage in 3.1 the landscape structure on medium scale will be important. As *landscapes without natural borders* require the most intensive herding, the tendency for grazing out of season will also be higher in such landscapes than *landscapes with natural borders*. Imagine the case of a summer pasture limited CPR hosting a relatively large herd with low productivity. In a landscape without natural borders between summer and winter pastures adjacent pastures could be used out of season, thus removing the limitation set by the capacity of each of the seasonal pastures. The potential adaptation of *keeping a large herd on insufficient summer pasture while compensating by using winter pastures out of season* provides a possibility of increased output in the short run, but grazing lichen pastures not protected by snow-cover drops R , and may thus leads to *resource depletion and herd reduction* in the long run.

3.2.3.4 Summing up

In this subchapter we started with a one-pasture model which was extended to a two-pasture model. The stability properties were also discussed in relation to elements of pasture geography. Very simplified the stability properties of different parameters, for the one-pasture model, is summed up in Table 3.4, while the corresponding for the two-pasture model is depicted in Table 3.5.

Table 3.4. Correlation between stability and change in parameters in the one-pasture model

Parameters stabilizing by increase	Parameters destabilizing by increase
m	r
D	K

m = herbivore mortality rate, r = herbivore intrinsic growth rate, D = self-saturation coefficient, K= vegetation carrying capacity

The contents of the table are in accordance with our conclusions from section 3.2.1. In the one-

pasture model two pairs of parameters are important for stability; (r-m) constituting the herbivore net growth rate and K/D being a measure of accessible pasture capacity. High values of both pairs will promote instability.

Table 3.5. Correlation between stability and change in parameters in the two-pasture model

Conditions and parameters stabilizing by increase	Conditions and parameters destabilizing by increase
WPL*	SPL*
g_{Su}	g_L
m	n
D	R

* WPL and SPL are conditions

WPL = winter pasture limited, SPL = summer pasture limited, g_{Su}*= summer vegetation intrinsic growth rate,* g_L*= lichen intrinsic growth rate, m = herbivore mortality rate, n = natality,*
D = self-saturation coefficient for summer pastures , R = residual lichen biomass

In the two-pasture model we observed stability problems resulting from deviations from the situation of perfect pasture balance and classified the impact of change in parameters in line with that. We notice that there are three pairs of parameters which could be expressed as relations; g_{Su}/g_L, *m/n and D/R. Increasing these relations would be equivalent with a development towards more winter pasture limitation and be stabilizing.* Vice versa would decreasing therse relation imply reduction of stability.

Including our pasture geography considerations, geology as a source of plant nutrition affects the g_S/g_L–relation, as both more nutritious soils on summer pastures and poorer soils on winter pastures increase it. This relation is also affected by climate – both a high level of precipitation on summer pastures and a low level at winter pastures increases it. The m/n–relation is mainly linked to lichen biomass, as stochastic climate effects are not included in our modeling. The parameter R is linked to both climate and landscape. Both a low annual level of precipitation in the form of snow, and a landscape without borders may decrease R. D does not seem to be affected by pasture geography. The parameters D and R are both influenced by technological changes, which is studied in the following subchapter.

Having explored the dynamics of both pasture geography and pasture – herbivore dynamics, we now proceed to the technology of production.

3.3 Production Technology in Change

Besides the already stated independence of humans for winter fodder, the reindeer is a fully *self-supportive, self-reproductive* and *gregarious wild* animal, but it is *tameable* for humans. These facts are obvious, but nevertheless important. In spite of being semi-domesticated for generations the animal itself can manage and thrive as member of a herd in nature independent of man when left on its own. The reindeer is prey for several predators[19]. Homo sapiens seeks to prevent reindeer mortality due to predation by herding the animals and by (to a varying degree) hunting the predators. The animal can be the *source of raw materials* both for domestic needs and commercial sale (meat, blood, milk, fur and hides for clothes, sinews for sewing, antlers and bones for handicrafts etc.).

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[19] In Fennoscandia wolf, wolverine, lynx, bear and eagle are included.

Under human control the reindeer has furthermore properties making it a *possible object of private property.* The animals are individually recognizable and establishment of a label system signaling ownership to the relevant group and individual is possible. The relationship between mother and progeny is identifiable and the reproductive capacity of the species is relatively limited inasmuch as each fertile doe normally gives birth to but one calf per year. Thus ownership can be sustained. Under control the animals are a storable resource suitable as a carrier of human wealth (cf. Ingold, 1981:224-227).

Individual animals can be hunted or tamed, but in our context *herd control* is the relevant point of departure. As a corollary of the basic facts above human reindeer-herding control must be imposed by coercion and it needs to be constantly renewed to maintain a certain *tameness grade.* Thus the tameness grade of a reindeer can deteriorate drastically in a few years time (Beach, 1981:41). Control can be exercised both on herd level and on individual level. Basic herd control means human control over the movements of a group of animals usually ranging from a few hundreds up to several thousands by means of direct physical contact between man and animal or indirectly by means of various technologies. This work called *herding* (Paine, 1964:83), constituting the bulk of the labor, is carried out collectively by a group of cooperating herders. In the collective part of the work should be included not only strictly herding tasks, provision of common facilities like fences and corrals, but also defense and improvement of property rights.

Herding can be characterized on a continuum between the relative levels of *intensive* and *extensive.* Intensive herding means close and contious reindeer-herder contact and a high level of tameness. Extensive herding means less contact, more separation, and a lower tameness grade (Beach, 1981:34-3). In order to maintain a certain degree of control at an obtained tameness grade, the herders need to consider parts of their labor as an investment in future control ability. *Herd extensivity can thus be considered as a force working like gravity: if not actively counteracted it will decisively determine further extensivity.*

In addition to this, *individual* control is exercised when the herd as such is under control, e.g. in a corral. *Work operations providing and securing the output for the individual owner* (e.g. earmarking of calves, castration, slaughtering) are subsumed under Paine's (1964:85) notion *husbandry.* The performance of husbandry tasks thus is conditioned upon sufficient herding. There are no established terminology characterizing husbandry work in dimensions of intensity, so I have chosen to classify husbandry in levels of *how intensive the exploitation of the herd's biological growth potential is.* That is, the husbander can by his decisions of life and death for individual animals design a herd with a herd structure, composition in age, sex and other characteristics (growth potential being one of them), in accordance with his goal of production. The mix of factors contributing to the output can be named *production systems.* Generally we think of each production system having a *production function* of the form;

$$Y = Y\,(V, L, H(V, L), W_{herd}(T_{herd}), W_{husb}(T_{husb})$$

where Y is output
V is summer vegetation biomass
L is winter vegetation biomass
H is herd size (biomass of standard animals)
W is labor

T is technology
The subscripts *herd* and *husb* are kinds of work also used about technologies supporting the work: herding and husbandry, respectively.

As stated above the reindeer can be the source of a multitude of outputs for subsistence. Y can thus be a vector. In the analysis we focus the contemporary system where the main output is *meat* produced for marketing.

The factors V and L are analyzed in the preceding subchapter. We now continue by inquiring the two kinds of work; herding, W_{husb}, and husbandry, Whusb, and their related technologies, T_{herd} and T_{huSb}, respectively.

In the introduction we focused technological change in herder societies as a technological revolution. Pelto (1973) named his book "The Snowmobile Revolution". My point is that the snowmobile only was the first phase of a series of technological innovations which had major economic and societal implications. In addition to changes in herding technology, changes in the *technology of husbandry* also had considerable potential of change. We start with inquiring the implications of change in herding technology.

3.3.1 Herding and Change in Herding Technologies

Herding is traditionally conducted with very simple technology (cf. Paine, 1994) as bells on some animals, dogs to drive animals, simple fences out of natural materials, with skis and draught reindeer as the only means of transportation. Modern society and the opening of external markets for sale of reindeer products provided for import of new types of herding technology Use of fences with steel web wire became usual before the snowmobile. The introduction and spread of the snowmobile was followed by a series of other vehicles as cars, all-terrain-vehicles (ATVs), and helicopters. In addition communication technology like walkie-talkies and mobile telephones have spread. Altogether this affects the relations between the production factors considerably. In my theoretical considerations I have chosen to focus machenery because it has the most important effects. T_{herd}-technologies can be defined in additive levels of technological facilities. The levels[20] may include, for example:

Table 3.6. Examples of additive levels of herding technology

Level	Description
T_{herd0}	Herder wherder with a dog, draft animal, *hergi* (castrated bull) and skis (winter), supplied with relatively low cost tools predominantly domestic production and natural materials
T_{herd1}	T_{herd0} + snowmobiles (in winter)
T_{herd2}	T_{herd1} + ATVs (in summer/fall) and cars (year-around)
T_{herd3}	T_{herd2} + helicopter (in summer/fall /early winter)

These options can increase both *labor* and *pasture* productivity, but also be substitutes for herding labor. Increasing levels of T_{herd}-technologies imply successively increasing levels of herd control and pasture exploitation as well as increasing monetary costs. In our modeling we will not use the specific examples i Table 3.6 directly, but imagine that there are *succesive, additive levels of herding technology* which can be taken into use. We will, however, make a distinction between *summer herding technology* and *winter herding technology* meaning

[20] The examples of levels mirror a historical development path.

herding technology affecting summer pastures and winter pastures, respectively. The reason for increasing herding technology is self-evident; namely to *increase human control over the herd.* This may in turn have external reasons, related to the landscape or neighbour herders or internal reasons (husbandry) as increasing output. We have a particular interest in revealing the implications of the changes, on the one hand, for production factors and output, and on the other hand for costs. We will first consider the production dynamics and next the cost dynamics.

3.3.1.1 Change in herding technology

Increasing the level of herding technology implies more efficient grazing by reducing the parameters D (at summer pastures) and R (at winter pastures). More concretely there are two reasons for that. Firstly, increased herd control means increased opportunities to govern the spatial movements of the herd. Thus the animals can be more efficient grazers by being kept in the areas chosen by the herders. Secondly, increased herd control also increase the possibilities of grazing out of season. Recalling our subsection of landscape structure above; for the lichen pastures, grazing out of season can lower R considerably. Let us look more in depth on the relationships. Again, consider the conditions for a constant standing crop of vegetation. The seasonal pasture zero-isoclines are:

$H_{Su}=(g_{Su}/c_{Su})(1-V)(V+D)$ (Eq.3.8.b)
and
$H_W=(g_L/c_L)L(1-l)\ (L-R);$ (Eq.3.22)

The herd zero-isocline (short-version) is:
$Y=H_W x = H_W(surA_{Sp}A_{Su}-1)$ (Eq. 3.28)

Winter herding technology

Continuing with winter herding technology and the effect of reducing R, we recall Figure 3.9, where *lowering R* meant lowering the lichen zero-isocline. As a lowered R means lowered standing crop of L, both *spring herd* H_{Sp} and *summer herd* H_{Su} (cf. Figure 3.12) are as a corollary *lowered* proportionally. As for the output given by the herd zero-isocline, we note that both H_W and the equilibrium harvest rate, x, have to be considered.

The full expression for output (eq. 3.37) with respect to R provides;

$$dY/dR= [g_L L(1-L)/c_L]\{[(L-m)/L](1+n)\ (\alpha L^3+\beta L^2+\chi L+\delta)[1+(rV/(V+D))]-1\}\{d\,[1/(L-R)]\,/dR\}$$
$$= [(g_L/c_L)[L(1-L)/(L-R)^2]\{[(L-m)/L](1+n)(\alpha L^3+\beta L^2+\chi L+\delta)[1+rV/(V+D)]-1\} \quad \text{(Eq. 3.41)}$$

The expression is undefined for L=R and zero for L=0 and L=1. All terms being positive for $0<L<1$ and $0<V<1$, makes *the partial derivative for the residual positive in the whole range.* This implies; *when R is reduced, Y is reduced.*

Observing equation 3.41 we note that the effect on output is working via winter herd reduction as the components contributing to the harvest rate, in the long { }brackets are

unchanged. That means that *investments in winter herding technology*, under the assumptions given, will reduce equilibrium herd sizes at all seasons, and *always will be unprofitable.*

The output effect of increasing level of herd technology at winter pastures is depicted in Figure 3.22.

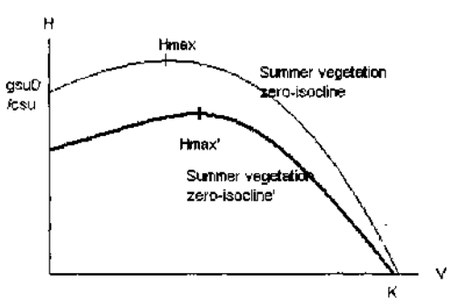
The fine-lined curve is the output curve for is the same as (the perfect pasture balance curve)in Figure 3.21. The bold-lined curve is the output curve when R is decreased.

Figure 3.22. Output effect of decreasing R by winter herding technology

Studying the figure we can sum up these effects of increasing the T_{herd}-level at winter pasture: (1)Output is generally reduced, and (2) the carrying capacity for a herd, H_{WMax} is also lowered.

Summer herding technology

Starting with summer herding technology and effects on D, direct inspection of equation 3.8.b, reveals that reducing D will shift the isocline down. Maximum sustainable summer herd size which is achieved (cf. eq. 3.10 and 3.11) at the vegetation level V_{MSY} = (K-D)/2 = (1-D)/2. Reducing D will increase the level of V_{MSY}, and also lower the intersection point with the H-axis at $g_{Su}D/c_{Su}$ (cf. Figure 3.23).



'is after D is lowered

Figure 3.23. Effects on herd size of increasing D on summer pasture.

Thus decreasing D will imply that *the summer-herd zero-isocline,* H_S, *in addition to the shift downwards also will be twisted more over to the right* (left when mirror-image curve*).*
That is, *herd size is reduced and the optimum adaptation is found at a higher level of V.*
To study changes in *output,* we differentiate the herd zero-isocline (eq. 3.37) with respect to D:

$$dY/dD = (g_L/c_L)[L(1-L)/(L-R)][(L-m)/L](1+n)(\alpha L^3+\beta L^2+\chi L+\delta)d[1+rV/(V+D)]/dD$$
$$= -rV/(V+D)^2[g_L/c_L][L(1-L)/(L-R)][(L-m)/L](1+n)(\alpha L^3+\beta L^2+\chi L+\delta)] \qquad \text{(Eq. 3.42)}$$

This partial is defined for the same values as dY/dR above and always *negative* when defined.

Differentiating once more (eq. 3.42) produces:

$$d^2Y/dD^2 = 2rV/(V+D)^3[g_L/c_L][L(1-L)/(L-R)][(L-m)/L](1+n)(\alpha L^3+\beta L^2+\chi L+\delta)] \qquad \text{(Eq. 3.43)}$$

The second derivative is always positive for positive V and L; output as a function of D is convex. Thus *lowering D means increasing output, and at an increasing rate,* cf. Figure 3.24.

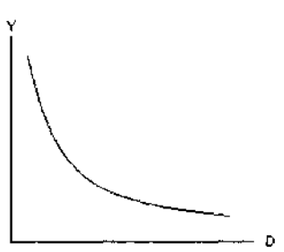


Figure 3.24. Output as a function of the self-saturation coefficient D

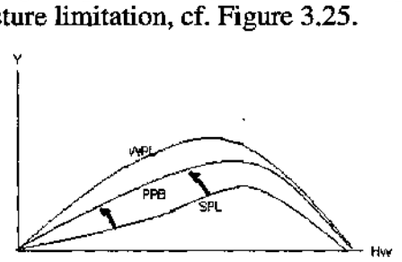
This means that; *the more D is lowered, the grater is the increase in output.*
The cross-partials (of eq. 3.37) with respect to D and V are:

$$d^2Y/dDdV=d^2Y/dVdD=$$
$$r[(V^2-D^2)/(V+D)^4][g_L/c_L][L(1-L)/(L-R)][(L-m)/L](1+n)(\alpha L^3+\beta L^2+\chi L+\delta)] \qquad \text{(Eq. 3.44)}$$

For positive L, the cross-partials are positive for V>D, zero for V=D and negative for V<D. That means that changes in V and D are reinforcing each other when V>D and vice versa. In other words; *reduction of D have the greatest impact at relatively high V-values.*

In this subsection we have found that decreasing D (1) lowers summer herd, but (2) increases output and that (3) these effects are stronger the higher V is and (4) the more D is reduced.

Comparing Figure 3.23 with the Figures 3.17-3.19 (keeping in mind that in these figures are the summer pasture depicted in mirror-image) we note that decreasing D, conditions on winter pasture being kept unchanged, will be parrallel to a development towards (stronger)winter pasture limitation, cf. Figure 3.25.



WPL is winter pasture limitation, PPB is perfect pasture balance, SPL is summer pasture limitation
The output curves are the same as in Figure 3.21.
The arrows indicate the direction of change for the output curves

Figure 3.25. Output effect of decreasing D by summer herding technology.

This developement is stabilizing , cf. Table 3.5.

Summing up

So far we have found that increasing grazing efficiency by increasing the level of herd technology at *winter pastures will contribute to decrease in output* while *at summer pastures* it will promote *increase in output, and at an increasing rate.*

Theoretically, implementation of herding technology should take place only at summer pastures, as output increase when D is lowered (cf eq. 3.42). Implementation at winter pastures would have merely negative effects, as output always decrease when R is lowered (cf. eq. 3.41). This is connected with the limitations of our model.

We can, however — when stepping outside the model, imagine that increasing the level of winter herding technology by *increasing herd control* could e.g. (1) bring the adaptation at winter pastures from an adaptation of undergrazing down to the winter pasture zero-isocline, (2) could make seasonal movements (between pasture areas) more effective, (3) could be promoted by competition with other herders, and could (4) be a means of improving social relations (transportation for contact with family and society) for the herders.

Furthermore, relevant for summer herding technology, when applying a pasture balance perspective, we found above the clearer the winter pasture limitation is, the higher the output becomes. This means that *the change most favourable for output increase is to increase grazing efficiency at summer pasture to create a pasture balance change from a summer pasture limitation to a winter pasture limitation.*

We can also imagine that a theoretically efficient increase in herding technology at summer pastures, which increases output, in a situation of summer pasture limitation, can be followed by *grazing out of season at winter pastures when feasible.* This will contribute to immediate increase in output, but may have the long-run effect of overgrazing, unless winter pastures are not highly in excess, reducing R, eventually to the extent that lichen pastures are depleted.

Our next step is to consider how the changed output pattern interacts with costs to create a profit pattern.

3.3.1.2 Cost and profit

As we found above, investment in winter herding technology reduces output, according to our model, while investment in summer herding technology increases output. Relevant to our study is *the case where investment in winter herding technology* (e.g. snowmobile) *already is made* (of reasons external to the model), *and the herder considers an investment in summer herding technology.*

We then consider the first investment as having a release effect on a possible series of succeeding investmensts. Investment in T_{herd} bought on external markets obviously implies increased monetary costs. These costs are related both to acquiring the machinery and to its operation. We assume that investment costs are relatively high and that there will be a necessary minimum in herd size, which may be denoted *subsistence minimum* (cf. Beach, 1981), to cover the initial investment, and the total cost curve will thus intersect the Y~axis.

The total operating costs are assumed to be increasing linearly. Revenue and a possible cost function are depicted in Figure 3.26 for a situation of summer herding technology investment.

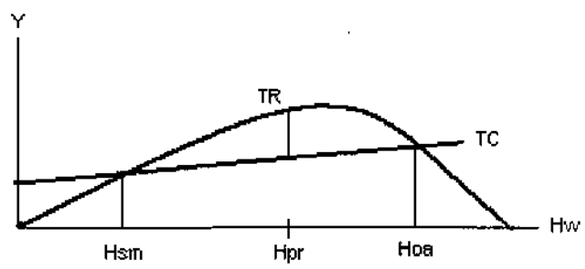
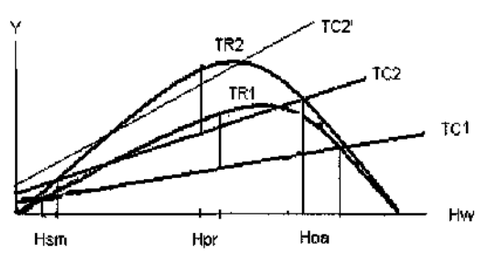


Figure 3.26. Implementation of summer herding technology. Cost and revenue curves. Possible equilibria.

The total cost curve intersects with the Y-axis, indicating the investment cost, and intersect the revenue curve at two possible zero-profit situations. The lower is the point of subsistence minimum, H_{SM}, and the higher is the non-institutional (open access) equilibrium, H_{OA}. A maximum profit equilibrium is the institutional (property rights; here a common property regime) equilibrium solution, H_{PR}, at a herd size lower than H_{MSY}. This is in accordance with general theory (cf. Figure 2.1[21]); *under effective property rights the size of the investment will on a more moderate level ensuring maximum profit, while we under open access will have an overinvestment to the level of zero profit.*Let us contemplate how a continued increase in the level of summer herding technology will affect costs and profits. Assuming both increase in revune and cost, including a raise in initial investment and a higher but still linear increase in operating cost, we have depicted the cost and revenue pattern in Figure 3.27.



TR1 and TC1 are total revenue and cost before the new investment, while TR2 and TC2 are after the new investment. TC2' is an alternative level of total cost associated with the new investment

Figure 3.27. Continued implementation of summer herding technology. Cost and revenue curves. Possible equilibria.

Considering the *property rights situation* (common property), first we note easily that if the increase in revenue is great enough relative to the cost increase, the continued implementation of new herding technology can imply an increased profit. New investment will thus continue to the level that it will not give more profit. In the figure the new

21 Note that in comparison, Figure 2.1 is laterally reversed, while an effort-curve would be similar to Figure 3.26.

investment will not be made if the cost level is at the curve TC2', but only for the cost curve TC2.

Under *open access* the situation will be different as investment will be made until there is zero profit. This make the new investment possible also when the cost curve is TC2'. That is; the level of investment will tend to be higher tahnunder common property.

To sum up both production and cost implications; investment in herding technology can have various effects depending on whether it affects winter pastures or summer pastures, and whether it takes places in an institutional environment of effective property rights or under open access. Investment in winter herding technology generally decreases output, and our model predicts that such investment should not take place. Positive effects not included in the model could nevertheless make investment in winter herding technology profitable, and such investment could have a trigger effect on investment in summer pasture herding technology.

Investment in summer herding technology generally increases output. *In an environment of effective property rights the investment in summer herding technology will be to the level found profitable. Under open access the investment in summer herding technology will be up to a level producing zero profit.* In cases of summer pasture limitation and feasibility of grazing out of season at winter pastures, R might be seriously reduced.

The further implications of the conclusions of this subsection will be discussed in subchapter 3.4.

3.3.2 Husbandry and Change in Husbandry Technologies

As for husbandry technology, we focus *herd optimization* (cf. Lenvik, 1989) as a means for increasing biological productivity. The biological foundation for the option is that (1) younger reindeer have a higher potential meat productivity (growth of meat per unit pasture) than older and (2) females have a higher productivity than males when offspring and expected mortality are included (Movinkel, 1966:248-256; cf. Persson, 1966,142-151). Different schemes of husbandry and strategies of harvest thus open for a variety of potential equilibrium harvest rates, x. Within the one-output (meat) perspective traditional production systems empirically have had a relative high proportion of males and a high average age of the animals. Herders have utilized this possibility for a long time, designing their herds to achieve the most profitable sex and age ratios. Contemporary herd optimization is to some extent supported by scientific methods[22] and extension services to increase output productivity. Husbandry technologies can be defined as *a series of optional harvest strategies* according to the target animal group for slaughter, for example:

T_{husb1} : *gaskek* - 2.5 to 3.5-year-old castrated bulls
T_{husb2} : *varek* - 1.5-year-old males
T_{husb3} : *miessi* -this year's calves
T_{husb4}: T_{husb3} + weight - selection of does

The increasingly younger target groups imply a higher general turnover rate and also a

22 The combination of scientific knowledge of biological dynamics, and *time-and-place information* (von Hayek, 1945:521).

increasingly lower male proportion. A movement in the direction from T_{husb1} towards T_{husb4} includes successive changes in herd parameters, where mortality, m, is reduced and natality, n, and regrowth, r, are increased, all contributing to a stepwise increase in potential harvest rate, x. That is; $x_{Thusb4} > x_{Thusb3} > x_{Thusb2} > x_{Thusb1}$.

The possibility of increasing output through increasing the herd zero-isocline harvest rate, is founded upon herd optimisation by age and sex structuring (cf. Lenvik, 1989). An intensified exploitation of the biological growth potential by increasing the net growth rate, can, in principle, be achieved by: (1) increasing the turnover rate by reducing the average age of harvested animals, and increasing the slaughter of herd segments with relatively high potential winter mortality, (2) increasing the portion of reproducing females, does, in the herd, and (3) optimising their reproduction rate by limiting the herd-vegetation ratio. The examples above utilize to a varying degree, these effects. Increasing the T_{husb} level includes making the biological transformation process from plant material via animals to domestic and marketable animal products more effective. The implementation influences the herd zero-isocline and makes possible an increase in the harvest rate x, expressed:

$$x=(surA_{Sp}A_{Su}-1)= [(L-m)/L](1+n)(\alpha L^3+\beta L^2+\chi L+\delta)[1+(rV/(V+D))]-1] \qquad \text{(Eq. 3.37b)}$$

We note that the parameter changes of; decreasing m, increasing n, and increasing r, all will inevitably contribute to the increase of x. Variations in the relative change of the parameters can affect pasture balance, but we leave that discussion out, assuming no significant variation in relative parameter change.

Following the example levels above, the level T_{husb2} can be achieved by reducing the portion of older bulls in the herd, while using more one-and-a-half-year-old bulls as stud animals. The level T_{husb3} is equivalent with a herd having a high percentage of reproducing females. The offspring rate becomes high, by (a) slaughtering a high percentage of calves, especially males, (b) selecting for high-weight animals, and (c) slaughtering all males at the age of 1 1/2 years (the young males are able to accomplish the necessary mounting their second autumn). All this is conditioned upon the individual animals realising their full biological growth potential, i.e., herd size below MSY-level (Lenvik, 1989). Slaughtering the segment of animals least likely to survive winter reduces winter mortality. The level T_{husb3} requires a more systematic selection of does, building on systematic criteria, where weight selection of potential mothers can be an important part (Lenvik, 1989). The change in potential production between a production system including e.g. T_{husb2} and one including e.g.T_{husb3} may be illustrated directly by means of Figure 3.28.

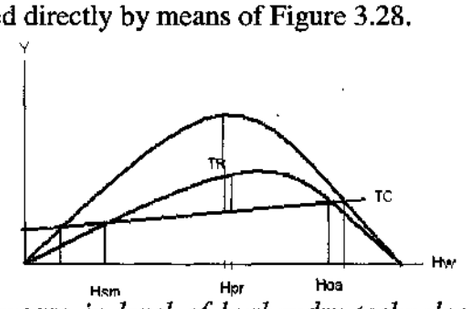


Figure 3.28. Increase in level of husbandry technology. Possible equilibria. Level of cost assumed to be unchanged

We note that nothing but the revenue curve is changed. We assume the monetary costs connected with this change are always limited. For simplicity we have assumed unchanged costs. The change will thus imply a net profit. The increase in the revenue curve implies *a potential for profit increase,* but that is *dependent on a property rights* (common property) *equilibrium.* We note that the changes in open access equilibrium seem to be insignificant.

Above we have considered possible changes in herding and husbandry technology and their direct influence on the production function of reindeer management. We now turn to possible Indirect influences known as CPR problems.

3.4 Potential CPR problems

Though the reindeer are privately owned, the work organization makes a CPR approach to work contribution relevant. Due to the collective character of the herding part of the workload, we may conceive potential *maintenance problems* (cf. 2.1 and Table 2.2). Individuals can be tempted to *shirk and free ride* on the herding activities of their fellows, but be on the spot when the individual harvesting of the offspring takes place, gaining an "easier" profit than their fellows (Riseth, 1992:1: 25). If the aggregated herding work supplied amounts to less than some critical limit, this can mean that necessary work is not carried out, implying an immediate loss for everybody. If repeated, this can be the start of a run-away process or a vicious spiral in that "*decreased herding-work investment leads to decreased herding profit and to further decreased work investment,* etc."(Beach, 1981:31; cf. Riseth, 1992:1: 27).

Intensive herd management means good herd control and depends on a sufficient and skilled work force. With an inadequate work force, extensivation may occur. We should note that very extensive reindeer management might resemble reindeer hunting. Calling Table 2.3 to our minds: wild reindeer cannot be stored, and a herd management approaching hunting thus faces a maintenance dilemma. *This is a second-order dilemma: a sufficient number of skilled appropriators have to agree to provide enough labor to ensure that needed collective work is accomplished.* An applied typology of potential CPR problems (cf. Table 2.2) for reindeer management is summarized in Table 3.7, which also includes cases not previously mentioned. Here I have focused problems, which are both flow and stock-connected, as these are considered to be the more serious. Some of the cases will be commented below.

Insufficient maintenance

For a vulnerable nature-based production system, external defense and conservation of the basic resources by physical or institutional means are obviously of utmost importance. When the CPR is complex and the external border relations are difficult (cf. Ostrom's (1990:90) principle 1), this can be a challenging task. Free riding may create a skewed workload. More serious is that insufficient resource defense and conservation may lead to the permanent destruction of the resource or parts of it. Herd extensivation because of insufficient herding activity, as discussed above, is as a rule not permanent: it is mainly a question of labor investment to regain a sufficient tameness grade. However, if the tameness grade is driven too low, the border between herd and wildlife management may be crossed.

Table 3.7. Potential CPR-problems in reindeer management

PROBLEM TYPE	MAINTENANCE PROBLEMS		HARVESTING PROBLEMS		
PROBLEM NAME	Insufficient maintenance		Over-harvesting externality		
				Assignment problems	Technological externality
RESOURCE	Herd	Pastures, use areas	Winter pastures	Pastures	Herd and pastures
POTENTIAL PROBLEM	Insufficient herding	Insufficient external property rights or borders	Herd per vegetation – ratio too great	Seasonal imbalance (particularly *summer pasture limitation*)	Difference in efficiency imply difference in control
POTENTIAL OUTCOME	Decreasing herd control, i.e.: extensivation	Insufficient pastures/ use areas implying reduced output and /or reduced potential stock level	Overgrazing lichen pastures implying reduced stock -level and reduced regeneration rate	Using pasture out of season, may promote overgrazing	Imposing change in technology or production system

Over-harvesting externality

This problem has extensive implications, due to the stock level's impact on the regeneration rate. The standard example here is overgrazing of lichen pastures. The concept also includes the sub-types *assignment problems* and *technological externality* (cf. chapter 2). The former rests on the additional condition of variation in natural productivity leading to competition for the best areas, which become overused, while the poorer ones is underused and in thus suboptimal use of the total CPR. A more serious assignment problem can be connected to seasonal imbalance in pasture capacity - the situation of a summer pasture limitation. Recall our finding that landscape without natural borders could promote the adaptation of a pulsating summer herd grazing lichen pastures out of season making R-values extra low and thus cause lichen pasture depletion. Herders being adjacent to lichen pastures may misuse the opportunity to graze out of season and thereby cause serious overgrazing.

One example of the latter subtype, technological externality, is the relation between the two different technologies of traditional reindeer pastoralism, the combined meat and milk pastoralism (cf. Appendix X) and the meat pastoralism. The former has a considerably higher labor requirement, but a lower capacity for handling large herds. When these meet, a larger and more extensive meat pastoralism herd will tend to attract the more intensively kept animals from the combined herd, so that it will be difficult to maintain the two technologies side-by-side. This is an example of a technological externality where one of the technologies will tend to expand in use at the expense of the other. This type of externality may encompass both the control of herds (here, primarily) and pastures (here, secondarily). Control can also be created more directly by physical means, e.g., fences

Complex CPR problems

The different CPR problems of Table 3.7 do not necessarily exist in isolation. We therefore introduce the concept *complex CPR problems,* meaning *problems caused by various harvesting and maintenance problems in combination, reinforcing each other.* Let us look at a couple of possible examples:

(1) Insufficient herding implies reduced herd control and tameness grade and as a corollary increased difficulties conducting husbandry tasks, including harvesting. To the extent harvest is incomplete, this may initiate or strengthen already existing harvesting externalities, and thus promote development of an over-harvesting externality. That is, *insufficient herd control may imply insufficient harvesting.*

(2) We can also imagine combinations of assignment problems and technological externalities. Building on the example of grazing out of season on lichen pastures, we can assume that the potential overgrazing would not take place with the current herding technology. *The implementation of new technology as ATVs could advance the grazing out of season by making it feasible.*

Combinations of different CPR problems may be an even more serious threat since *an apparently insignificant problem may develop to a serious one through various domino effects.* Whether the potential problems will develop or not is dependent on both the physical attributes of the CPR, production technology, the actors, and the availability of institutional solutions. We will now study how technological change influence potential CPR-problems.

Exploring further into our second example, we may consider *an environment of open access.* In this setting an increase in the level of T_{herd} rnay create a powerful dynamic. A herder obtaining a higher T_{herd} level, with an immediate competition advantage in herd and pasture control compared to the herder with the lower T_{herd} level, can promote the development of a technological externality. This advantage may only be levelled out by the adaptation of the technology by all potential competitors. *New herding technique facilities will thus have a tendency to expand quickly forcing all co-users to invest in order to avoid loss in competition* (cf. Riseth, 1987:18-21, cf. Paine 1994:155). The investment thus becomes a necessary entry-ticket for new participants.

Recalling the effect of new cost curves (TC2, TC2') in Figure 3.27, we may imagine that in an open access environment, this will imply reinforced competition, which will tend to promote the process of increasing the over-all T_{herd} level. Consider *a series of T_{herd} investments:* in addition to the need for herd increase because of increased costs, the strengthened herding capacity also strengthens everybody's power to compete for the use of pasture resources. Thus the technological externality introduced above will not tend to disappear, even if the imbalance in T_{herd} level is leveled out.

Moreover, we will expect the competition to be sustained and the externality to reappear on a higher level (for example, skiers against snowmobiles, and later helicopters against motorbikes). Accordingly *the externality generally tends to be a treadmill forcing the users to pursue the T_{herd} level of the most advanced user, or lose in the competition for pasture and herd resources.* We should observe the resemblance to "The Agricultural Treadmill" (Cochrane, 1958, cf. Borgan 1981:208) in competitive investment, but also the great difference: the object for the competition is not a market, but the basic resources. However, one important implication is similar: both industries will tend to propel out surplus labor force. *Due to this treadmill effect, the open access equilibrium is not stable* as in Figure 3.26. (cf. Figure 2.1).

We face an example of a complex CPR-problem: here a *technological externality promotes an over-harvesting externality more serious than the standard type.* The effects are most serious for the case of grazing at lichen pastures out of season. *Not only is the rent depleted economically, but also the vulnerable lichen resources are step-by-step more intensively exploited by an increasing T_{herd}-level.* The reason is that each new herding technology makes possible a level of resource exploitation, which was not feasible before.

While in the open access case the T_{herd} level was decided by the first successful implementer, *in the case of effective property rights there is no treadmill effect.* The herders can in this case consider whether increasing the T_{herd} level, by means of implementing new machinery, is profitable or not. This depends on the shape of the revenue and cost curves. The reason is that with effective property rights the herders do not compete over the pasture resources In effect, *for the case of effective property rights, new herding and husbandry techniques will be implemented if they are profitable, the H_{pR}-equilibria* (cf. Figure 3.27) *being stable.*

However, we can imagine that a technological externality may undermine a common property regime by promoting an over-investment in herding technology, establishing a costlevel that reduces profits, and lead to resource competition.

3.5 Strategies and Hypotheses

Having explored the dynamics of core production factors of reindeer management, we no turn our focus towards the implications for the choices of reindeer management strategies made by each husbander. Our focus from the start of this study have been the empiric case of winter herding technology (snowmobile) introduction. In line with our assumptions in 3.3 we therefore imagine that a herder has made his choice of implementing winter herd technology and now considers *options for increasing his total revenue* and thus cover his increased costs. For analytic clarity we assume that further investment in herding technology will be made in summer herding technology and that initial herd size is the level set by the pasture zero-isocline of the limiting seasonal pasture. What are then the options for increase in revenue?

Above we have scrutinized the potential of different technologies. We found two options with potential of revenue increase: (1) investment in summer herd technology, (2) increase in husbandry technology. However, in a CPR context externalities is noy unusual. Table 3.7 focus over-harvesting externalities; implying an additional option; (3) to *increase herd size.* This option imply overgrazing and pasture capacity reduction, but it can be feasible, at least in the short run. The option is nevertheless attractive as herding technology increases the potential of herd control.

Characterizing these options, we know from above that option (1) can be profitable under effective property rights, or it can give zero profit under open access and even contribute to lichen pasture depletion through a treadmill effect caused by a complex CPR -problem. As for option (2) this can be profitable under effective property rights, but will provide no attractive opportunities of any externality under open access (cf. Figure 3,28). As for option (3) this will be profitable and unproblematic if herd size is under the herd zero isocline (of the limiting season pasture). When this isocline is transgressed, the option can cause an over-harvesting externality under open access, while it is unattractive in the case of effective property rights.

Can these options be combined? On comparing the characterics we note that option (1) can be implemented under both regimes, producing different outcome. The remaining options (2) and (3) are on the contrary mutually precluding each other when the herd zero-isocline is reached. That is; we can consider *options (2) and (3) as opposite strategies of revenue increase.*

We therefore denote as *Strategy A increase in husbandry technology* implying *expansion in productivity or quality,* while we name as *Strategy B increase in herd size* implying *expansion in quantity.*

We note that Strategy A is stabilizing, promoting options in accordance with the given set of zero-isoclines, while Strategy B challenges stability by inducing overgrazing. Let us now inquire under which conditions these two strategy options are probable choices.

Strategy A is equivalent with increasing the herd zero-isocline, while Strategy B is equivalent with transgressing the limiting pasture zero-isocline; being promoted by open access.

It seems obvious that the tendency of choosing a stabilizing strategy is stronger, the stronger is the the limitations of the situation. That is; in our two-pasture model *in situations of winter-pasture limitation* (and situations with similar features), we would *expect Strategy A to be the dominant choice.* This is because the lower is the expected level of winter survival, the lower will the propensity to pursue herd expansion tend to be. Similarly, for landscape; a landscape

with natural borders having by itself a stabilizing effect, would also promote a stabilizing strategy. Generally we would expect *stabilizing physical attributes and stabilizing strategies to be mutually reinforcing.*

Conversely we would expect the tendency to choose strategies promoting instability (Strategy B) to be strongest when the limitations of such strategies are weaker. That is; in our two-pasture model, in situations of summer pasture limitation or in a landscape with relatively few natural borders..

Including our considerations in subchapter 3.2, we may suggest hypotheses and implications. We would expect these attributes of the physical world to promote Strategy A and herd stabilization:

(H1) *When winter pastures are the limiting factor in seasonal pasture balance, Strategy A and herd stabilization will be promoted.*

Implications of (H1) would be:

Strategy A and herd stabilization are favored by these properties, individually and/or in combination:
(H1a) Nutritious and easily degradable bedrock on summer pastures
(H1b) Oligotrophic and heavy degradable bedrock on winter pastures
(H1c) High annual precipitation on summer pastures
(H1d) Low annual precipitation on winter pastures
(H1e) Relatively high proportion of annual precipitation falling as snow

For landscape we can consider brokenness both within one seasonal pasture and between seasonal pastures. Within one seasonal pasture we have:

(H2a) *A landscape broken up by many natural borders, yielding relatively small-scale CPRs, will tend to promote Strategy A and herd stabilization*

Conversely the opposite features will favor Strategy B. Between seasonal pastures both a more macro scale and interseasonal borders can have an effect. We would expect that:

(H2b) *In the case of large scale CPRs, lack of or insufficient borders between seasonal pastures would tend to favor Strategy B and herd expansion more than for a small-scale CPR.*

Recalling our scale reflections in 3.1 we can add with respect to the capacity for transformation:

(H2c) *An open landscape with relatively large scale CPRs will promote a community with a lower capacity of transformation than the converse.*

In our next chapter we will develop hypotheses regarding institutional features affecting the husbanders' choice of main strategy.

Chapter 4
Institutions of Reindeer Management

Based on our analysis of the production system of reindeer management we have above developed hypotheses for under which physical conditions stabilizing vs. expansive strategies are more and less probable. Recalling our dynamics of institutional capacity in 2.5, the more physical features promotes expansive strategies, the higher will the need of coordination be. Our next step is to inquire the institutional system surrounding the production system.

This chapter is used to develop hypotheses covering institutions affecting both need and capacity of coordination as of transformation. We will consider a herding society without an internal top authority existing as a minority enclave dominated by, and gradually becoming politically integrated into, a majority state society. Our intention is to use general social theory, and specify the model enough to cover the Sami herder societies, which have long existed in Norway, Sweden and Finland[1], and it may to some extent be applicable to other herder societies as well. We intend both to describe basic features of traditional reindeer pastoralism, and to give a basis for analyzing the dynamics of general societal modernization processes and development of the welfare state. To account for the dynamics between the local CPRs and central state authorities in an applied IAD Framework perspective we need a minimum[2] of two action arenas. We therefore introduce as a basic action area (1) *the Reindeer Herding CPR* and as a higher order one (2) *the Minority-State Encounter* to represent the diversity of relevant real-world arenas.

4.1 The Reindeer Herding CPR

Recalling Figure 2.3 we start our analysis at an operational level where the physical attributes already are described in chapter 3. The institutions of the local CPR add up the remainder of the basic action arena. In chapter 2 we specified the concept of institutions into attributes of community and rules-in-use. We start with the basic properties.

4.1.1 Attributes of the Community

In this section we will examine how properties as (1) resource dependence and demographic features, (2) relative self-sufficiency and relative independence from external markets, and (3) a society without an internal top leadership can influence the ability to resolve CPR problems. The first couple of features, as well as the physical attributes discussed in chapter 3, affect the institutional need for coordination, while the last is more connected with the institutional

1 The Russian case is different insofar as the USSR's collectivization of primary industries also included the reindeer management of both the Sami and other northern aboriginal peoples, with a complete expropriation of property rights (cf. Eidlitz, 1979).

2 We might have achieved a more accurate model by introducing more levels, but, relying on the principle of *maximizing leverage* (King et al. 1994: 29), I conjecture that the predictive power of a relatively simple model will be sufficient for the purpose of analysis.

capacity of coordination.

4.1.1.1.1 Demography and Resource Dependence

In addition to the possible growth in herd size per household (vertical growth), growth in the number of resource users (horizontal growth) can also be important for the total level of resource exploitation (cf. Brox, 1990:223). In Chapter 2 we focused access/entry as one of the basic operational rights of a regime, and presented as a part of Ostroms (1990:90) design principles clearly defined boundaries of who have appropriation rights. Runge (1992) points to a high level of *resource dependence*, as a basic feature in many CPRs of developing countries. This can be true in most traditional communities. As well as the properties of institutions might influence entry/exit dynamics for a CPR, the *entry pressure* from want-to-be appropriators, might also be an important factor. The strength of such a pressure, in addition to the relative attraction of herding as source of income, will also be dependent upon demographic factors. Thus, the higher the relative number of culturally competent potential appropriators, the higher will the need for coordination be. This is because increased potential competition enhances the need for restrictive entry rules and/or exit promoting mechanisms. However, in admitting that demography — as an internal factor of the herder society — is a factor that can increase the need of coordination, we do not have good reasons to connect demography to the choice of strategies for income increase.

That is, *we would expect that entry pressure would increase the need of coordination independently of the choice between Strategy A1 and Strategy B1*. Thus we will include demography as a factor in our analysis without a hypothesis connected to choice of strategy.

4.1.1.1.2 Missing Markets

Both herding societies and other "pre-modern" societies have managed well over the centuries, more or less without access to markets. Our main interest here is to examine how imperfect or absent markets can influence economic behavior in a herder society. We will assume the following set of markets to be of particular significance: (1) markets for sale of production outputs, (2) markets for purchase of production inputs, (3) capital or insurance markets, and (4) labor markets. *Even though markets may exist, physical or institutional barriers may limit the use of markets to bare necessities due to transaction costs.*

Sales markets are basic — without significant markets for sale of production output, such as meat, the main consumers of the products of the herder society will tend to be the herders themselves. That means that the production unit will also tend to be the consumption unit. This will be in line with the logic of peasant societies introduced by Chayanov (1966). Since the household is the unit of both production and consumption, *the subsistence needs of the household is the ultimate goal of production*. Further implications of this would be that the size of the production, the labor input and the use of the resource base can be traced back to the subsistence needs of the household. One of Chayanovs suggestions, is that of *family cycles*; households will tend to adapt their use of the resource base to current family size, can easily be transferred to reindeer herd management.

Subsistence herding imply as a rule *modesty in consumption*. Johan Klemet H. Kalstad (1997) brings this to attention. When you are trained to minimize consumption you can better stand difficult situations and an uncertain environment than persons used to a high and certain level of consumption can. If the herders minimize consumption, as an additional insurance strategy, *efficient utilization of their resource endowment become important.*

Lack of *markets for production inputs* implies that the basic means of production are natural assets or tools produced in the household or the local society. Even though some collective task may need an extensive work contribution, the monetary cost will tend to be low. On the other hand, if the utilization of sales markets increases, the purchase of commodities for use will also tend to increase. Thus they will reinforce each other. Extensive purchase of production inputs would probably be contingent on relatively stable sales markets. The possible dynamics described in subchapter 3.3 is relying on the existence of both markets for production inputs and output sales markets.

Lacks of insurance markets create a need for *insurance strategies*. One implication of having an income target set by subsistence needs is that when the target is achieved, herders prefer to invest in herd increase instead of increasing the production. Not fully considering the herd as capital in economic sense implies not imposing a requirement of return comparing with a standard or an alternative investment. An alternative individual insurance strategy could be *supplementary sources of livelihood* like hunting and trapping, fishing, and harvesting other types of natural resources. It could also be labor markets. Considering other sources of livelihood involves *portfolio balance* reflections. If other sources are meant to be supplementary, they have to be accomplished within the confines of the work requirements of reindeer management. Another supplementary strategy could also be development of relations of reciprocity, both within and outside reindeer management.

Focusing on reindeer management more directly, the anthropologist Tim Ingold (1980:274-276) has reviewed published ethnographic literature on reindeer hunting and pastoral societies. On that basis he has made an effort to rethink the logic of reindeer economies. A few of his conclusions may reveal some of the more specific common features of these cultures. Generally the author finds that *pastoralists seek autonomy through attempts to become independent of others through herd accumulation and parsimony in harvesting* (i.e., limiting harvest rate to an absolutely necessary level). These conclusions are in accordance with an earlier contribution from Robert Paine (1971:166-170)[3]. His statements include: (1) *herd expansion is a basic pastoral value*, and is often practiced whether there is opportunity for corresponding expansion of pastures or not, and that (2) pastoralists choose to *draw minimum incomes from individual herd capital* and undertake minimal conversions from this capital form to another. This has important implications for the pattern of consumption.

Modesty in consumption, discussed above, is equivalent with parsimony in harvesting. As a storable asset, reindeer under human control are thus natural capital. *In a situation of missing capital markets, we would therefore expect herders to invest their wealth in animal capital; that*

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3 One of the explicit sources of inspiration for Ingold's work, built on a more limited ethnographic material.

is, they will have a propensity to herd accumulation.

Societies under change will often have an uneven development. Imperfect capital and insurance markets can coexist with well-functioning sales markets. Thus we can imagine situations where herders use sales markets and markets for production inputs, though capital and insurance markets are missing or imperfect. We would also expect that in societies where external markets play a peripheral role, the general attitude towards investment in other types of capital, even if more profitable, would be reluctant. This would thus imply a tendency to higher investment in herd capital than in societies where external markets are more integrated into the economy. In this type of situation we would, under otherwise equal conditions, expect Strategy B to occur relatively more often than Strategy A.

We can formulate our expectations as a hypothesis:

(H3) *When markets play a peripheral role in the economic life of a herding society we would expect a propensity to herd accumulation and also find Strategy B more usual than Strategy A.*

So far — in this chapter and the preceding one — we have discussed features having implications for the need of coordination. We now turn our attention to the capacity of the institutional system.

4.1.1.3. Acephalous societies

In Chapter 2 we stated that some general features of a culture might be viewed as basic institutions or meta-institutions, conditions for the more designable part of the institutions or rules-in-use. These features play a particularly important role in explaining how stateless societies — sometimes referred to as *acephalous societies,* meaning societies without a single head or body of supreme authority — can solve the problem of how to constitute and sustain order. For example, the Sâmi people have never had a state of their own — nevertheless there is evidence of a well-ordered society back through the centuries, to the extent that science allows us to see. In this subsection we introduce a general approach which can illuminate how acephalous societies handle their problem of order.

Regulatory principles

Many outside observers, including representatives of colonial powers, have considered acephalous societies as lacking institutions. Absence of visible palaces and prisons does not, however, mean lack of a social order embedded in the shared understandings of a people. Considering the cattle-owning, nomadic or sedentary, Nuer people of Southern Sudan, the anthropologist Mary Douglas (1980:61-62) focuses on the importance of *regulatory ideas surfacing and marshaling activity.* Following her vision, the political scientist Wal Duany (1992:5) starts his analysis of the same Nuer by stating that such regulatory ideas depend upon a shared community of understanding.

"There is then some more general system of expository ideas that shapes the intellectual world in which people live. We need to consider the realm of ideas that people use to understand the world in which they live, think of themselves, and how they relate to one another and to different peoples with which they may have contact (Duany, 1992:5-6)."

Some examples the findings of Duany may illuminate what is meant by such ordering regulatory principles:

(1) an *open decision process* is the essence of the governance process
(2) general equality, personal freedom of action, and *reciprocal accountability* are fundamental
(3) some individuals are "ordained" to exercise priestly and mediating roles that carry unequal authority in conflict resolution (ibid.: 6-8)

This last finding is an example of specific authority roles being possible without a state, insofar as the roles are performed on behalf of the society as such, not on behalf of a ruler or a ruling body. Another example is the long-lasting historic Icelandic Commonwealth (Eggertson, 1990) which had an effective court, but lacked an executive branch. Enforcement was private, more precisely a matter of kinship responsibility. The same finding also reminds us that many traditional societies practice, or at least have practiced[4], *religion and belief-systems where gods, spirits or other supernatural beings have played important roles in their authority systems.* Modern western intellectuals may have a tendency to be blind for or underestimate the importance of such mechanisms dismissing them as superstition. It is therefore interesting to note how the role of old *oral tales* told among people in a traditional society can be interpreted in cultural psychology. Nergård (1996) begins with Jung's (1991) concept of "the collective unconscious"[5] and focuses on how this deep layer of human mind, acting as a reservoir of a spiritual landscape, can be asked for advice on how to act in relation to nature and interpersonal relations. In indigenous cultures, *a sacred part of life may therefore play an important role in traditional resource management systems,* without many signs visible for outsiders. Generally we would also expect oral tradition to have a predominant role in non-literate cultures.

Theorizing upon village societies and their encounters with imperial and state governments the political anthropologist F.G. Bailey (1985:147-155) proposes some contrasting features of what he calls *peasant*[6] and modern ideologies. They may also give insight into the broader cultural world of acephalous societies:

(1) Generally accepted *norms of behavior* include keeping competition for material and political prizes within certain moral bounds. As political procedure, the principle of

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4 Many of them have been forced or persuaded to abandon by western missionaries.

5 Sigmund Freud developed the concept of «the unconscious». C.G. Jung was a student of Freud, but broke with his master. He developed his concepts of "the collective unconscious" — a layer of human mind, which does not owe its existence to personal, but to some form of collective experience —"and his theory of the archetypes - mental structures resembling instincts. Nergård interprets Jung to mean that this faculty of human mind is not inherited in biological sense and aims to use the concept as a tool of analyzing complicated, but important, collective cultural processes (Nergård 1996:69-71, cf. Jung, 1991).

6 Peasant societies may deviate from *pastoral societies* in some respects, but I find that less essential at this stage of discussion.

consensus, which emphasizes solidarity, instead of majority voting (which is thought to be separating) is an important normative rule.

(2) In their *common understandings* of the world, peasants act as though they believe they play a zero-sum game, which turns out to be an argument in favor of *status quo*. Spectacular personal successes for some individuals in situations where many fail tend to be given supernatural or anti-social explanations. As a consequence, plus-sum situations as a result of cooperative efforts, have no place. The goal of increased wealth is thus both nonsense (as man has not that degree of control over productive resources), and immoral, as antisocial behavior.

(3) As for people's *preferences*, this means that honor, prestige, wealth, or ritual purity are culturally well understood and accepted while, for example dedicated service to the public good is not, and when expressed, seems like hypocrisy.

Paine (1971:166-170) also comments that *supernatural mediation* is far from absent in herding societies. It is, however, of less importance than for hunters, and is usually employed in post-hoc explanations of ill-fortune, while "luck" is one of several explanations of good fortune, and that pastoralists have a more severe ethic of the work contribution of each individual than hunters. The latter statement is of importance when considering the possibility of maintenance problems (cf. Table 3.7). To derive a reliable picture of possible coordination principles for an acephalous reindeer management society, we need to include some balancing principles of the same type as discussed by Duany. Generally we therefore might conjecture that a sketch of common regulatory principles for acephalous reindeer herding societies would include most of the following:

(1) household heads (a) are their own masters and (b) consider each other as equals and reciprocally accountable to each other
(2) independence, skill (including efficient resource use), and dignity are important personal values
(3) the consumption (subsistence) needs of the household are the ultimate goal of production
(4) security against uncertainty is pursued through (a) herd accumulation, (b) social relations through family bonds, and (c) modesty in consumption and, (d) possibly additional sources of income
(5) the consensus principle is more common than majority rule as an ultimate societal decision rule
(6) status quo and tradition are important guidelines for collective-choice decisions
(7) conflict resolution mechanisms may include both (a) particular mediator roles and (b) supernatural mediation

Considering this preliminary sketch of common regulatory principles, we could divide them into two very broad parts, one which is based on individual independence (e.g.; la, 2, 3, and 4a) and the other which underlines responsibility towards fellows, society, nature, and possibly the spirits (e.g.; lb, 4b, 5, 6 and 7). As bundles they represents the *individual* and the *collective* interest, respectively. *To sustain a society, both types of principles are needed.* The set of principles must both provide the individuals with opportunities and constrain their behavior.

There also need to be some balance between the types of principles. We may denote this requirement as the *individuality - collectivity balance*. Imagining this balance as a scale, the relative weight can have an overweight on either of the sides.

We have above defined a *second order common* as a CPR with groups of users instead of single households. We have also contemplated the situation of the need for coordination in a second order common in a landscape without natural borders. On examining the capacity for coordination, we assume that nested systems require multiple layers of organization (cf. Ostrom 1990:101). That is, in a CPR consisting of units on two levels, single households and groups of households, there will be a need for regulatory principles on both levels. The principles on the first and the second level may deviate with respect to the balance between *individuality* and *collectivity*. We can therefore imagine a situation where the users play the game of Assurance at level 1 and Prisoner's Dilemma at level 2. *A corollary is that the most successful Assurance - players at the first level will tend to be winners in the Prisoners Dilemma-game at the second level*[7]. The regulatory principles on level 2 will thus be decisive for the outcome. To expect an overall game of Assurance the game therefore should be Assurance at both levels.

Before we develop hypotheses on the capacity of the institutional system we will also consider aspects of the concrete regime involved.

4.1.2 Rules-in-Use

We have above considered the role of regulatory principles in acephalous societies. It is, however, important that these principles are connected to rules-in-use implementing the principles in the concrete resource management. The actual rules-in-use are determined by the needs created by the relations of the physical world and the rule-making and enforcement capacity of the society in question. In a society where the resource base is vulnerable and may be jeopardized by expansive individual strategies, there will be a considerable need to balance individual and collective needs by establishing collective strategies or effective rules-in-use. In Chapter 2 we stated that *the strength of a regime is a function of the extension of its property rights*.

4.1.2.1 Operational level rules

A herder society faces a relatively uncertain environment involving considerable risk of loss of the source of livelihood. This calls for vigorous and competent herders. Even the youngest herding hand may have the full responsibility for the herd in a critical situation and need to be prepared. Nergård (1996:35) refers to herding culture as *ostensive* in terms of teaching. Children are taught through taking part rather than through explanations. This does not mean that oral communication is unimportant. Paine refers (1970:54-59) to endless discussions of herding tactics among Sami herders both as a pedagogic device and to promote unanimity among fellow

7 Current director of the Agency of Reindeer Management, Jon Aa. Mel0y, called my attention to this (cf. Mel0y, 1997).

herders. We thus expect herders to be flexible in their operative decisions. Flexibility in operative decisions is not, however, equivalent to lack of operational rules. Uncertainty in the environment calls for certainty of what is the correct action in a given situation.

In empirical analysis of herding societies will we generally consider *boundary, entry/exit, and withdrawal* rules and conventions to be particularly important. More specifically, we have to search for both external and internal exit-entry dynamics and both direct and indirect withdrawal rules. The actual regime thus consists of the set of rules and social mechanisms, which govern the daily operation of the CPR.

Generally we would expect herding societies to have some kind of *social and cultural entry barriers*. These barriers may be rather effective obstructing external newcomers. Thus whether sedentary neighbors are culturally close or not may influence the level of *external entry pressure* from would-be appropriators. The importance of such rules will, however, be dependent on the strength of this pressure, which partly will depend on the relative attractiveness of herding compared to alternative options. Whether rules and cultural barriers promote or obstruct exit through *sedentarization* may be decisive for *equilibrium between entry and exit* from the herding society. In this respect Fredrik Barths (1961) classical anthropological analysis of the Basseri-nomads of South Persia is illustrative. There are *shedding mechanisms* both on the "bottom" and the "top" of the nomad wealth hierarchy insofar as conversion of animal capital to agricultural land is a feasible and attractive option for wealthy sheep-nomads.

Within a herding society, the sustenance of the families and households through *inheritance rules* and *rites-of-passage* have important implications for the number of appropriators from generation to generation and how the herd capital is assigned over time. If all internal would-be appropriators had the right to establish, this would ultimately lead to that the common property regime for the group becomes open access for those within the group (cf. chapter 2.5, cf. Bromley, 1991: 32). We also need to consider how balance and consensus are maintained among families and groups through customs and rules. When contemplating *withdrawal* rules, we should widen the scope to encompass performance that influence appropriation and maintenance of basic resources.

Concerning property rights for the group, the operative rules and mechanisms in a CPR setting are concrete applications of a community's underlying regulatory principles. The rules are property rights, and we recall the possibility of a number of distinctions between the no-property situation and the full common-property situation (cf. Table 2.5) the more extensive the bundle of property rights, the higher the regime's capacity for coordination tends to be.

Rules include sanctions, and compliance requires monitoring and sanctioning. One of Ostrom's (1990) design principles for CPRs, that have had a stable resource adaptation sustainable over the centuries, is named *graduated sanctions*. The ethnographic literature of African pastoral groups (Swallow and Bromley, 1994:6, cf. Niamir, 1989) illustrates this with five types of internal punishment used to enforce community norms of behavior and resource management. These are, in increasing severity:

> (1) fines, (2) temporal exclusion, (3) physical punishment, (4) permanent banishment, and (5) curse.

We would generally expect a similar ladder in all herder societies. Rules without possibility of sanctioning will tend to become rules-in-form.

The institutional capacity of an actual herding CPR will depend on both the regulatory principles of the herding society and the strength of the concrete regime. Recalling the strategies of subchapter 3.5: A; expansion in quality (herd productivity) and B; expansion in quantity (herd size), we would in situations of abundant pasture resources (cf. the game of Prisoners Dream) conjecture that the character and strength of the regime would have minor influence on the herders' choice of strategy.

On the contrary, in situations of resource deficit, or such being in sight, we would expect a clear connection between regime and choice of strategy. Strategy A would require a more extensive cooperation between herders as higher levels of T_{husb} also include collective decisions on elements of husbandry work (e.g. design of herd structure), cf. 3.3.2. Thus, within societies governed by regulatory principles having an individuality-collectivity balance with an overweight on collectivity, we would expect a higher propensity to choose Strategy A, whereas for societies having an overweight on individuality, we would expect a higher tendency to choose Strategy B.

Further, for the strength of regimes, as in Table 2.5, the stronger is the regime (the more complete bundle of property rights), the higher is the propensity for choice of Strategy A.. Thus, in line with this, the weaker is the regime, the higher is the tendency for choice of Strategy B, as pursuit of this strategy is favored by open access.

Summing up, we can hypothesize about traditional CP-regimes:

(H4) *Herding CPRs, which (a) belong to a society stressing collective responsibility in its set of regulatory principles, and (b) have a strong common-property regime with effective monitoring and sanctioning, will have a higher probability to pursue Strategy A and herd stabilization than herding CPRs having the opposite features.*

4.1.2.2 Collective-choice level rules

When there is an imbalance between needs and capacity for coordination, which is most probable in situations of rapid change or major external influence, the society's capacity of transformation becomes important. Ostrom (1995:33) has pointed out that all *rapid exogenous changes*, among other things in technology, are a threat to the continuance of any self-organized system, because the traditional mechanisms may become insufficient when change is rapid. Slower changes provide more opportunities of adjusting institutions to the changes imposed.

In an IAD framework perspective, institutional change involves higher-level action arenas, mainly the arena of collective-choice, but in some instances also constitutional-choice. The arena of collective-choice may be a dominant group of herders, representatives for all herder households, the assembly of all adults in the society, or a board of elders. The important part is the *existence* of the arena and *the legitimacy of its decisions*. Legitimacy is dependent upon the

compliance to the relevant collective-choice rules — prescribing how the actual rule change is to be accomplished. Some societies may require formal bodies and explicit collective-choice rules; others may not. Legitimacy may then be achieved through *consensus procedures.* In both instances it is, however, urgent that *necessary rule changes are made, and that the new set of rules normally is complied with.* A society, which lacks or has insufficient ability to carry this out, is lacking capacity for transformation.

We have in 2.5.2 considered a number of factors influencing the ability to create new institutional capacities. We found the existence of common understandings, including a judgment of the need for change, and leaders who can find and implement solutions, which are both effective and culturally appropriate solutions, to be important. Generally we would hypothesize that:

(H5a) *The more developed is the general understanding of the need for implementing change, the higher will the capacity of transformation be.*

(H5b) *The existence of leaders who can find and implement solutions that are considered culturally appropriate will tend to enhance the capacity of transformation.*

Besides technological change, another type of fundamental exogenous change, is political integration under another people's state apparatus. We have chosen to examine this within the confines of an additional action arena.

4.2. State Encounter Arena

So far we have considered a reindeer herd management operating freely inside a CPR without any top-level governing. In reality we know that historical reindeer-keeping societies have experienced state apparatus encounters, as a rule from colonial government. Therefore we need to extend the scope of our inquiry. The focus of our attention is neither on the state *per se,* nor on some possibly emerging "chief level" of the originally acephalous society. We center rather on *the encounter itself as an action situation, with state representatives composing one subset of actors and herders composing its counterpart. We assume that the parties over time will develop their interactions, thus constituting a cross cultural action arena of relative stability.* Considering these interactions as a reciprocal process, we will examine particular situations being of interest in our context.

4.2.1 State, Majority and Minority

An encounter between a state and a herder society will affect both. Our main interest is in the herder society and the interaction between the higher level now introduced and the basic CPR level. Thus in our continued analysis we need to link two action arenas and their reciprocal influence, following the pattern of Figure 2.3. However this being our main focuses, an external state apparatus will always represent an external population. We therefore first need to consider the relation between the two populations directly.

4.2.1.1 Majority and Minority

Considering the cultural ecology of two ethnic groups in contact, Barth (1969:19) outlines the following possible forms of interdependence:

(1) The groups occupy *clearly distinct niches* in the natural environment and are thus in minimal competition for resources, though they co-reside in an area.
(2) The groups may monopolize *separate territories* but be in competition along the border.
(3) The groups may have a *symbiotic* situation of interdependence of goods and services.
(4) The groups are in at least partial *competition* within a niche.

The alternatives 1-3 refer to stable situations while 4 more probably will tend to lead to one group displacing the other or some kind of increasing complementarity and interdependence. *The level of resource competition is a basic feature in an inter-group relation.* In addition, the demographic balance is substantial, insofar as:

> "A group's adaptation to a niche in nature is affected by its *absolute* size, while a group's adaptation to a niche constituted by another ethnic group is affected by its *relative* size" (Barth, 1969:20).

However, regardless of the course of politics, the actions of particular groups of people will be of specific significance.

Bromleys (1991:32) remark (cf. chapter 2) on how common property regimes *for the group* may become open access *within the group* can be useful clarifying a situation of two competing population groups within a state society. The distinction for and within the group reflects that property rights have two dimensions important for the strength of the regime. The strength can be diverse in the different dimensions. We may conceptualize the distinction into *property rights for the group,* meaning property rights versus the competing population group and *property rights within the group,* meaning property rights within the one population group we are investigating. Similarly we could use the concept for any relevant group to analyze property rights for.

In chapter 2.5 we cited and commented upon Bromleys description (1991:28) of how common property could be undermined by external pressure. We would expect that *the stronger is the pressure from any external resource competitor, the stronger will the tendency for undermining the common property regime be.* We would expect this to be independent of the internal strategy choices of the herders. Thus we will not formulate a hypothesis on resources competition, however, we will consider resource competition as a factor directly influencing the strength of the operating regime.

4.2.1.2 State and Minority

The attributes of resource competition and relative size will frame the group relations also for a herder society in an encounter with a state built up by another ethnic group. Bailey's (1985:144-

182) description of so-called encapsulated structures, societies not fully integrated in a state, but dominated by the same state, could be used as model for State - Minority relations[8] for an acephalous herder society having a similar relation to an external state apparatus. Following Bailey (op. cit.), the State leadership can consider possible strategies, or what more precisely could be called levels of *governing ambitions:*

(1) non-interference,
(2) predation, that is, claiming *tributum,*
(3) indirect rule, with non-interference unless basic principles of the State leadership are violated by Minority, and
(4) integration.

These ambitions would be included in the State actors' set of preferences.

Governing ambition number 2 means that Minority is compelled to buy itself peace from State, whose operations resembles those of *Cosa Nostra.* Number 3 must be conditioned both on State's claim of state territorial sovereignty (and thus provision of defense versus third parties) and on some degree of autonomy for Minority. This kind of policy may in part be founded upon "a moral conviction that people are entitled to their own beliefs and should be allowed, as far as possible, to preserve cherished institutions" (Bailey, 1985:151).

Integration (ambition number 4) can be on different levels. For our purposes we can distinguish between: a) a boundary regulation of the relationship based on the predominance of the interests Majority's inhabitants in the case of conflict, and b) full *assimilation,* with the ultimate objective of imposing Majority's cultural values on Minority. These ambitions could also be considered as *a possible sequence of State strategies,* where the elevation to a new level would reflect current level of State's power over Minority as an outcome of the parties' interaction. In cases where ambition level 4 is reached and to some degree accomplished, the whole sequence may considered as phases in *a long-run process of domination and integration* of Minority into the Majority society.

Nevertheless, the outcome of the interaction is dependent not only upon features of the State actors, but also on the Minority actors and the action situation *per se.* Regarding State's preferences: it is one thing to have governing ambitions and quite another to have the corresponding *ability.* Considering the constituting factors of an action situation, the first possible obstruction is *physical,* assuming that the core of the Minority society is based in relatively remote, sparsely populated rural hinterlands (cf. Bromley 1991, 142-143), which are not easily accessible for governmental monitoring and sanctioning. The second possible cluster of obstruction factors is *cultural.* Recall the importance of the level of a community of understanding; outsiders will interpret observations of actions in Minority with their own culture as a frame of reference, leading to an incomplete understanding of the actions taking place. Monitoring thus being ineffective, sanctioning will also tend to be ineffective and have unintended consequences.

The most important possible obstruction factor is *political;* it is a question of whether Minority

[8] We use State, Majority and Minority denoting the principal parties of the Bailey model.

inhabitants will resist and at what level. Initially their reaction strategies against governing attempts from State may include options ranging from warfare, sabotage, civil disobedience and other forms of active and passive resistance to bargaining and negotiation or even passive or active subordination. Resistance will depend upon the degree to which Minority inhabitants esteem their own institutions and the extent to which the values of these institutions differ from the values of Majority and, of course, the total *resources* they dispose (Bailey, 1985:151-152).

When Minority inhabitants face State governing ambitions at level 4 (integration), Barth (1969:33) considers the strategies open and attractive to a particular subset of Minority actors. More precisely he focus "the persons normally referred to somewhat as the "new elites": the persons in the less industrialized groups with greater contact and more dependence on the goods and organizations of industrialized societies." The author suggests that they have the choice between these basic strategies of ethnic identity management:

(i) incorporation, meaning a high level of integration,
(ii) accepting a "minority" status, accommodate to and seek to reduce their minority disabilities by encapsulating all cultural difference in sectors of non-articulation while participating in the larger society as Majority members, and
(iii) emphasize ethnic identity and actively use it to develop their society.

I find it difficult to separate (i) and (ii) clearly. Barth (ibid.) reasons that successful implementation of strategy (i) will probably imply that Minority "remain as a culturally conservative low-articulating ethnic group with low rank in the larger social system" while strategy (ii) will probably lead to assimilation. I find it difficult to maintain (i) and (ii) as different strategies and choose to consider them as various aspects of strategies leading to Minority's assimilation into the Majority society. On the other hand I find strategy (iii) clear and follow Barth's statement that it can generate movements ranging from nativism to new states; the process created is somewhat confusing denoted as ethnic incorporation (Eidheim, 1971). In our context I would rather call it *ethnic liberation.* This type of process is a counter-process to integration and assimilation processes and may, at least to some extent, reverse an ongoing integration. At least, it has the potential of strengthening Minority's position within Majority society.

In an IAD framework perspective, the existence of an external state with governing ambitions on level 4 (integration) and particularly on level 4b (full assimilation), interferes with the arenas of collective-choice and constitutional-choice. If the state is trying to impose new operational rules upon the reindeer herders, the rule-making body will be a collective-choice arena. *Whether those laws and rules will become rules-in-form or rules-in-use depends upon the ruler's ability to monitor and sanction lack of compliance* (cf. Figure 2.3.) which again is *contingent upon the level of cultural and political resistance in the herder society* (above). Thus the question of the legitimacy of the state ruling attempts is a *constitutional* issue; do the herders consider an externally imposed "Act of Reindeer Management" as a proper device governing their actions, in their own CPR?

If they generally consider such an act to be a device advancing the interests of for example sedentary farmers, who are at least partly competitors within the same niche, we would not expect them to consider the act as legitimate. Whether the rules of this law to some extent create

rules-in-use would then dependent upon the state's capacity for monitoring and sanctioning. The general situation would thus tend to be one of *competing regimes;* there might be considerable deviation between the *de jure* regime and the *de facto* regime. The herders would, as far as possible, be inclined to stick to their traditional set of rules and the state would try to implement its law. A situation of competing regimes would also tend to vary with the level of the state ruling ambitions. With state ruling ambitions at level 4a (boundary regulation), the combination of the herders being recognized as *de jure authorized users* by the government, but executing a regime of *de facto proprietors* (cf. Table 2.5) does not seem improbable. However, a low level of property rights implies low level of safety towards external threats of encroachment and disturbance and may thus promote considerable maintenance problems.

The general situation would be even more serious in a case of ruling ambitions at level 4b (full integration). The long-term outcome of a situation of competing regimes would, however, be associated with general ethnic- or minority politics. If the state pursues and succeeds with a full assimilation policy, we would expect the compliance to the law to increase over time. If, on the contrary, the minority people resists, and manage to create a political counter-process of ethnic liberation, we would expect the laws made to be more in line with the herder's cultural tradition and the interests of the herder society.

The state government is external to the herding society, which is an encapsulated structure, and as such the state is not necessarily considered to be legitimate among the herders. Generally, the better the correspondence between state governmental institutions and the herder's community of understanding are, the more effective will they tend to be, e.g., *formalizing of traditional institutions will thus tend to be more effective than imposing institutions without an internal cultural basis.* Time is also important; the duration of periods of positive versus negative interaction between the two societies can also influence the level of correspondence between *de jure* and *de facto* regimes. The existence of relevant middleman roles within the executive governmental agents will also tend to promote more efficient governmental action. Generally the more developed a process of ethnic liberation; the more effective the relevant public policy would tend to be. More specifically, we will also assume that the better organized, in a modern sense, the herders are, the greater their influence is on how public sector policy is exercised.

4.2.2 Middlemen and Co-Management Systems

The State actors of the encounter will usually not be members of the principal ruling group. As a rule, agents, placed in a bureaucratic structure, acting on the behalf of the ruler will carry out policy implementation. One basic task for such agents will be to bridge the *communication gap* between the two cultures in question. They will therefore act the roles of *middlemen* (Bailey, 1985:167). Such roles will often tend to be more diverse than the one of the simple, pure messenger, a *go-between* (Bailey, 1985:170) which may be the dominant role when Minority has a high degree of autonomy and no interaction on basis of shared values.

When some level of integration take place, more complex middleman roles will tend to be more abundant. When a number of aspects of Minority inhabitants' life is influenced by the larger society, both sides need and act as middlemen, directly or indirectly, now keeping one foot in

each camp. This kind of position provides opportunities for strategic information management.

A classic pair of roles is that of the middleman acting as a *patron* versus his *client,* in this instance a member of the herding society. Anthropologists analyzing the interaction between the few whites and the many indigenous in settlements of Arctic Canada discuss these roles. A patron is considered by his clients to be *the ostensible source of decisions and favors* (Paine, 1971a: 5), that is, their relationship are asymmetric. Nevertheless, both parties being mutually dependent upon each other (Paine, 1971b: 8), but the patron can be distinguished from his client in that "only *values of the patron's choosing are circulated in* their relationship" (ibid.: 15). The *patron* as a benefactor creating dependent clients may be an attractive role for State agents, which then may develop their middleman-role by maintaining the Minority-Majority-barrier, possibly also as an object for rent-seeking.

Swallow and Bromley (1994:4) summarize the experiences of sub-Saharan Africa where, *state agencies, that have been given responsibilities to directly manage public domain resources, have generally proved to be ineffective*. The authors point to these contributing factors:

(1) rigid rule application,
(2) ignoring or attempting to undermine indigenous political structure and institutions,
(3) lack of power, authority, and/or will to implement rules proscribed at regional or national levels, and
(4) state employees who are responsible for the enforcement of resource-use rules are often remunerated, legally or illegally, through the collection of fines

It is not difficult to observe here elements of the patron role in pursuit of deviating goals.

A more modest appearing middleman role is that of the *broker* who attracts followers who believe him able to influence persons controlling favors, that is; the broker is perceived as "trading" values that are not his own (Paine, 1971a: 8). In situations of ethnic liberation, broker roles can be important in lobbyist functions and in general development of new patterns of communication between Minority and Majority (cf. Barth (1972). Hence *the broker role can thus be a possible position for both ethno-politic organizations* (cf. Brantenberg, 1985) *and state agents pursuing goals deviating from the ones of the ruling group. Brokers may thus promote a process of ethnic incorporation.*

The potential importance of middleman roles for the dynamics of a herding CPR will be conditioned on both the level of Minority versus Majority group interdependence and the general Minority - State political relations. If resource competition is limited, and state governing ambitions are modest, the type of middlemen roles performed would hardly have a significant effect on the resource adaptation in local CPRs.

If, on the contrary, Minority and Majority are competitors within a niche, e.g. when majority farmers encroach upon important reindeer pastures in a situation of insufficient external borders and/or weak property rights, brokers may play an important role in strengthening the position for either of the parties. Improvement of property rights may contribute to the solution of serious provision problems. On the other hand, it is also obvious that the severity of possible inefficiency of state agencies, will depend on whether there are actual or potential CPR

problems in the first case.

Furthermore, Ostrom finds on a general basis (1990:212-214) that regional and national *governments may play both positive and negative roles concerning whether local CPR users will supply their own institutions or be dependent on external authorities and enforcement.* The case of ground water pumpers in California can thus be seen as an illustrative example of how appropriators probably could not have managed to solve their challenges of institutional change, while through governmental support they nevertheless managed successfully. The support included resource information services, conflict resolution services providing legitimate settlements, and officials that were able to ensure equitable solutions.

On the other hand we have situations where *government officials presume that they,* rather than the appropriators, *have to solve CPR problems.* Then we can *expect appropriators not already having sufficient local institutions to handle their problem to wait for governmental handling of their problems.* Thus the temptation of free riding can be considerable in this class of situations. We would also expect that some appropriators focus their creativity on presenting the local situation for officials without detailed local knowledge, in such a way that the officials will be led to create institutional solutions leaving some individuals better off than others. Individual resources, of course, will affect who is the more likely to manage to influence rule changes to their advantage.

In situations with institutions perceived as working well considerable resistance may be expected if rule changes are imposed. Another problem is that officials who can create suitable institutions for some local CPRs in part of their jurisdiction may try to impose uniform rules throughout the whole jurisdiction. Rather than tailoring specialized rules for local conditions, this may lead to rule configurations which do not seem effective and fair to local appropriators and therefore will tend to be ineffective and difficult to enforce. In the worst cases, those of corrupt centralized regimes or officials, the most probable solutions for the appropriators are those of creating their own local institutions outside the legal framework.

We recall the Schlager and Ostrom conclusion that the stronger the regime (e.g. the more extensive the bundle of property rights), the more effective it is in resolving CPR dilemmas. *The question of which role an external state government and its agents will tend to play will thus tend to be dependent on which position it takes versus the preexisting traditional regime.* If state officials really act as supporters on the herders' premises, they may contribute positively. In the case of a government managing resources from the top down, we must generally expect their engagement to have mainly negative impacts, both from a general resource management and from the herder society, point of view.

In sociological theory, traditional and modern societies differ with respect to the forms of association characterizing them, such as *Gemeinschaft* vs. *Gesellschaft* (Tönnies), *mechanical* vs. *organic* solidarity (Durkheim), *dead primary* vs. *secondary* groups (Cooley). Voluntary non-governmental organizations are a feature of modernity. In European history, the emergence of formal organizations working for particular goals coincides with the great changes in society brought forward by the expansion of industrial society. We would also conjecture that herder societies not exposed to significant external pressure would be less inclined to establish their own organizations for promoting their interests than ones endangered with resource competition

at their pastures. Thus we might find that the apparently contradictory connection of external resource encroachments promotes establishment of organizations and the process of *ethnic liberation* in the long run. The organization can then play a *broker* role advancing the herders' interests versus a state authority.

The experience of Swallow and Bromley mentioned above provide us with evidence that external forces surrounding the local CPR — here the responsible state agency — can contribute to the undermining of indigenous institutions and hence weaken the coordination capacity directly. It is of similar importance that the state governing ambitions often prove ineffective. Therefore we also need to study how state governing attempts have influenced the total capacity of coordination.

A general experience from a wide array of CPR-situations is that top-down resource management by centralized government agencies does not work well, and purely local-level management is often ineffective in the complex world of multiple stakeholders. This general statement is particularly true for situations of acephalous societies experiencing a nation-state encounter, which is followed by state ruling attempts. Co-management systems are often considered a general solution. Co-management is based on two basic assumptions. First, local people must have a stake in conservation and management, and second, partnership of government agencies with local communities is essential (Berkes 1997:5). More rigorously, *collaborative management* (co-management) is:

> "A partnership in which governmental agencies, local communities and resource users, non-governmental organizations and other stakeholders share, as appropriate to each context, the authority of a specific territory or a set of resources" (Borrini-Feyerabend, G., 1996, cited in Berkes, 1997).

Berkes (1997) has summed up conditions for successful co-management:

(1) Are there appropriate institutions, both local and governmental?
(2) Is there trust between the actors?
(3) Have local rights legal protection?
(4) Are there economic incentives for local communities to conserve the resource?

I would add, for my own account:

(5) Are there political incentives for the government to promote success?

Trust may be a particularly challenging condition to establish when considered in the light of the history of state encounter and ruling attempts versus the local CPR-users which now is to be state partners.

Co-management is obviously *an attempt to find new institutional solutions in situations where neither traditional local management nor central governmental management is sufficient.* One major precondition is *trust* between the actors. Trust is usually considered a basic element of social capital in a society. In this connection we examine segments of two different societies which share a common history where the one party has tried, more or less

successfully, to dominate the other. The history may be an obstruction for the establishment of this trust, obviously between the parties, but also within the parties. Both differences in governing ambitions on the state side and differences in strategies of ethnic identity management on the minority side might contribute to the latter possibility.

Fundamental questions for the minority representatives may be; which are the real majority motives? Are there any concealed motives? Is this just a more advanced way of dominating us? To establish trust where there is distrust is a challenging task, more than anything else, it takes time. Personal contact over time provides opportunities to discover that persons on the other side of the bargaining table may be reliable. One participant in a co-management system told me in confidence that he had made a discovery about one of the participants on the other side of the table: "NN is nothing but a human being, too." This was uttered in full seriousness, after the two persons in question, which I both knew rather well, had met regularly in the same setting during several years. It is one thing to establish trust among a limited circuit of top-level people. Quite another is to spread this to larger groups of people, for example CPR-users. Particularly in this respect, *brokers* may be important in creating a basis for trust. We would thus conjecture that herder societies having experienced state officials in broker roles would have better prospects in developing trust crossing the cultural border between two societies. Recalling that ethnopolitical organizations may also be interpreted as playing broker roles, we would assume that the more well organized a herder society is, the better is it prepared for co-management participation.

We have earlier considered various co-management endeavors. Path dependence of institutional change means that history matters; some options may be closed and others difficult due to past events. Building *trust* to establish a co-management system is a major challenge if the proceeding centralized government has been repressive. Building trust depends on (1) preceding overall relations, (2) time available, (3) middleman relations, and (4) degree of organization on the CPR-user side.

Collaborative management is by definition partnership governance of, for example, a CPR involving actors with various standings, like governmental authorities and user organizations. The main potential of co-management systems is the possibility of "internalizing externalities," i.e., making different parties coordinate their decisions and implement them in common. I have elsewhere (Riseth, 1992:11: 125) characterized the establishment of a co-management arrangement, with a government and a herder organization as parties, as the choice of *power sharing instead of tutelage* for the former and *taking responsibility instead of shirking it* for the latter. In essence, it is a bargain where the government trades away formal authority, and the non-governmental organization gives up right of free opposition. The revenue side for both parties is the *potential of gaining increased real control* In reality, co-management is a very demanding governing system, which includes a considerable number of pitfalls. We have above considered a number of key conditions for successful co-management. Condensing those, we can thus hypothesize:

(H6) *The following characteristics of a co-management system can promote that its effectiveness:*

(a) mutual trust between the parties,

(b) the appropriateness of both the local and central institutional system, and

(c) economical and political gains for both parties,

Co-management systems will usually not be complete and designed at a *tabula rasa*. Rather, they will often be partial and operate in combination with both informal and traditional *de facto* institutions and formal governmental *dejure* institutions. Whenever that is the case, it is the total fit of the institutional system, which matters.

(H7) *The higher the overall consistency of a regulatory system, the higher will the capacity of coordination for the operating regime tend to be.*

Generally a condition for successful implementation of efficient public policy in a state-minority encounter, is that the responsible state actors really pursue goals of bridging the gap in culture and power. This will require some amount of cross-cultural understanding. Thus the minority representatives must have good reasons to trust the system before it can become effective.

(H8) *The higher is the level of cross-cultural understanding among the responsible state actors, the higher will the capacity of transformation tend to be.*

Chapter 5
METHODOLOGY AND RESEARCH DESIGN

The topic for this study is a causal one: how can the observed development pattern with rapid herd growth and lichen pasture down-grazing pattern in Finnmark, and particularly West-Finnmark, be explained? In the introduction we presented different explanations suggested by various scholars. Though these, and other, contributions have brought valuable insights, the scope of many of them seemed to narrow to encompass the full depth of the problem.

Building on Chapter 2 we in Chapters 3 and 4 developed a more comprehensive model, ending up with a number of hypotheses to be confronted with empirical material. A series of our hypotheses focus on the choice of strategies and which factors (independent variables) we believe to influence the choices. We cannot observe these choices and their effects directly. They can be considered as intermediate variables influencing our *dependent variables*, state of the resource and economical outcome, which both can be observed. Others of our hypotheses focus institutional features that can be observed.

Considering reindeer management in the region we study as a system as in Figure 5.1, we can see the independent variables as *systemspecific explanatory variables*.

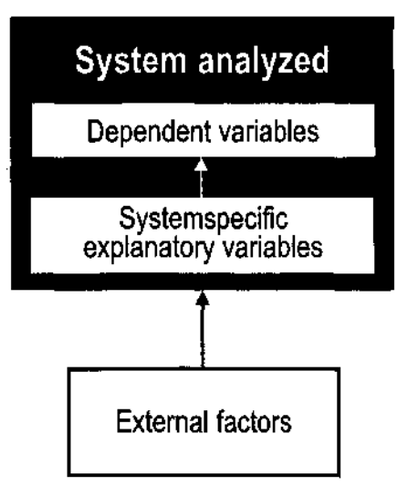

Figure 5.1. A system exposed to external influence

When the system is exposed to an external influence, as in the figure, we observe the status of the dependent variables, while the systemspecific explanatory variables are use to explain the systems response to the external influence. To reveal the interconnections between the full set of relevant interrelated factors, we need to develop a research design where the causal relationships are discerned through a number of steps.

5.1 Causal inference

Causal inference implies that we search for which factors determine an observed outcome. A causal effect means observed change in the dependent variable for a particular change in the explanatory variables. A more precise definition of causality is: *the causal effect is the difference between the systematic component of the observations made when the explanatory variable takes one value, and the systematic component of comparable observations when the explanatory variables takes on an another value* (King et al., 1994: 81-82). In a controlled experiment, for example in physics, we keep the control variables (independent variables that we are not interested in investigating at the time) constant, change the explanatory variables, and observe the changes in the dependent variables. Moreover we rerun the experiment sufficiently many times to be certain of our results.

In social science we face the so-called *fundamental problem of causal inference* (Holland, 1986); we cannot rerun history. We then have to rely on so-called *second-best assumptions;* we repeat our experiment in two different units [1] that are homogenous. *Two units are homogenous when the expected values of the dependent variables from each unit are the same when our explanatory variables takes on a particular value* (the same X-value cause the same E (Y); King et al., 1994:91). Homogeneity can be sought across time and/or space. Attaining unit homogeneity is often impossible, but understanding the degree of heterogeneity in our units of analysis will help us to estimate the degree of uncertainty or likely biases to be attributed to our inferences. Unit homogeneity implies that the differences we observe in the values of the dependent variables are the result of the differences in the values of the relevant explanatory variables.

Another assumption that enables us to get around the fundamental problem of causal inference is *conditional independence,* which is the assumption that *the values are assigned to explanatory variables independent of the values taken by the dependent variables* (King et al., 1994: 94). This means that the causation is working only one way (X=>Y, not the opposite). In controlled experiments we can freely change the values of the explanatory variables and thereby create necessary variation in them, and the question is then how to ascertain the conditioned variation in the explanatory variables. In "big-n research" we achieve this by *random selection* of units. In "small-n cases" other strategies must be pursued.

5.2 General Method: Comparative Analysis

If n is too little, randomization may be impossible. It may even be unwanted as it may imply loss of important information. One alternative method is obtaining unit homogeneity by using *comparative analysis.* Comparative case studies compare several units that have *varying values on the explanatory variables* and *inquire which of the explanatory variables can explain the variations we observe in the values of the dependent variables.* Comparative analysis may include both qualitative and quantitative elements. Following King et al. (1994), we will stress that qualitative and quantitative research are united by a unified logic of inference. The

[1] Units are the *loci of observations* and may be e.g., people, organizations regions and years.

sociologist Charles Ragin (1987, 1994) allocates different tasks to different methods, cf. Table 5.1.

Table 5.1. Comparison of methodologies.

METHOD	USE	GOAL
Qualitative method (the study of commonalities)	In-depth study of a relatively few number of case	(1)Giving voice to marginized groups, (2)interpreting historically/ culturally phenomena, and (3)advancing theory
Comparative method (the study of diversity)	Examination of similarities and differences across a moderate number of cases, knowledge of each case is important.	(1)Exploring diversity, (2)interpreting cultural and historical significance, and (3)advancing theory
Quantitative method (the study of co-variation)	The study of basic patterns and relationships by examining patterns across many cases	(1)Testing theories and (2)making predictions

Based on Ragin (1987, 1994)

In comparative analysis, an alternative to randomization is to achieve unit homogeneity through the use of *intentional selection of observations* (King et al., 1994:140). We can thus select observations providing the sufficient variation of explanatory variable(s), cf. conditional independence (above in 5.1). As a specific approach within intentional selection of observations, we have the particular option of *selecting a range of values of the dependent variable* (King et al, 1991:141) as an alternative to choosing observations on the explanatory variable. In a retrospective research design we thus *select observations with particularly high and particularly low values of the dependent variable.*

This approach will not be sufficient to discern the full causal relationship between explanatory and dependent variables, but is well suited for an exploratory study. In a second instance we may then design a follow-up study which observations are selected only on the explanatory variables and thus achieve conditions for full causal inference. When choosing observations on basis of the *dependent* variable, it is, however, crucial to select observations without regard to the *explanatory* variables. This is necessary to avoid searching for observations that fit into our *a priori* theory.

Moving from general methodology to our concrete research, the question of how to explain the West-Finnmark herd increase and lichen overgrazing, is a specific causal question addressing the factors contributing to a particular development pattern in a defined area and time period. We can ask counterfactual questions of the type, "What would have been the probable development pattern if influence of external politics had been weaker?» but we cannot rerun history, and our main method of inquiry has to be *comparative.* That is, we need to test our hypotheses on empirical material covering both the area, and the time we primarily want to study, and compare it on other areas and/or time periods we use for comparison.

I have chosen the specific type of comparative analysis ~ *selecting high and low values of the*

dependent variable ~ to find explanations for our research question. Selection on the dependent variable is well suited for comparison between West-Finnmark and Trøndelag because the interregional differences on resource status and income (dependent variables) are very pronounced.

We implement an *exploratory study*; comparing the performance of reindeer herd management of West-Finnmark (Guovdageaidnu), in our study denoted as *North*, with the South Sámi areas of South Trøndelag/Hedmark and North Trøndelag, in our study altogether denoted as *South*, on basis of dependent variables *of state of the resource* (pasture biomass) and *income*. Though the variation within the North and the South is considerable, the two regions very clearly show high and low levels on these variables. We will address further the variation within the North and within the South to discern which factors seems to contribute most to the outcome. For factors where we are in lack of data within these two areas, we to some extent complete our material by including relevant data from other areas.

In this study, we compare the two defined areas. However, each of them consists of about 10-20 local CPRs, thus n in our study is mainly intermediate. As we saw in our introductory reflections upon other contributions to the problem of overgrazing, much of the work done, mainly by anthropologists and ethnographers, uses the qualitative method. On the other hand, quantitative methods are systematically used in works based on agricultural economics, like the total accounts for the reindeer management industry (Økonomisk Utvalg, 1981-1996), and also in animal science (cf. Lenvik, 1989) and ecology research.

To some extent, comparative method is also used in relevant contributions for our topic. One example that does this is a book chapter by Ottar Brox (1989), written in the field of institutional economics. Robert Paine also uses comparison in parts of his recent book (1994) and in a theoretical article (1970). Tim Ingold's book (1980) also is comparative, but mainly theoretical, so also the contributions of the economists Anders Skonhoft (1996) and Reidar Øye (1996). The historian Bård Berg (1997) also uses some comparative elements, as well as the sociologist Johan K. H. Kalstad (1997), but not as main perspectives.

Besides the appropriateness of comparative method to reveal the explanation sought by our primary research question, the method's general goals of *exploring diversity, interpreting cultural and historical significance and advancing theory* seem suitable for the research situation of reindeer management institutions. I also consider my work as a step towards building a theory of institutions and resource economics for reindeer management. Such a theory can be a vehicle in the continued examination of the Sámi reindeer management society. As a pioneering work, this study is exploratory, focusing on main patterns rather than determining full causal relationships.

5.3 Supplementary Methods and Sources of Data

The main part of the data used in the empirical analysis is already published scientifically or in professional administrative contributions. Much of Sámi culture and history is well explored. The public statistics of reindeer management from 1980 on are extensive. My contribution here is mainly recombining and to some degree reinterpreting. Using a broader approach than usual

gives the opportunity to treat important questions more extensively. Though the main analysis is comparative, the "raw material" is provided by the supplementary methods. The data on dependent variables is mainly produced by quantitative method through statistics. On the other hand, qualitative methods are most important for evaluating the independent variables.

Document analysis is the most extensively used method of the empirical analysis of this study. A considerable part of the documents, which are a basis for this study are from the files of the public reindeer management administration. A part of this set of documents is published in Riseth (1992). Other documents are referred to when directly used. Some documents used are file material, others are reports and journals. In some instances newspaper articles also are used.

The value of the file material is enhanced by the use of *observation* as a method of data collection. Thus my own experience from work in the administration is an important source of data. To improve inter-subjectivity, I try primarily to use other sources of data when possible, thus limiting dependence of my pre-understanding. When using own observations directly, I also try to be specific about what the observations are. Experience also provides me a basis for assessing a diversity of data. Knowing many herders and their conditions and also the public government system from the inside provides a broad empirical background for considering both the reliability and validity of diverse data. For example, in public debate, herd size assessments are often claimed to be unreliable. As a former official, I am confident with a variety of judgements of such data and can have a reasoned opinion of them, and I also know whom to ask about what when my knowledge is incomplete. This provides opportunity to question claims of unreliability in terms of how unreliable, where, and when? Even though my role as an actor in the administrative system could introduce a bias in some questions, I nevertheless had knowledge of the stands and judgements of other actors, and this provided me with picture having more nuances than a full outsider could have. Also, getting to know older generations of administrators brought important knowledge about their way of thinking.

The field work part of my investigations fills holes in established knowledge and existing data. For example, public statistics on reindeer management are relatively incomplete before 1980. File research and informant interviews both of civil servants and herders have been necessary. This requires qualitative research interviews as a method. Interviews with predominantly elderly herders is used as a means of obtaining *descriptions of their everyday world*, insofar as written sources and official statistics both will tend to be incomplete and somewhat biased.

These interviews are thus used as a complementary source of data. The interviews were conducted in Norwegian in the home of the interviewee. Most interviews lasted one to two hours. The interviews were taped and transcribed by the author. Altogether ten herder interviews were conducted in 1995 and 1997. The herder interviewees are kept anonymous and are given fictive names in the text, as well are their exact attachments. This has been necessary to establish open conversation about matters, which to some extent are sensitive in relative close environments. I have made one exception to this principle: The now-retired herder Anders Fjellheim, R0ros, has been very prominent both in herder organization work and as a local leader. His personal contribution to changes in the production system of the South area is so clear that his role should be illuminated openly.

As a method, the interview seeks to interpret the meaning of central themes in the life-world of

the subject and seeks qualitative knowledge of focused aspects through open and nuanced descriptions (Kvale, 1996). The interview is semi-structured with pre-designed research questions and interview questions, which are posed to the interviewee in a professional conversation. An example of a general interview guide used is provided as Appendix I. The method allows the researcher to critically follow up the interviewee's answers and test his interpretations immediately.

The interviews have, to a varying degree, been focused on historical events and conditions I knew the interviewee has had particular insight into. Professionals and administrators, state officials, and herder organization leaders and workers have been consulted, partly rather informally and in some instances through formal interviews. Some of these interviews are taped and transcribed, while others exist as notes from a conversation.

5.4 Research design

In the preceding chapters, we have outlined both a general and a specific theory for causal inference about CPRs and reindeer management. While Chapter 2 gave a general background on CPR problems, our main focus in Chapter 3 has been the production system and the basic resource dynamics. Chapter 4 analyzed the institutions of herding societies and their surroundings.

We have used the different theories in these chapters, connected by IAD framework to predict how physical and institutional features may affect need and capacity of coordination. Changes in the production system, triggered by external technological changes as described in Chapter 3, influence the need for coordination both directly, and indirectly, via the state of the CP resource. In Chapter 4 we discussed how attributes of the herder community, as demography and market independence, may influence the need of coordination. Further we investigated how properties of herder societies and their regimes may affect capacity of coordination. Moreover we discussed how different factors in minority-majority/state relations might influence the capacity of coordination.

We have assumed that, in the period we investigate, the most important strategy choice for the herders is between individual/expansive strategies versus cooperative/stabilizing ones. We have therefore developed a set of hypotheses directly connected to how the properties analyzed in Chapters 3 and 4 can influence both the production system and the institutional system through both need and capacity of coordination.

As depicted in Figure 2.5, the need and the capacity of coordination follow different paths, but we recognize that they may be connected via the factor capacity of transformation, to which we also have connected a small bundle of hypotheses.

Our research design is illustrated by Figure 5.2, which sums up the main interconnections in our total model for the empirical analysis to be undertaken in the following chapters. We have assumed that the factors focused in the hypotheses influence the choices of which strategy to pursue.

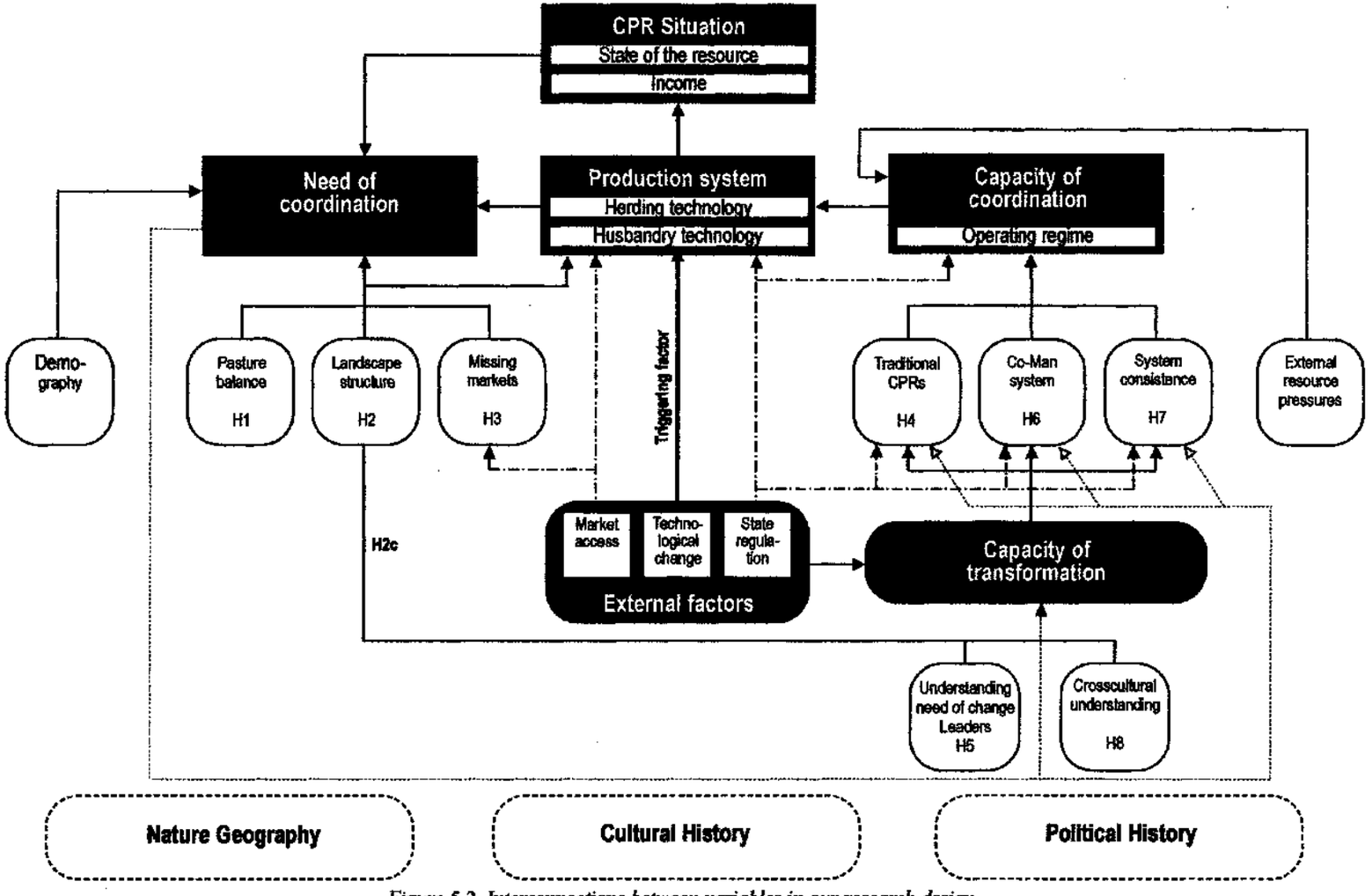

Figure 5.2 Interconnections between variables in our research design.

In as much as the choices cannot be observed directly we have to start with variables that are observable (from the top of the figure) and infer towards observable factors (downwards the figure). First we observe and compare the CPR-situation and the production system (Chapter 7). Second we use this to make inferences about the need and capacity of coordination comparing North and South for observations of the factors included in our hypotheses (Chapter 8).

The connection between external influence (independent variables), production system (intermediate variables), and the state of the resource and income (dependent variables) is the "stem" in our model and thus our first level of empirical study. We address these elements in Chapter 7.

Starting out on the top, considering the state of the resource and income in subchapter 7.1, and continue with the external factors in 7.2, we focus the production system development in 7.3. The chosen production system can be seen via the two variables, herding and husbandry technology. The balance between them will, according to our theory, affect the actual need for coordination and the final outcome variables. The relative changes in these variables can be directly observed and thus indicate the change in actual need for coordination which is not itself directly observable.

The need and capacity of coordination (intermediate variables) are closely connected to the stem and important for the connections to the remaining parts of the model. Both of them are directly influenced by a number of factors given by the hypotheses, as well one control variable each[2], and both influence the development of the production system. At least some of the factors, which influence need of coordination also influence the production system directly. The need of coordination is also influenced by the development of the production system. Further changes in the production system influence the dependent variables.

In Chapter 8 we dig deeper and address the factors, which directly influence the need and capacities of coordination and transformation. These factors are the variables we want to study as potential explanations for the variation in adaptation given changes in external factors. Recalling our hypotheses, the need part which we are going to study in 8.1, is covered by H1 to H3. The factors considered in hypotheses H1 to H2b are all parts of the physical world and, as such, rather constant, though they may be influenced by human action (e.g. pasture encroachment, fencing). They are also observable, though their measurement does not need to be self-evident. H3 is also a directly observable variable.

In 8.2 we turn to the capacity of coordination, which encompasses as operative institutions both cultural features like norms and common understandings and concrete rules-in-use. In our setup, this part is covered mainly by the hypotheses H4, H6 and H7. This set of factors is not directly observable like the physical factors; we need to monitor and interpret behavior to discern them. It is not sufficient, for example, to observe the existence of rules in documents; we also need to monitor the level of compliance to ascertain whether the rule in question is a rule-in-use.

Even though this introduces some uncertainty into our considerations, I find the institutional

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[2] demography and external resource pressures, respectively

explanatory factors possible to reveal. Though we cannot observe the capacity for coordination directly, we can observe the capacity, which is actually used. Whether there is an excessive capacity ready for use is, however, not directly observable. What is observable, on the contrary, is lack of coordination capacity; observed as unsustainable resource use, for example, introduction of new herding technology may imply overuse of lichen pastures due to insufficient rules-in-use of the established regime. Thus we will here include data from Chapter 7 in our considerations.

We also believe that need and capacity of coordination can be connected directly through these factors or indirectly through a capacity of transformation. For the period we are examining, external influence through increased market access, technological change and regulation are obviously important.

When there is a capacity deficit, we assume that the capacity of coordination can be increased directly through some of the variables, or indirectly via *the capacity of transformation* which is examined in 8.3. It is connected to our hypotheses H2c, H5 and H8. The transformation capacity is a general society parameter, which has to be evaluated in a long-term perspective by considering general and specific historical events. We may consider this factor to be a meta-explanatory variable. By this we mean that it influences a number of the explanatory (independent) variables and, as such, affects the dependent variables indirectly.

In our analysis, we assess a number of *background variables*, which serve as application conditions for our theory. We hold nature geography, culture history, and political history to be of fundamental importance. We start our empirical analysis by focusing on these variables.

TRØKKERIET
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Chapter 6
Aspects of Nature Geography, Cultural and Political History: Sapmi and Norway up to the 1960's

In this chapter we proceed further into the general empiric background factors, presented in the introduction and connected to our analysis in Figure 5.1. The subchapters on nature geography and political history are rather summarily, while cultural history (6.2) is more extensive giving priority to institutions being inherent in the Sámi culture. The empiric material in this chapter provides a general basis for the specific analysis in Chapters 7 and 8.

6.1 Nature Geography[1]

Sapmi covers middle and northern Norway, northern Sweden and northern Finland and the Kola Peninsula of Russia. It covers an area from 62° too more than 70° N. lat. (extending north of the Arctic Circle), and from 10° to 40° E. long. The northernmost Sámi live as far north as Point Barrow, the northernmost point of Alaska, or the South tip of Novaja Semlja. We might expect an arctic climate so far north. The north Norwegian coast is, however, the only part of the Arctic coastline, which is ice-free all year.

The explanation is the Gulf Stream, which provides the coastal areas with temperate water. The isotherm for 0 °C average in annual temperature bends north along the Norwegian coast, so that most of Sapmi is south of this border. Even more important is the isotherm from +10 C° average July temperature, which is the southern border of the arctic climate zone. This line reaches North Cape and follows the outer coast zone of Finnmark and the Kola peninsula to the White Sea (Russia), and thus the north of Sapmi is a practically completely a *subarctic area.* The southern parts of Sapmi have a *temperate* climate.

Large parts of Sapmi have a continental climate: rather warm summers and stable, rather cold winters with limited precipitation and wind. In the northern parts, the mountain range is near the coast. The coast, which in the very north is just a narrow belt, has a more stable temperature, with mild winters and chilly summers and considerable precipitation and wind year-round. Most of the precipitation falls during the winter, mainly as snow, but also as rain. Deep and packed snow mixed with ice is usual.

In Norway south of Finnmark/Troms (cf. Figure 1.5), the mountain range is further from the coast, and in the southernmost parts, the ridge is separated into separate mountain massifs. In these parts, the coast does not have a stable snow cover. Here the coastal mountains are low or absent, producing a sub-oceanic climate which stretches far into the continent. This means there is a more unstable winter climate, with a considerably higher precipitation than northern areas at a similar distance from the coast.

Figure 6.1 expresses a typical cross-section of central parts of Sapmi (Scandinavia).

[1] An important source is Aarseth (1995a).

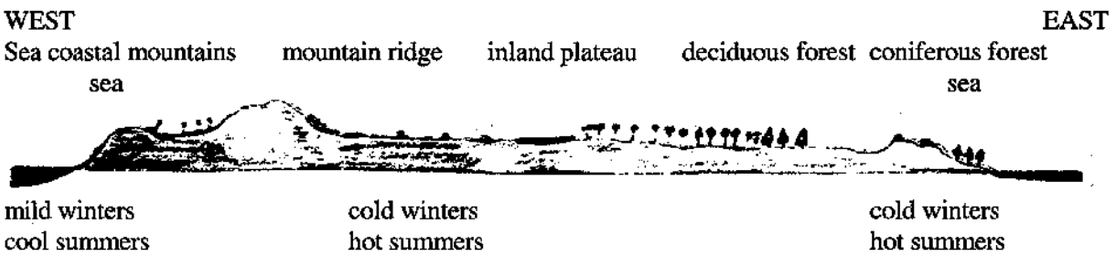
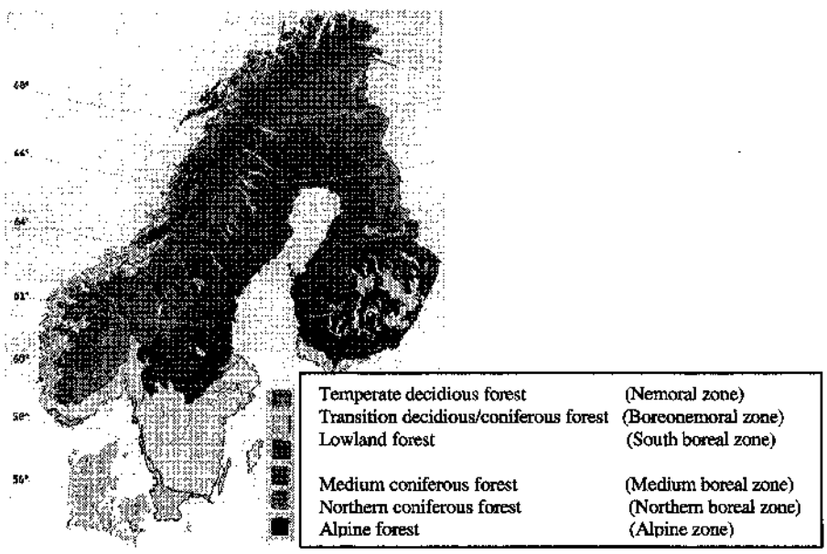


Figure 6.1. West-East cross-section of Sapmi (Jernsletten and Solbakk, 1983:14)

Most of Sapmi is situated on the low Fennoscandia bedrock shield, which is covered by glacial sediments. The mountain range consists partly of metamorphic rocks and rich Cambro-Silurian rocks. Moraines and rolling stone hills, forests and shrubs, mires, and numerous lakes and ponds cover much of the landscape. Finnmarksvidda and adjacent inland areas comprise a low undulating plateau of low mountains, birch-covered hills, low pine forest, and open lichen land. Major vegetation regions of Fennoscandia is depicted in Figure 6.2.



The reindeer belongs to the alpine and the northern boreal zone. The latter is dominated by spruce forest (birch North of the Arctic circle in Norway) when moisture is sufficient or pines at drier and poorer ground. The alpine zone is dominated by heather, dwarf birch and willow thickets in the lower subzone and with grasses and snowbeds in the medium subzone.

Figure 6.2. Nature Vegetation Regions of Fennoscandia.
Source NUB, 1977:34, cf. Gaare, 1997b.

The continental forest areas form a fringe of the Siberian taiga belt. The vegetation is dominated by spruce (birch in the northern parts), pine, and willow thickets. In the dry, inland heather moors, mosses and lichens are usual. Due to rich and easily weathering bedrock, considerable parts of the mountain range are very productive, providing rich mires, grass and herb-rich fields and meadows. Sapmi has an ordinary boreal fauna with ocean fish and mammals, inland fish, sea and land birds, and terrestrial animals like reindeer and beaver. The Arctic coast and fjords also have a richer animal life than we might expect at that latitude, on account of the Gulf Stream.

Sapmi is very heterogeneous, compared with other northern landscapes such as Siberia or northernmost America. In an European context, the inland is rather unproductive, while the ocean and Arctic coast are relatively rich and provide the basis for much of the settlement, particularly that of the Nordic peoples. The reindeer is adapted to maximize nutritional intake in summer and economize with limited resources in winter. On account of this adaptation, the reindeer has very specific requirements for each season. The considerable regional variations in temperature, precipitation, bedrock, and vegetation over the area give rise to different annual migration patterns in various parts of Sapmi, cf. Figure 6.3.

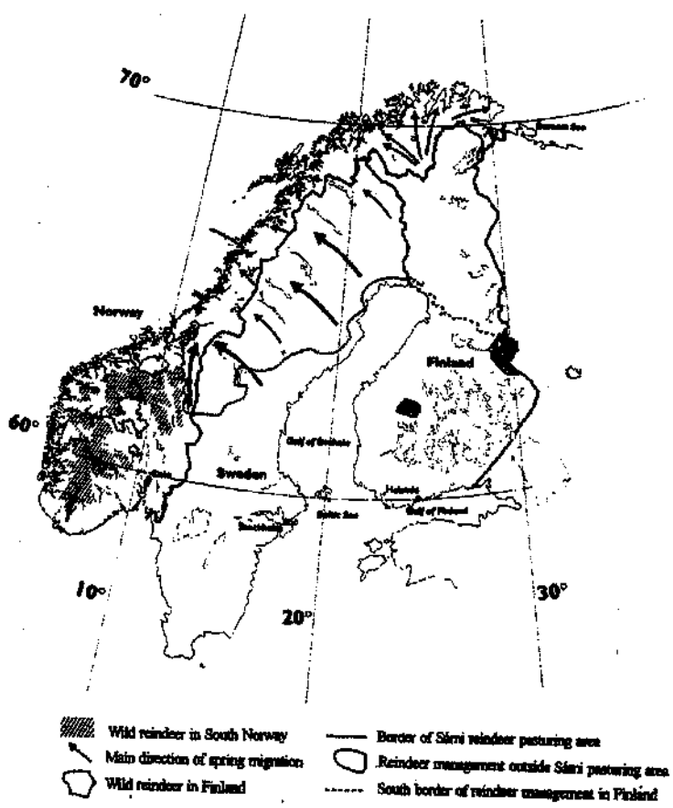


Figure 6.3. The Extent and Migration Pattern of Reindeer in Fennoscandia.
Source: Staaland and Eikelmann (1993), cf. Gaare 1997.

In Finnmark and parts of Troms (for the names cf. Figure 1.4), the usually mountainous summer pastures are situated on or near the Arctic coast and fjords, while the winter pastures are in the continental inland, where lichen beds are under a relatively light snow-cover. This is generally considered an ideal situation for reindeer pasturing. The importance of good winter pastures is to some extent reflected in the difference of relative magnitude of herd size between the two Finnmark regions and the remainder of Norway (cf. Figure 1.4). In the rest of Norway South of Finnmark and in Sweden, the summer pastures are in the Norwegian-Swedish border mountain range, while winter pastures are found both on the western oceanic coast and in Swedish inland pine forests. This is equivalent to two distinct migration patterns, and traditionally there have been two types of herding in this area, a *mountain type* with long migrations to continental winter pastures and a *coastal type* with shorter migrations (Bergsland, 1994; J. A. Kalstad, 1982). In Finland, supplementary winter-feeding is widespread, due to lack of natural winter pastures.

The innate ability of reindeer to utilize lichens as winter food is a distinctive characteristic not shared with other cervids and ungulates. Lichens can amount up to 80 % of winter feeding (cf. Gaare, 1997:23) when highly accessible. This is one of the properties making survival possible under the demanding winter conditions.

6.2. Cultural History

The Sámi is today officially recognized as the indigenous people of Northern Fennoscandia. The full extent of historical Sapmi (cf. Figure 1.3.) is difficult to assess accurately, because the historical Sámi was not a literate people. The historical accounts of Sámi and Sapmi are therefore based on encounters between Sámi and neighboring peoples. The Sámi are, however, the first known ethnic group of Fennoscandia. Archeologists have been cautious about drawing a link between stone-age settlement of north Fennoscandia and Sámi ethnicity, but the findings from about the time of the birth of Christ can with great certainty be classified as having Sámi origin. Finnmark is today the name of Norway's northernmost county. In Old Norse language the name Finnmork meant "the land of the Sámi"; an area north and east of Norway (Bergsland, 1970).

6.2.1 The hunting society

In older times, the Sámi had a multitude of sources of living; hunting, trapping and fishing being basics. Hunting of wild reindeer was cornerstone in their economy. Their adaptations were *semi-nomadic,* with a band consisting of a limited number of families (households) migrating between different seasonal locations within their multi-resource CPR area. The North Sámi term *siida (sijte* in South Sámi) describes both the area and the band. The siidas had own names, and had clear borders between them following natural landscape borders. Inland they often encompassed a watershed, and on the coast around the fjord they encompassed both inland areas and fishing sites far out in the fjord (Vorren and Manker, 1976:190). Siida borders were borders of property rights recognized[2] by courts set up by the nation-state rulers (Solem, 1970:83). The hunting siida can be defined as *an organization of households, which utilize common-pool-resources for hunting, trapping, and fishing in a geographic area and which claim exclusive rights to these resources.*

Tame reindeer have a long history in Fennoscandia. The internationally known[3] rock carvings of Jiebmaluokta in Alta, Finnmark, dated from 4,200 BC to AD. 500 have reindeer as their predominant animal. The existence of wild reindeer was probably a reason for stone-age settlement of hunting people in Scandinavia during glacial time. On the basis of the rock carvings, hypotheses have been put forward that tamed reindeer were used as decoys in hunting and as draft animals as early as five or six thousand years ago in northern Scandinavia. The first certain historical account of tame reindeer is the narrative of Hålogland chieftain Ottar to King Alfred of England just before AD 900, which describes how the Sámi used them as decoy animals (cf. Pedersen, 1994).

Wild reindeer were obviously an important resource in the traditional hunting society. From the end of the sixteenth century and during the seventeenth century, the existing herds of decoy and

2 from the 17th century

3 member of UNESCO's world heritage list

draft animals are assumed to be basis for *a new adaptation to full nomadic reindeer pastoralism'*, where the household follows the reindeer herd year-round. The main reason for the change from hunting to reindeer pastoralism is asserted to be a heavily increasing demand in Europe for the furs of a number of Arctic and Boreal animals (reindeer not included) satisfied through trade or taxes paid to the Nordic states. Reduction or depletion of the resources of fur-bearing animals is believed to have led to profoundly increased pressure on wild reindeer, due to increased hunting and trapping. This is asserted to have initiated a process of transition to a reindeer pastoralism - because controlled tame reindeer was a more certain means of subsistence when the wild reindeer became scarce (Vorren, 1978:153). The history of reindeer pastoralism is somewhat different in the two regions we compare. The culture historian Bj0rn Aarseth (1989b: 21) points to an ancient difference between North and South Sámi insofar as the former group tamed *herds* and the latter *single animals.* He finds this to be a probable reason for why the milking tradition never was so far developed in the North as in the South.

6.2.2 Reindeer pastoralism

Reindeer pastoralism is a social and economic system in which *the basis of the economy is formed by herds of reindeer, and families follow the herds year-around, with their activities and economy primarily tied to reindeer and reindeer products* (Vorren, 1978:156-157). Reindeer pastoralism has clearly been performed over several centuries, at least back to about 1500-1600, some researchers believe it stems from even earlier (cf. Fjellström, 1995:49-50). The internal organization of the traditional Sámi herding society during its whole period of existence had two main levels; the household, *baiki* in North Sámi, and the band, *siida (sijte,* in South Sámi). We can define the household as *a family group with a nuclear family as the core, possibly supplemented with servants or old people as parents of the wife or the husbander.* The siida of reindeer pastoralism is developed from the preceding hunting society and has developed a distinctive design in the herder society. A contemporary definition of the Sámi reindeer herding siida is *a unit composed of one or more reindeer management families that, together in a social and labor community, keep control over a reindeer herd by herding* (Mel0y, 1997).

Parallel with the origin of reindeer pastoralism, other more specialized adaptations also developed in the 1600's and 1700's, e.g., keeping of domestic animals like cattle and sheep, more specialized fishing, etc. (Fjellheim, 1991; Pedersen 1994:52). Reindeer pastoralism seems to have been expanding both in space and in numbers of animals and people during the seventeenth and eighteenth centuries. For most of Sapmi, including Finnmark and Troms/Nordland on the Norwegian side and the two northernmost counties (Norrland/Västerbotten) on the Swedish side, the natural migration pattern of the reindeer conflicted with the traditional siida areas. Pedersen (1994:60-63) finds that in Finnmark, some of the pastoralists of the eighteenth century had their basis in inland siidas and migrated to the coast with their herds during the summer, while others had their basis in coastal siidas and migrated with their herds to the inland for the winter. Other siida members developed other adaptations. Generally the pastoralists seem still to be multi-resource users, and they also conduct both a very intensive herding and husbandry (Pedersen, 1994:63, cf. Schnitler, 1985). During the 1700's, narratives of rich reindeer herders that do not fish or hunt because of lack of need and time appear (cf. Lenvik, 1995). In Guovdageaidnu (North), the intensive production technology of summer milking seems to have been sustained into the early 1800's (Sara, 1993:68, cf. Smith, 1938), when a practice of free-roaming summer herds on islands and peninsulas was established. As a result of *border closures* between the states from the second half of the 1800's, Guovdageaidnu Sámi were more or less forced to move southwards into Sweden, bringing extensive summer herding with them. This practice met

opposition, but the long-term result was a technological externality, where *the intensive milk and meat pastoralism gave way to a monoculture meat pastoralism* (Ruong 1982:68-69. In an extensive analysis of the change processes among the Sámi pastoralists of northern Sweden and Troms county of Norway, the historian Andresen (1991:152) finds that agricultural settlement expansion, and the Guovdageaidnu immigration were the main factors explaining the change in production systems in this region. The often-longer migrations of reindeer nomadism and the change in occupation led to disintegration, or at least a transformation, of the old siida type. For the reindeer herding Sámi, a new siida type developed. Bromleys (1991:142-143) tentative model for choice of management regimes implies that increasing the value of a resource is consistent with developing a regime with higher transaction costs. We would therefore expect a movement towards private property on account of a transition from hunting to herding. We would also expect the greater focus on reindeer to lead in the same direction. Our observations are in line with these expectations. Compared with the hunting society, the transition over time has lead to: (1) more elongated siida areas, (2) diminishing household numbers per siida, (3) a change in the individuality-collectivity balance, moving the "center of gravity" from the siida towards the household, and (4) sustained cooperation in labor with individualized output (Solem, 1970:81-104; Vorren et Manker, 1976, cf. Aarseth, 1995b,cf. Lenvik, 1978, cf. Mel0y, 1997).

6.2.2.1 The Production System Development

One process giving premises for the changes from the 1960's on is *family sedentarization for a settled life.* The process generally started about the turn of the century and lasted at least up to the Second World War (Fjellheim, 1991; Solem, 1970:39; Vorren, 1964). Sedentarization can be considered a process indirectly promoting increased market contact and integration in the surrounding society. This implied a considerable degree of separation between family and herd. The process was generally promoted by obligatory schooling, which made it necessary for children, and women to live in reach of the school.

In the South, the change in production system by abandoning intensive summer milking initiated the process. In South Tr0ndelag/Hedmark a transition to meat pastoralisrn meant reduced self-sufficiency and that women and children and elderly people moved into houses which the male herders mainly used as a supply base. During the four first decades of this century most reindeer managing families were established with peasant farms with 2-3 cows and some sheep which were an additional source of income (Falkenberg, 1985:20-28). The same pattern is also found in inner districts in North Tr0ndelag (Ramstad, 1967).

In Finnmark Solem (1970:38-39) reports that around 1930 most reindeer managing Sámi in Varanger, Polmak and Karasjok either have a peasant farm, a winter house or at least rent housing for the family in winter time. Guovdageaidnu was an exception - practically all reindeer managing Sámi still were full nomads, living in a tent year around. According to Vorren (1964:5-10) the transition to winter settlement in Guovdageaidnu took place in the late 1930's, but mainly during the postwar reconstruction period. In the period 1952-57 most households live in houses along main-roads or near local agricultural societies. A significant portion of the households still had firm contact with the herd, due to short distance. Kalstad (1997: 32-33, 94-95) describes how economic integration processes have promoted further settlement concentration with the outcome that most people today live in the municipality center.

To study the more direct changes in the *production system* we need to see them in connection with the nature geography of each of our regions.

North

The West Finnmark winter pastures are situated on the lichen-rich bedrock inland plateau, while the spring/autumn pastures in a more hilly highland zone, naturally divided into three zones named Oarjebealli (western zone), Guovdajohttelit (middle zone), and Nuortabealli (eastern zone). The corresponding summer pastures are mainly on coastal peninsulas *{njarga)* and islands *{suolo).* Both types include areas varying from coastline to mountain peaks, but also partly the outskirts of the inland plateau *{nanne),* out of the sight of the coast. A subtype of the inland type is on the high terrain around the tree line *{orda),* cf. Paine (1994:35). Extensive summer herding spread in njarga (peninsula) and suolo (island) districts during the 1800's. In addition to the physical shape of the summer districts Sara (1993:70) holds that insect harassment gathered the herd and absence of wolf both were factors making summer extensivity possible. At least from about 1925 and the 1930's fences completely cutting off a njarga become built. Sara finds (1993:72), however, those smaller pastoralists have performed milking less regularly, that is, when the herd was gathered as well, up to the 1950's, but in some siidas it continued until the 1960's. I understand by this that the transition was gradual over a very long time. Milking of female reindeer requires a relatively high tameness grade. Another work operation, which calls for a controlled herd, is separation (of intermingled herds). Solem (1970) reports "separation corrals is seldom in use among Norwegian Nomadic Sami" (in the 1930's, my translation). Sara (1993:73) explains that separation outside corrals is a main method till the 1950's when the Nomadic Sami request better separation corrals for using at the fall. He finds that the coalescence with the end of milking era is no coincidence.

Based on data from one of the first years in our period of analysis, 1962, Paine (1994:100) provides descriptions of the cycles of annual variations in herding intensity for different types of local CPRs, expressing three different patterns, cf. Table 6.1. The table demonstrates that the two patterns of (l)herded calving and (2) free calving let the herds find their own ways in different seasons.

Table 6.1. Patterns of herding intensity in Guovdageaidnu (1962)

(1)HERDED CALVING	(2)FREE CALVING	(3)SUMMER HERDING
Herded calving on spring-time land	Free calving on summer land	Herded calving on spring pasture plus summer herding
Waiting behind fall-fence (critical autumn crowding)	No waiting (avoidance of crowding)	No waiting (avoidance of crowding)
Full herd knowledge December – January	Full herd knowledge End of October	Full herd knowledge Year around
Most njarga herds, Typical of Gouvdajohtelitt (Medium zone)	All soulo herds, most nanne herds, a few njarga herds, typical for Oarje-bealli (west) and Nourtabealli (east)	A few nanne herds

Source: Paine (1994:99-102)

Pattern 1 (herded calving option) include that they calve (in May) on the spring pastures, which by then are rich in lichen and have early green vegetation. The high altitude summer pastures still are snow-covered into June when these herds arrive and are let roam free, with exception for calf-marking roundups, the rest of the summer. In September the herds are gathered against the summer/fall fences, often having to wait with overgrazing and loss of weight as the outcome. When let through the fences and into fall pastures the animals move southwards in crowded pastures and get intermixed. Separation in corrals is usually necessary on the way towards winter pastures. This option is used by most njarga herds, and is typical of the medium zone.

Pattern 2 (free calving option) includes letting the calving take place on the summer pastures where the animals run free to find their nourishment. In the cases of nanne and njarga herds the terrain allows for easy movement, and is not hindered by the terrain or fences to wander southwards into the fall pastures. The level of herd intermixture is lower than for the herded calving option herds. Most herds from the western and eastern zones practice this option.

Pattern 3(summer herding) combine treats of both (1) and (2), and its practitioners have the most complete herd knowledge, insofar as herding at calving grounds are extended into summer keeping full control over the summer and into the autumn to hinder mixing with other herds. A few nanne herds conduct this option (Paine, 1994:99-102).

Further Paine has analyzed (1994:115-130) herd composition and harvest structure for seven households from these three herding patterns; finding that each of the herding patterns has its corresponding and distinct pattern of husbandry including a set of objectives. Thus we can consider this as three *merging variations of herding and husbandry creating subtypes within one production system.* The three subtypes, which are related directly to the types 1, 2 and 3 of Table 6.1 are:

(1) The *extensive njarga management,* which has a low growth potential, but where the owners, who have the possibility maximize relative herd size and perform a traditional harvest (relative high portion of bull and castrate slaughter),

(2) The *less extensive* (intermediate) *suolo and nanne management,* which have a higher reproductive capacity, a harvest based upon animals of higher growth (the bulk of the bulls harvested are varit (1 1/2 years). These owners maximize income and can be expected to balance herd size to pasture resources.

(3) The *intensive nanne (orda) management* conducts continuous herd control and a high calf growth, higher slaughter weights and expansive capacity. High control make a traditional harvest possible (elder male animals are not straying so much as in the (1)-case).

These observations are interesting, we particularly note that the (1) njarga management has the lowest expansion potential and that the (3) intensive nanne management has a high growth potential, but both perform traditional bull/castrate -slaughter. We also note that the (2) medium reproductive form has a tendency to pursue income goals and harvest animals with a higher reproductive capacity. With respect to our theoretical strategy choices described in Chapter 3, (1) is consistent with Strategy B and (2) with Strategy A, while (3) may choose either, but does not utilize its potential fully (in 1962). This material is consistent with *a fairly good balance between expanding and stabilizing strategies in the early 1960's; before the snowmobile revolution.* However, the subtypes of the production system have differences in their potential for adaptation to technological change. We will study this in subchapter 7.5.

South

In the South, the main traditional winter pastures are in the east continental Swedish inland pine forests, but also on islands, peninsulas, and low mountains on or near the Norwegian coast (coastal winter pastures). The summer pastures are mainly around the mountain ridge which the Norwegian-Swedish border follows (Kj0len). This is equivalent to two distinct migration patterns, and traditionally there have been two types of herding in this area, a *mountain type* with long migrations to continental winter pastures and a *coastal type* with shorter migrations (Bergsland, 1994; J.A.Kalstad, 1982). Wide spruce forest areas rather sparsely populated by a farmer population divide the bare mountain areas on the Norwegian side. Some CPRs are contiguous, however, without natural borders to the next CPR, which makes expansion and competition feasible. A main physical border[4] (partly a fjord and partly a main valley) divides *inner* from *outer* contemporary reindeer pasture districts (RPDs).

After centuries of relative stability in the South production system, important changes took place in the RPDs nearest to the Swedish border in the first two to three decades of our century. In most of these districts, milking was abandoned. Sverre Fjellheim (1991:28-29) provides an explanation based on changes, starting on Swedish side. Herd management becomes based on bigger herds with less intensive herding, because agricultural settlement and expansion from the first part of the 1800's was responsible for 1) directly limiting pastures, 2) increasing herd size (due to Sámi herding of an increasing number of animals for the settlers), and 3) also the administrative introduction of so-called Sámi villages (similar to RPDs in Norway). These changes imposed a "stray animal problem" upon the Norwegian Sámi adjacent to the Swedish border. Falkenberg (1985) points to that governmental policy in Norway, the RPD introduction, also imposed an increased herd size being incompatible with continued combined production, and the first sijte on Norwegian side started to abandon milking in 1902. The geographical border between inner and outer areas protected the outer areas against the technological externality, and some sijte continued up to about 1960 (Fjellheim, 1991).

There was a transition to a monoculture meat pastoralism based on greater herds and a more extensive herding. The anthropologist Yngvar Ramstad (1967) points to that decreasing control opens for competition of both pastures, animals and work power (that is owners with few animals had to worker for owners with many animals when in a common herd) and that considerable numbers of reindeer stray half-wild in the mountains. Recalling our Table 3.1 this is an example *of maintenance problems,* complex such. In other words:

> "on account of a decreased herd tameness grade, the possibilities to profit from the pasture area, labor and reindeer have increased. Thus an important restriction on accumulation of capital is removed" (my translation from Ramstad, 1967:35-36)

Consequences of this include a tendency to overgrazing, deviations from the annual migration pattern, and herding on the outer borders in competition with neighbors. I have interviewed elder herders both from the district which is the main basis for Ramstad's analysis, let us call it "Mountain", and other inner districts in the South. I find that Ramstad's analysis has empirical support also in my material, at least as a tendency, but the situation across districts seems to have been rather variable, though.

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[4] along the axis: Trondheimsfjorden-Snåsavatnet-Namdalen-Vefsndalføret-Ranafjorden (or along the current E-6 mainroad)

My interviewees (all born in the 1920's), in another district, let us call it "Valley", experienced a serious herd decline due to wolf predation around the Second World War, but thereafter they reestablished and managed well through the period up to the new changes in the 1960's and 1970's. They told stories of hard and intensive work, where the requirements of the labor with the animals governed their actions, but they managed to exercise a reasonable control. One idiosyncratic incident from "Naejla"'s life, let us name him that, can illustrate some aspects of their lifestyle:

> At an age of 17, in summer, Naejla was out on an expedition together with his mature partner "Elias". Sitting on a peak they studied the mountain slopes of their district with binoculars, and suddenly discovered a herd of 2-300 head on a mountain 40 kilometers away. They did not have supplies for more than one day, but Elias decided they had to go and get hold of this herd. Naejla brought with him one loaf of bread and they went on by foot doing some fishing under way. To fulfill their mission they walked about 200-250 kilometers in 4 days with very sparsely supplies.

Naejla told me that the work intensity was kept up year around; the only exception was the rutting time - in September.

In retrospect, *it should hardly be any surprise that, in a time where all work still was manual, all districts did not manage to keep up the high intensity of work to keep the required control.* My material supports that this happened to several of the South inner districts. Some of them also abandoned seasonal migrations for periods up to a couple of decades. Thus, in our terminology a number of these districts in the 1950's and 1960's faced a problem of insufficient maintenance (cf. Table 3.1). Ramstad (1967:59) finds *a rather widespread dissatisfaction* with the situation among the herders, in particular because the production system requires actions conflicting with traditional standards for work and social relations.

We have two indications of control problems in Mountain district: (1) The district had not conducted regular seasonal migrations for a number of years, and (2) a straying herd of old bulls is also problem noticed in several Lapp Sheriff annual reports (Lappefogden[5], 1959-1975). One of my interviewees from Mountain (born in the late 1940's) reports that the end of the 1960's and beginning of the 1970's was a very difficult period of conflicts between the elder and the younger, where the former controlled the capital and the latter the labor force. The younger generation, supported by some of the elder, understood that it was necessary to implement changes. Their main objective was to regain herd control. A central instrument was to remove some older reindeer.[6] One of the implications was the beginning of a change in herd structure.

Another of my interviewees, Anders Fjellheim (born 1930) comes from a district, Riast/ Hylling, South Tr0ndelag/Hedmark, which faced a similar problem. Riast/Hylling's special version of their management problem was even worse; one person owned about half the herd, the seasonal migrations had ceased and the tameness grade was extremely low. Having heard in the narratives of his grandmother how tame their reindeer were before the turn of the century, he became determined at an early age to establish control in reindeer management again. He and his family solved the control problem temporarily by establishing a new herd in the winter area, which was temporarily "empty" (1955). Eleven successful years of high work intensity made them build up their herd from 300 to 3500. The government imposed Anders Fjellheim and his fellows; to join with the "old herd" which was in their summer district. In doing so they had to face two

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5 The exact reference is not given, as that would make the real name of the district easier to identify.

6 Under insufficient human control old reindeer develop "bad habits" finding their own way.

challenges: (1) keeping sufficient control over the united herd, and (2) the problem of a "full" district: how could they be able to increase the output of the available resources?The answers of these challenges were two major transformations in the production system: (1) *the snowmobile revolution* and (2) *the revolution of herd productivity*. We will consider these further in chapter 7. We now proceed with describing the institutional system of reindeer pastoralism; first the basic principles of regulation inherent in Sámi culture.

6.2.2.2 Regulatory principles

In chapter 4 we started out with Duany's (1992) development of the concept of regulatory principles, building on Douglas (1980), and sketched a number of possible principles for an acephalous reindeer herder society. Most of them are, not very surprisingly, consistent with herder societies observed. However, building directly on empirical knowledge, we can be more specific. In this section I suggest five principles which seem to be valid up to the 1960's, at least for the Norwegian parts of Sapmi, and to some extent up to the present. The analysis is based on secondary sources. My contribution is to formulate regulatory principles from that material. The principles are summed up in Table 6.1 and commented below.

Table 6.1. Regulatory Principles of the Sámi Herding Society

Principle 1	The autonomy of the husbander; is it
Principle 2	The social bonds of the extensive kinship system; maadtoe
Principle 3	Partnership and siida solidarity
Principle 4	Dialogue and consensus
Principle 5	Responsibility towards the land and the spirits

Principle 1 The autonomy of the husbander; *isit*

The two kinds of work encompassed in the life of reindeer herd management has different requirements and therefore implies different interpersonal relations. The same persons are both autonomous and partners. In the sphere of husbandry, a married man is a husbander, *isit*, while he in the sphere of herding is a partner, *goibmi*. *The* husbander is the senior custodian of his family herd and, as such, responsible both for current family income and for sustaining the family wealth. The decisions of husbandry are irreversible, for example to slaughter an animal, and to some extent strategic in character, since they design the future family herd. The production outcome is under the control of each husbander. Paine (1970:55) holds as axiomatic that *all husbanders are their own masters*. The decisions of husbandry are not shared with other husbanders; they are those of the husbander, and possibly of his wife. Unmarried children are expected to execute the orders of their parents and to not make their own husbandry decisions (Paine, 1970:53). The North Sámi word for husbander, *isit*, is the only word of superordination in the culture (Paine, 1970:54).

Principle 2 The social bonds of the extensive kinship system; *maadtoe*

The traditional system of family and kinship is a cornerstone of Sámi society, creating a network of mutual obligations and social safety net, in South Sámi called *maadtoe* (Kappfjell, 1998:39, cf. Kappfjell, 1991). The Sámi nomenclature of kinship and affinity is extensive and highly precise; each relation having defined mutual interpersonal obligations, and is possibly a

testimony to older times practices of *levirate*[7] and *sororate*[8] (Vorren and Manker, 1976:192, cf. Bergsland, 1942). Contemporary Sámi children are often well informed whether an uncle is *aekki* (father's elder brother) or *ceacci* (father's younger brother) and whether an aunt is *goaski* (mother's elder sister) or *muotta* (mother's younger sister). This is connected to the general feature that relative age in some respects is superior to genetic closeness (Kappfjell, 1991; 1998, Bergsland 1942); siblings and cousins at the same age are often treated as one group by parents, uncles and aunts. This nomenclature is consistent with Sámi practice of *bilateral descent.* This implies, according to Pehrson (1954:1076-1077), that a young Sámi entering marriage

> "may affiliate with his own or with his wife's paternal or maternal kinsmen. He inherits rights and obligations in both his father's and his mother's kindred. His marriage gives him entree to social groups of both his wife's father and mother ".

Besides through genetic relations and relations created by marriage, alliances and webs of duties and mutual expectations are created by selections for important positions such as godfather *(riista-eatni),* godmother *(riista-ahcci),* and spokesman by courting, *soagno-olmai,* (cf. Solem, 1970). Guest friendship *(verde)* extends reciprocal and non-market relations with external supporters in the parts of the countryside the herders live in (Vorren and Manker, 1976:193; Aarseth, 1995b). Together, genetic and social kinship creates an extensive web of interpersonal relations within a greater area than the siida area. Paine (1994:17) denotes this area as the *pastoral range*[9], the social and territorial unit in that the households live and move. Pehrson (1954:1078) holds that *each siida "is organized around a group of brothers and sisters who provide a nucleus to the genealogical structure of the band."* A key principle in the society is *sibling solidarity,* and the sibling group thus becomes the core of the extensive kinship network (Vorren and Manker, 1976:193). The network provides a person with a great number of potential relationships of equivalent or near-equivalent value. A herder can, for instance, have the choice between his brother, his brother-in-law, or his cousin as a partner (Paine, 1970:56).

Principle 3 Partnership and siida solidarity

The herding work concerns herd management within a purely ecological reference, the decisions being short-term and made on the basis of equality among the owners (Paine, 1970:54-55). In the work with the common herd, the husbanders cooperate as partners, regardless of differences in wealth, age, and domestic status. Ideally, a partnership is one of high mutual dependence and trust. Choice of partnership within the possibilities provided by the network takes into consideration the needs of both the pasture and the people. This implies that "even a father who wishes to have his sons as his partners cannot bind them; all he can do is to make it attractive enough" to make them stay (Paine, 1970:56). Choice and change of partners seem to reflect relatively pragmatic decisions, while the partnership may change. The web of potential partners based on kinship and relationships by marriage is stable. The partner of this year may, however, be next year's competitor, and the siida composition changes over time (Paine, 1970,1994).

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7 The younger brother of a husbander has a duty to care for the family of his elder brother, if he is absent for a long time or if he die, and eventually marry his widow.

8 The younger sisters duty of taking the position of her elder sister if she dies and eventually marry her widower if not married.

9 Gouvdageaidnu has 3 pastoral ranges, being consistent with the trisection of the fall/spring pastures (cf. Chapter 7), about 1960 encompassing 50-70 households and about 20,000 reindeer each.

In a typical Finnmark reindeer management, where the size of the siida varies with the seasons, the nature of partnerships varies. In the spring, when the herding units are smallest (one to three households), the partnership are closest (Paine, 1970:57), while only sharing a summer-pasture is not considered as siida-partnership at all (Meloy, 1997). *The solidarity between siida partners is usually strong and can often be stronger than the solidarity between siblings.* On the other hand, solidarity across siida borders, as for instance between poor herders against rich ones, is not usual (Mel0y, 1997). The total network of siida partnerships and the extensive kinship system create a network, in South Sámi *laahkoeh*, which dampen underlying conflicts on different levels. They cannot, however, remove the elements of resource competition between households and siidas.

Principle 4 Dialogue and consensus

Sámi herders value the discussions about herding tactics and other matters of common concern. Anybody who has attended a number of herder assemblies can hardly avoid noting the considerable time and energy that often are invested in achieving an outcome that can be supported by as many as possible, preferably everybody. In many cultures silence means agreement, but in the Sámi herder culture, *agreement should be expressed verbally.* That is, if you have not said you agree, it is an open question what your opinion is. Disagreement may be expressed by leaving the arena (Mel0y, 1997). As a principle for making collective-choice decisions, consensus manifest advantages compared to majority vote in that everybody and everybody's interests should be involved. On the other hand, the weaknesses are equally apparent; Paine (1970:59) has observed:

> The extreme pains that are ordinarily taken to make it appear that a decision is a product of a prolonged general discussion...and to make it appear that men who have disagreed about courses of action are unanimous in their support of whatever has been decided.

Pseudo-unanimity can, as Paine (ibid.) comments lead to necessary decisions not being made or that real conflict being concealed. It can also contribute to the origin of "dark secrets". Persons who know that a discussion will not serve their interests may try to avoid an arena of collective-choice, in order to have the option the partnership may change o the partnership may change f ignoring a not-welcomed decision (J. I. Haetta, pers.com.). Dialogue and consensus are important both within and between siidas. It is particularly important between siidas, because other bonds and mechanisms are weaker than within a siida.

Principle 5 Responsibility towards the land and the spirits

In common with other indigenous peoples, the Sámi have developed bonds between humans and landscape established on irrational or religious grounds. Cultural historian Sverre Fjellheim (1994:60) asserts that the Sámi cultural landscape may include both relations to religion and the ancestors. The Sámi pre-Christian religion was a nature religion with a shaman cult. Spirits lived in nature, and the dead continued their life in another world. Sacrifice, of animals or animal parts, was included, and on most sacrifice sites pictures of the gods are represented by *sieidi*, stones given a distinctive shape by nature (Vorren and Manker, 1976:162-170). Christian missionaries influenced[10] Sámi life significantly in the 1600's and 1700's. Some of them made extensive

10 Pollan (1993:26-27) holds that the most prominent missionary Thomas von Westen (active 1716-1727) did not use direct coercion against the shamans. However, the government considered shamanism as use of witchcraft and many was executed and burned.

records of Sámi religion. From the 1700's, the exact locations of *saajve*, holy mountains belonging to seven named South Sámi people are known. The mountains were objects of personal inheritance and high social status (Bergsland, 1985). Hatt (1928) was told how an old Sámi took leave of his land:

> There was an old man who, when he felt that he was not to return to his treasure land any more, skied around it to take leave with it; on three spots he made a fire and boiled coffee and poured the coffee over the soil as a sacrifice. And he wished that the soil should feed those who were to succeed him that it should be equally as good to them, as they had been to him. Thus it was custom to take leave of one's land when feeling that one was about to die. And one wished good for the successors, even if they were not one's own relatives. (My translation, JAR, after the text in Fjellheim (1995:75)).

Nils Oskal (1995) has described elements of reindeer Sámi ethics of Guovdageaidnu down to the 1960's. In this ethics, *coming to terms with the land*, all parts of which are the home of the reindeer, is an integral part of being an honorable person. That is, the land should be treated respectfully, like a person. Particular places have *spirits of patronage* whom one can ask permission of or make wishes to. It is important to come to terms with all parts of the land, covering the full annual cycle (Oskal, 1995:138-139). How you manage this challenge can influence your *reindeer fortune*. Reindeer fortune is a condition to achieve a beautiful and great reindeer herd. Your reindeer fortune is a life-long personal attribute. It is not constant, but cannot be changed intentionally. On the contrary, a persons "good" and "bad" actions and thoughts can, independent of the persons will, influence it positively or negatively (Oskal, 1995:129). In explaining the human relation to nature in the Sámi world, the psychologist Jens-Ivar Nergård (1996:136) building on C.G. Jung (cf. 1960:7) suggests that the unconscious part of man's psyche be revealed in his conception of and attitude towards nature. Professor Nergård points out that:

> Man's nearness to the logic and inner processes of nature itself results in the close relationship where nature is a "fellow citizen" and hence an object of projection of these inner unconscious processes like his next-door neighbor is.

Thus:

> The supernatural beings governing and protecting nature have their existence and rationality from the indigenous man's very well-developed understanding of nature and not as it often is seen from his premature understanding of it. (op. cit.: 137)

According to Nergård, the different gestalts (super-natural beings) governing nature tighten both the bonds between man and nature and those of social relations (op. cit.: 138). Different gestalts live among the peoples as oral tales. One example is a story of a herder making his night camp on a spot, which he did not know, was a common pathway. A grouse kept him from getting to sleep, and he was unable to scare it away. When he finally moved his camp, he slept well. In the morning he realized that it was the mythical figure *Gufithar* which had visited him during the night in the shape of a grouse. Nergård (op. cit.: 139) moreover reports that during his fieldwork in Finnmark has been told several stories about the appearance of Gufithar if somebody blocks a pathway or otherwise misuses places of common interest. Generally similar tales are told over large parts of Sapmi. Some are collected by the late culture researcher Just Qvigstad and republished by Pollan (1997). Nergård (op. cit: 140) holds that the tales belong to the terrain; you do not know the terrain before you know the tales that belong to it. Further, he explains that when somebody runs into trouble with a mythical gestalt like Gufithar, it is when he has not been listening to his inner voice when acting in the terrain. New incidents create new stories and add to the common knowledge of how to behave in the terrain. Seeing mythical gestalts as a part of a deeper cultural layer, in Jung's terms "the collective unconscious" (cf. 3.1.2.2), Nergard (op. cit.: 144) holds that Gufithar turns up for the herder in one shape or another, when someone is treating nature or an area badly. So if the herder does not pay attention, the culture does.

6.2.2.3 Rules-in-use

The rules-in-use seem to shape a regime at two organizational levels, through position rules and property rights.

Position rules

In Table 6.21 sum up basic positions in traditional herder societies for reference.

Table 6.3 Basic Position Rules of Sdmi Herder Societies

Position	Position rule
Household principal *{hit)*	The household principal is responsible for the family herd and takes the necessary operational and strategic herd management decisions about slaughtering, investment, movement, and so forth, sometimes in cooperation with his spouse.
Housewife *(Eammit)*	The housewife is responsible for home and children and provides a support and supply function towards the herd[1]. In marriage she brings own animals to the household.
Household member	Household members may have animals, which are their personal property. The animals are marked with personal marks[2] (distinctive knife cuts in both ears) following family tradition. The mark is considered to be personal property[3].
Children	The children acquire animals as gifts, inheritance, and work payment. Grown children living with their parents cannot make decisions about their own animals without their father's consent.
Servants *(Reannga / Biiga)*	Traditionally richer households have had both male and female servants. Payment was given in animals. Today larger (and elderly) owners also may have young hired men. A servant may represent the household when the principal is not on stage (e.g. at a particular herding occasion when a decision must be made).
Partner *(Siida-goibmi)*	The household principals herding in common in a siida consider themselves to be partners. Partnership is the basic herder-herder relationship and is based on informal contracts. The siida herd on pasture is managed as a common herd, a common responsibility for all partners and their agents. Operational decisions about, for example, movements and expeditions are taken on site, based on competence. Also, a relatively inexperienced agent may be responsible for the siida herd in given situations.
Siida Principal *(Siida-isit)*	The Sami pastoral siida is led by primus inter pares; siida-isit. He is never elected, but accepted as a natural leader, and is traditionally a mature and successful owner with the largest herd and a central place in the social web. The main decisions of the siida-isit are herding decisions, but in conflict he has the right to decide membership in the siida (Vorren and Manker, 1976).

[1] In the fully nomadic society the women took part in herding fully. In modern society the housewife has considerable responsibility for overall economy (often engaging in wage labor) and external relations.
[2] The calves following their mothers are marked in a summer round-up.
[3] most clearly in the South

The total network (laahkoeh) based on regulatory principles 2 and 3 includes a rich nomenclature of positions with associated position rules, being to extensive for our purpose (cf. Kappfjell, 1991; 1998, Bergsland, 1942).

Property rights

The land is common property for the siida. Recalling Table 2.4, the basic *operational level* property rights concerning land are access and withdrawal. *Access* is the right to use the CPR, in our context *the right to utilize the land by keeping reindeer;* a ticket of introduction.

Reindeer under human control are private property. The traditional earmark is the sign of property. Access can be achieved on two levels, the household and the siida. The basic rule of access is that *a holder of the property right of animals marks a reindeer given to you with your mark* (Meloy, 1997). The standard situation is a husbander marking a calf from his own doe to his child or to his servant; the holder of the right decides which new persons will become new

right-holders, but only within his household. In addition, *every young male from a herder household has the right to try to show he has the required ability to earn his living as a reindeer husbander.* And at marriage, the party moving to a new siida brings with him or her own animals into the new household (Solem, 1970). Giving a new household access to an established siida is a collective-choice right, and is considered below. *Withdrawal* is the right to harvest the product flow of the land, mainly pasture. In practice you have *the right to keep the number of animals you can control within the siida area.* Siida-isit or the collective of siida-guoimit cannot limit the herd size of one of their partners. That would be in conflict with the husbander's autonomy (principle 1). The consequence is that *there is no clear division between access and withdrawal rights within the confines of the siida.* Horizontal growth (entry) means potential vertical growth (growth in herd size), which is in accordance with Chayanovs (1966) theory of family cycles.

We recall that the hunting society had clear (inter-siida) borders of property rights. This attribute has at least to some extent been transferred to the herding society. Finnmark winter siida pastures were mapped as early as 1910 (Nissen, 1985). Further a 1933 study of Sámi institutions underlined that the Sámi reindeer pastoralists had clearly established perceptions of *which pasture areas belonged to which siidas, and that these perceptions passed on from one generation to the subsequent* (Solem, 1970). Figure 6.4 indicates that the West Finnmark winter siida borders of about 1960 are clear, but to some extent overlapping.

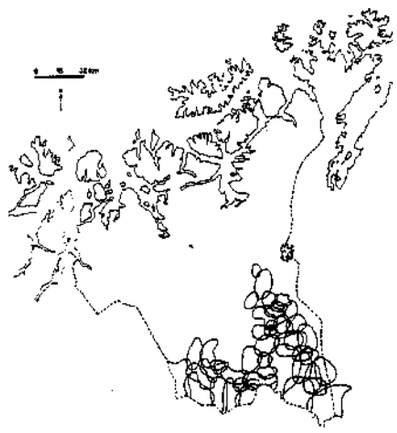

Figure 6.4. Winter pastures of Guovdageaidnu (Paine, 1994:77)

The ethic of respecting another's pasture seems to have been rather strong. This is, however, modified by the rule that *everybody had right of access to alternative pastures, when in need* (Solem 1970:190, Paine 1994:83). On the other hand, "it is considered as rather coarse action to trespass into another's siida without strict necessity" (Solem, 1970:190, my translation). More generally, *"the common interest and understanding that mutual consideration is ultimately what benefits reindeer management in the long run is, in the end, the surest incentive that the Sámi mutually respect each other's pasture areas"* (Solem, 1970:191, my translation). This is consistent with valuing dialogue and consensus (principle 4).

The main property rights in arenas of *collective choice* (cf. Table 2.4) are management, exclusion, and transferability. *Management* is the right to regulate use patterns and transform the resource by making improvements. Matters of management are normally solved by means of dialogue and consensus. If unanimity between siida-partners is not achieved, some cases are

determined by siida-isit as the ultimate authority. The right of *exclusion* includes the right to determine access right. A herder achieves access to the siida by being accepted as a new partner by the siida-group, and brings the herd he has into the siida. *Entry into an established siida normally requires unanimity* (Mel0y, 1997). Skill as a herder, and social acceptance through the network are requirements.

The right of *transferability* is the right to sell or lease the full set of rights, included in an owner or user position. Transferability is limited in *the traditional herder culture.* Reindeer, which are private property, are fully transferable, normally as slaughter animals, but also as elements of a herd. The transfer of herd animals, when bought by an established household implies extension of the access obtained previously. For a new household, buying animals does not imply new rights of access — that would require a collective-choice decision of entry. Transfer of owner/user position includes transfer of traditional earmark to another person, usually by *inheritance,* while transfer of the position by *sale* or *lease* is not known as a traditional practice (note that animals are sold) in the Sámi herder culture. However, taking into consideration that the culture is developed within a pre-market society, this is not surprising. I would therefore not use limited transferability of collective choice rights as an argument[11] to limit the extension of rights. Today the transfer of position is limited by law (the set of persons to which the may be transferred is limited), in order to limit entry pressure.

Based on the general responsibility towards the land and the spirits (principle 5), traditional Sámi herders have developed some kind of *general terms of appropriate reindeer management conduct,* having norm status. These terms are transferred through the generations by ostensive teaching (Nergård, 1996:35) and by different oral techniques ("endless discussions of herding tactics" (Paine, 1970), general storytelling (Balto, 1996:49), and tales involving supernatural beings (Nergård, 1996). Some of my informants have provided elements of these terms of conduct, but I have not found extensive written description of them. The possible reconstruction of them is a challenging task, which should be accomplished while the generation that grew up with them can still describe them. Part of the difficulties of a reconstruction is that many institutional patterns of actions have become *conventions* and, as such, *not very conscious for the insiders.* Since they are not spoken of, the patterns can be *rather invisible for outsiders.*

Not having extensive ambitions of my contribution in this field, a few examples may, however, provide some traces of the traditional general principles of appropriate reindeer management conduct. (1) *The natural rhythm of migration and movements in the terrain should be followed,* including using each pasture at the right time and to the right extent. For example, rotation of winter pastures is a traditional practice some places; that is, each pasture area is used only one of three subsequent years. Concern for overgrazing is inherent in the Lule-Sámi term *båralkem landa;* severely overgrazed pastureland in need of considerable herd reduction (Rensund, 1986:30). Further (2), the pastures along the seasonal migration routes should be used carefully (cf. Solem 1970:191). (3) Moreover, you should refrain from making a camp-fire at spots of good winter pasture, and (4) you should not camp where you block others' use of an area, particularly not a common pathway (cf. Nergård, 1996). Finally, (5) you should respect others *hergi'dievva* (traditional winter campsite, cf. Paine, 1994:83). My Guovdageaidnu interviewee Jovna (born 1923) focused on the three firsts mentioned as important in traditional reindeer management and regretted that contemporary young people did not care so much about such principles. Seen as a whole, such general principles of appropriate reindeer management conduct can be considered as

11 However, this is a possible point of disagreement. A conclusion of the position *proprietor* (cf. Table 2.5) is also possible.

indirect withdrawal limitations, meaning that these five limitations impose important restrictions on each herder's pasture use.

We have now focused on the most relevant property rights for a CPR and characterized the regime. We need, however, to focus on *sanctions,* also a part of the rules-in-use. The ultimate intra-siida sanction of excluding an established partner is mentioned above. Recalling Ostrom's (1990:90) principle of graduated sanctions and observing the need for inter-siida sanctions, we consider some examples; provided by Paine (1970:62-64), when other sources not are mentioned.

(l)Ridicule is a minor but appropriate sanction in a society where personal reputation is highly important and a lot of time is spent in camp with partners and competitors. (2) *Radkit,* the sanction of separating the herd outside the standard seasonal separations, means that one or more partners separate their herd from a partner they want to punish. It can for example be used when a man is recognized to be a reindeer thief. (3) If conflict between siida-partners is insoluble, *siida-isit* has the ultimate power of *expelling the partner who is unwilling to fall into the line when the interest of the siida requires it* (Vorren and Manker, 1976).

(4)Encroachments upon pastures can in some situations be acceptable (mutual disturbance between siidas is to some degree unavoidable) and in other situations be interpreted as aggression or a punitive sanction. While encroachment upon pastures affect all the households of a siida, (5)-molesting *animals* affects only the owner and can be a more precisely directed sanction. As a rule the pastoralists will be able to interpret from the situation whether, a «thief» or a «policeman» accomplishes an otherwise illegitimate slaughter. Kappfjell (1998:40, cf. Petterson, 1979) calls attention to the sanction (6) *deprival of network position* (laahkoeh); a person offending network rules-in-use could be deprived his position and thus be addressed only by his/her formal name. This means full social exclusion and has the implication deprival of all rights, e.g. right of caring in case of disease, an extremely serious sanction.

Recalling the importance of proper behavior to retain one's reindeer fortune (cf. principle 5), we find clear elements of a ladder of graduated sanctions in the traditional Sámi herder society, though a closer study could probably provide a pattern with more nuances. However, the sanctions probably are more effective between households than between siidas.

Recalling the Schlager and Ostrom definition of positions ranging from authorized user to owner, constituted by increasing rights, *the position of a traditional Sami reindeer herder is consistent with being a full co-owner* (cf. Table 2.5). Nevertheless, there are two connected features deviating from the ideal full owner position: *at the operation level both access and withdrawal rights are relatively extensive.* This may be *a potentially weak point* of the regime because it can be near to open entry/free withdrawal for siida members (cf. Bromley, 1991:32). The counter-rule which balance this potential weakness is the *indirect withdrawal limitations* which when fully intact can be sufficient to ensure the regime with the required capacity for coordination.

The need of coordination is influenced both by net herd growth potential (dependent on predators and herd composition) and the production system. Relative low growth potential and labor intensive production systems thus limit the need for coordination. We may preliminarily conclude that *the regimes before 1960 seem have had a correspondence between the regimes' capacity and the need determined by other factors.* How good the correspondence was varied, of course.

An increased need of coordination in the wake of technological change may shift the balance between need and capacity, creating a capacity deficit. The regime described above seems to be *vulnerable to changes in the need for coordination.* The indication for this is the lack of direct access and withdrawal limitations. Technological shifts may increase the pressure on pasture resources considerably. *The crucial point is then whether the indirect withdrawal limitation is sufficient to balance the increased need of coordination.* Probably an increased capacity for coordination will be required through strengthening the existing regime. We should also note that the rights are *de facto* rights and, as such, potentially threatened by competing right claims of encroaching industries, which achieve legal support.

Looking back on the system of regulatory principles and property rights we note that the traditional Sámi herder society seems to be very close to our idea of an acephalous society, as we cannot find a structure of authority over group-level (siida). All inter-group connections seem to be horizontal. Seeing this property in relation to external changes, using the concepts introduced in subchapter 2.5,we can imagine that this type of society will be double vulnerable. Firstly need of coordination may increase fast, and secondly, and probably most important, capacity of coordination may not increase that fast.

The lack of authority structure also has implications for Sámi relations to external powers.

6.3. The Sámi and the States: Elements of a Political History

The ancient Sámi society consisted of independent and semi-nomadic siida groups with limited cooperation among themselves. Organized power was not well developed. The preconditions for development of an authority structure of chieftains or a Sámi state do not seem to be present in the Middle Ages (Aarseth, 1989a:49).

6.3.1 Colonization by the Nordic States

In early medieval times, Sapmi was surrounded by expansive chieftain realms, which still did not constitute fully developed states. Nevertheless, because of their military forces, the realms were able not only to trade, but also to collect tribute from their more weakly organized neighbors. During the first centuries of the second millennium, Norwegian fishery settlements spread along the northern coasts, Swedish peasants moved up the western side of the Bay of Bothnia, Finnish peasants expanded northwards in contemporary Finland, and eastern trading and hunting peoples expanded towards the Kola Peninsula and eastern Finnmark. In sixteenth through eighteenth centuries, the kingdoms of Denmark-Norway and Sweden-Finland plus the Tsar Empire of Russia competed in taxation, trade, and sovereignty claims, gradually covering whole Sapmi (Aarseth, 1989a: 47). Historical sources indicate, however, that up to about year 1600, the Danish king transferred taxes collected from Norwegian settlers on the Finnmark coast to Sámi siidas. This can be interpreted as a sign of acceptance of Sámi sovereignty, but after that, the crown kept the taxes, and the sovereignty was ended (Aarseth, Niemi, Aikio, Brenna and Helander, 1990: 33). However, the relative strength of the Sámi and the surrounding states from late medieval time made a final colonization and partition of Sapmi only a question of time (Aarseth, 1989a: 50). The beginning of this partitioning was the Norwegian-Swedish[1] border, established in 1751. To determine the border, extensive studies were made. The main work was the border examination protocols of Major Peter Schnitler from the years 1742-1745 (3 volumes printed 1929, 1962, and 1985). His main source was interviews with Sami,

particularly reindeer herders. The border treaty appendix (The Lapp Codicil) regulating Sámi rights and duties was *liberal* in allowing cross-border migration. The Codicil later earned the name of "The Sámi Magna Charta". The mission of the appendix was clearly "preservation of the Sámi nation".

Reindeer herding was still expanding at the time of the border establishment, and the border did not obstruct this expansion during the first century of its existence. The Codicil supported the continuation of this expansion across the established border (Aarseth, 1989a:57). We should, however, note that this is a time of considerable changes in the Sámi society. The general transition from hunting society towards a spectrum of ways of living is one important feature, while Christianity's final victory over "the heathens" is another.

Further we will consider the direct regulations implemented by colonial power(s).

6.3.2 Governmental regulation

Important political changes took place early in the nineteenth century. After the Napoleon wars, Sweden lost Finland to Russia (1809) and received Norway from Denmark (1814). The contemporary Norwegian-Finnish border in Finnmark thus changed from being a border between Denmark and Sweden to become a border between Sweden and Russia. Russia recognized the borderline, but not the appendix (The Lapp Codicil). The present border between Norway and Russia was established in 1826, and the current Finnish-Russian border was finally established in 1944. After failed negotiations in the 1830's and 1840's, the Russian government closed the border between Norway and Finland for pastoral migration in 1852. In 1889, the Swedish-Finnish border was also closed. The border closures created extensive repercussions in land use and migration patterns of reindeer herd management.

There was a considerable dislocation of pastoralists, particularly in Guovdageaidnu. This took place in several waves, but was initiated by the 1852 border closure. One of its immediate repercussions was that the Finnmark Sámi was deprived of considerable parts of their winter pastures. It also caused movement of a great number of households from Finnmark to northern Sweden, with far-reaching consequences for the land use there.

The border closure also led to the first governmental regulation of seasonal pastures in Finnmark, the Act of Finnmark Reindeer Management in 1854, extended in 1857 and supplemented by other regulations in an act of 1888. This was in force until a law for all of Norway was established in 1933. The main pattern corresponds to the contemporary one. We should remark that these regulations were motivated by the need for improved pasture management when these resources had become scarcer.

During the eighteenth and nineteenth centuries, there were several waves of settlement expansion into the South Sámi areas. In the last decades of the nineteenth century, a new ideology achieved supremacy in the twin kingdom of Norway-Sweden. *Sámi reindeer herd management was considered inferior to the majority people's expanding agriculture.* A political struggle by the farmers, supported by both local and central authorities (Falkenberg 1988, Berg 1990) gave rise to The Common Lapp Act[12] (1883), which had the clear objectives in limiting the extent and rights of reindeer management. The act was later extended with an appendix (1897) to apply to

12 No. : Felleslappeloven.

both Sweden and Norway *south of Finnmark.* The main elements in this set of regulation efforts were (Berg, 1994:18; Riseth 1992 I: 79; Severinsen, 1979):

(1) In Norway south of Finnmark the *property rights for the group* became from 1892 limited to a defined *Sámi reindeer pasture area.* This included most of the traditional Sámi reindeer management areas, but Sámi property rights without any compensation, particularly in the southernmost parts of Sapmi (e.g.: Gauldalsvidda).

(2) Outside this authorized area, conduct of reindeer management became conditioned upon permission from owners and governmental recognition on a case-by-case basis.

(3) All pasture areas within a defined Sámi pasture area was divided into reindeer pasture districts (RPDs).

(4) The herders of each RPD had the duty of electing a trustee as an *external go-between* vs. government and others (particularly farmers).

(5) The herders were imposed a collective duty of compensation for (alleged) damage on agricultural land.

(6) Every husbander was imposed a duty of giving a statement of number of persons in herd size for his herd size when entering an RPD.

(7) The establishment of Lapp Sheriffs[13] (implemented 1894-1899), who had the task of mediating, especially in the relationship between pastoralists and settled farmers. They were State officials with the Regional commissioner as their superior. From the start they had a police background.

The offensive against reindeer management was a part of a general offensive towards Sámi culture and language, both in Norway and Sweden. It lasted down to the post-war era.

The union between Norway and Sweden ended in 1905, and Norway became an independent state. Finnmark received its first Lapp Sheriff in 1929. The first Act of Reindeer Management covering all of Norway was established in 1933. This act also included the main elements from the 1883 act, cited above, to also include Finnmark. Before 1933, the reindeer management in Finnmark and the remainder of Norway had been governed by different laws, which had both an internal and an external motivation, as argued above. The Act of Reindeer Herd Management of 1933, in force until 1979, considered pastoralism as *a dying way of life. It should be allowed to exist until vanishing, the presumption being that it would give way in conflict with agriculture* (Indredepartementet, 1904). The external property rights (rights towards agriculture, etc. thus seem to be weak, and the general position of a herder is described as *tolerated use*[14] (cf. Arnesen, 1978), which is a weak user right position resembling the Schlager and Ostrom (1993:16) position of *authorized user* (cf. Table 2.5).

After Norwegian independence, the migrations across the Norwegian-Swedish border previously regulated by the 1751 Lapp Codicil were regulated by bilateral conventions between Sweden and Norway. Sámi interests were given low priority. The Sámi were considered only as inhabitants of the states and not as an independent party, a people with established rights. While the 1751 Codicil was built upon a principle of mutual advantage between the states, after 1852 (the partial border closure) the Norwegian Government considered the remaining cross-border migration as a unilateral burden upon Norway, giving advantages only to Swedish Sámi (Lae, 1977:8). The migration pattern with summer pastures in the Norwegian counties Nordland and Troms and winter pastures in Sweden had expanded considerably after 1852 (Aarseth, 1989a:68). The interests of the expanding agricultural population of Troms also heavily influenced the official Norwegian stand. Statements of central Norwegian politicians characterized the reindeer herding Sámi in more or less social-Darwinist terms (Lae, 1977:140-141). As a consequence of this attitude, the conventions of 1919 and 1972 permitted a successive reduction of this cross-border

13 No: Lappefogd.

14 No: *tålt bruk,* which includes to give way in conflict with stronger property rights.

pasture utilization. The rights of the Norwegian Sámi for winter pasture in Sweden were reduced in the 1919 convention (Kielland, 1974:56), and an (illegal) expansion of Swedish Sámi (caused by change in production system) forced the Norwegian Sámi of Helgeland, Nordland county, to shift westward (Vorren, 1986). A convention between Norway and Finland was established in 1952. A convention from 1926 and agreements of 1949 and 1977 regulated the relationship to Russia. All three national borders today have bar fences, which physically obstruct, reindeer border crossing, though not completely.[15]

Both the general regulations and the establishment of Lapp sheriffs clearly must have been a challenge to the internal autonomy of Sámi reindeer pastoralists. The Lapp Sheriff position was a typical middleman role, leaving to the holder some freedom of choice to conduct their role as a patron or as a broker. The governmental directives clearly imposed a guardian role upon these civil servants, but there are also positive examples of Lapp Sheriffs promoting positive development and supported Sámi organization establishment (Berg, 1994; Riseth, 1992:11: 15-19); of these Peder Hagen (Nordland) is the best known.

The generally negative State attitude towards Sámi and reindeer management slowly turned more positive in the years after the Second World War. Of particular importance was a public committee (Samekomiteen, 1959) which proposed a series of undertakings to improve Sámi culture and life conditions. The parliament, Stortinget, generally was very positive to improvement of the conditions for the Sámi, but changes were neither easy nor swift in coming. Paul Fjellheim (1987b: 11), NRL chairman 1965-1973, holds that the governmental administrators had the politicians' intentions very little on their mind and that they were still (at his time as an active organization leader) colored by the social Darwinist thinking underlying the 1933 Act of Reindeer Management.

6.3.3 Sámi self-organization

As we learnt above, the southern part of Sapmi was a frontier area for both non-Sámi agricultural settlement and governmental regulation efforts. The first organized political resistance from the Sámi emerged in South. In the first decade of this century, local Sámi organizations were established in both the Tr0ndelags, Helgeland, and in adjacent areas in Sweden (Salvesen, 1979). Berg (1997:10) states that there is no doubt that the Sámi of the South were completely out-maneuvered politically by the farmers and the authorities. That is, the *regulations implemented gave rights to farmers and imposed duties on the Sámi.*

This organized ethnopolitical activity resulted in congresses in 1917 and 1921. Most of the participants[16] were South Sámi; only a few came from the North. The main topic for the meetings was the legislation of reindeer management. The authorities during the preparation of the law directly consulted the South Sámi. The North Sámi were not consulted, and it seems that they were not politically active, even though the new legislation was to include all reindeer management in Norway. Berg (1994:102, 1997:19) states that the main explanation must be that *they lacked the meeting culture and organization apparatus the South Sámi had established from the turn of the century*. In addition, he finds that the South Sámi had both a higher competence in

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15 The combination of steep terrain and snow accumulation would some places require fence heights of, for example 5 meters, while the fence in practice is limited to 2 meters.

16 About 100 in 1917, 37 in 1921 (Berg:1997:14-17).

the Norwegian language and several gifted writers who were able to polemic against the government and those with competing interests. The organization question came up again after the end of World War EL The Association of Norwegian Reindeer Herding Sámi (NRL) was founded in 1947. The organization included all reindeer managing Sámi in Norway, but the point of gravity was in South in its first decades.

During the 1950's, a pan-Sámi movement grew. Organizations were established in both Norway and Sweden. A cooperative organ among Sámi organizations in Norway, Sweden, Finland, and Russia, today named Sámi Council, was established in 1956 (cf. Aarseth et al, 1990:92). In spite of this progress, the conditions for Sámi NGO work in the late 1950's and early 1960's were still poor, due to lack of resources and slow advances, important steps towards the later organization policy were taken. For example; in the period 1953 - 1964 a herder journal (Reindriftsbladet) was published with up to 4 issues a year. The editor from 1958, Anders Fjellheim, also NRL secretary for a number of years, also made other important contributions in the decades to follow.

6.4 Summing up

In this chapter we have learnt that Sapmi, as a geographical area, is far more heterogeneous than most northern landscapes, and well suited for reindeer; particularly Finnmark with highly accessible lichen pastures at winter. The Sámi reindeer culture is ancient and has been through a number of transformations through the centuries, so also the type of reindeer management. The latest phase of reindeer pastoralism up to the 1960's also perform some regional variation. The institutions of the Sámi herding society can be described in terms of regulatory principles and rules-in-use and seem to be fairly well adapted to the requirements in the period up to the major technological shifts in the latest third of the 20th century. We found that the traditional position of the Sámi reindeer herder to be near to the one of a full co-owner as a de facto position.

The once autonomous Sámi have through the second millenium gradually been colonized by its neighboring nation states. From the latest part of the 19th century and to the period after the Second World War an ideology based on Social Darwinism dominated governmental policy towards the Sámi, as well in Norway as in Sweden. Reindeer management was considered inferior and imposed to give way for agricultural expansion by the neighboring peoples. *Contrasting the internal de facto position, Sami reindeer herders were dejure treated as nothing more than authorized users.* The Sami organized; and started to achieve some progress in the postwar period.

Chapter 7
North and South in Change
- CPRs and Production Systems exposed to external influences

This chapter focuses on "the stem" of our analytic model presented in Figure 5.2. Using the comparative perspective we start with an examination of state of the CPR, continue with a focus on external factors, and the development of the production systems. After summarizing the regional differences in performance, we end the chapter by a more detailed analysis of how the overgrazing developed in West Finnmark.

7.1 The state of the CPR

Here we will go behind the data presented in the introduction and present a more detailed development pattern for the regions we are comparing. We start with the state of the resource.

7.1.1 The State of the resources

From the 1960's on reindeer management was to an increasing degree considered as an industry both by herders themselves and state officials. That made resource assessments increasingly relevant. Since reindeer management is a two-resource undertaking, resource evaluations need to include both pastures and animals. None of the assessment methods developed alone provides full information. This implies that all assessments will to some extent be based on judgement.

7.1.1.1 Assessment methods

Resource studies usually combine several methods (Reindriftsforvaltningen, 1998:25-42, cf. Gaare, 1998). The methods presented below should be considered as complementary to each other.

Pasture assessment survey

Pastures can be studied *directly* or *indirectly* via the growth and weight development of the animals. In Norway, systematic pasture assessment surveys were introduced and developed in the 1960's by pasture consultant Erling Lyftingsmo, Selskapet for Norges Vel[1], and refined by Loyd Villmo, the state consultant in reindeer management, during the late 1960's and the 1970's. The method is random sample based; line surveys where a number of straight lines through a pasture area define spots with fixed distances between them. At each spot, botanical vegetation type, cover percentage for the different species, and *grazing degree* is registered. Particularly the last undertaking requires a considerable amount of professional judgement. The most used

1 A philanthropic foundation promoting countryside industrial development.

classes of grazing degree for lichen pastures are; (1) slightly grazed, (2) overgrazed, (3) heavily overgrazed. Grass and herb pastures have similar classes. The collected data are used for calculating actual pasture capacity.

The above method requires a high amount of intensive fieldwork, but is much used. Combining the method with use of aerial photos has saved field time, and from 1973 steadily improved satellite technology has provided picture series with relatively objective and complete vegetation data. The contemporary method thus allows for pasture survey and monitoring with limited work in the field. The use of time-series makes this technology particularly suitable.

Animal weight registrations

In general normal weight development of the animals is an indication that herd size balances summer pasture conditions (cf. Klein, 1968 and Chapter 3). For registration either slaughter weights or live weights can be used. However, for comparative use (between districts) sample representation and standardization with respect to age, sex, and (for slaughter-data) slaughter-time is a necessary requirement, which in practice is difficult to fulfill. Random influences such as annual variation in climatic factors in most cases have a greater predicative power for weight than animal per pasture ratios (Reindriftsforvaltningen 1998, Tyler 1997). Time series data on animal weights can even out this type of influence and can potentially be a tool for finding optimal resource use within each CPR. In comparative studies (between districts), continued (very) low animal weights will thus be a clear indication of too high grazing pressure on summer pastures. Live weight registration can also be an appropriate vehicle for selection of animals for continued life or slaughter. The state of lichen pastures seems more suitable for direct assessment than via animal weights, though clear correlation between low weights and low lichen biomass are found (Johansen, Johansen, and Karlsen, 1995).

Herd size

Herd size numbers basically build upon the herders' own statements to the government, while data, in particular from the late 1980's, to an increasing degree are based upon public counting. The certainty of the statements may depend upon whether the herders had something to gain or lose by providing the correct number. For example, tax per head provides other incentives (cf. Reindriftskonsulenten, 1968) than a tax proportional to net income. In addition, focusing on exact herd size may be felt culturally incorrect[2] (cf. Oskal, 1995). Professionals or experienced administrators assess the statements to deviate from actual numbers by 10-20% in general, with a few large herds possibly undervalued by up to 50%.

In sum, these features suggest; 1) we should consider herd size in public statistics more as indications than exact numbers. Further 2) we can generally expect the recorded numbers more often to be too low than too high, and 3) we can expect newer numbers to be more correct than older ones - due to closer monitoring. Moreover 4) we can expect the relative variations in the numbers (at least the directions) to be fairly correct.

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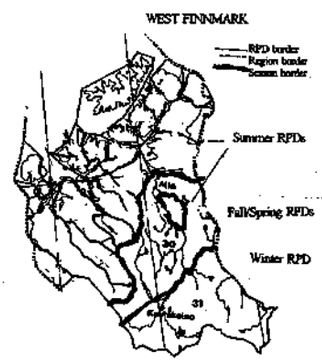
2 E.g. herd size focus may harm your reindeer fortune (cf. Chapter 6)

7.1.1.2 North

Pasture situation

To consider the West Finnmark pasture situation we need a picture of the current RPD (reindeer pasture district) seasonal borders, cf. Figure 7.1, note that RPD 30 is fall and spring pastures, while RPD 31 is winter pastures.



Summer RPDs in the Northwest, RPD 30 is fall and spring pasture, while RPD 31, in the Southeast, is winter pasture. RPD is Reindeer Pasture District (cf.6.3.2) "Kautokeino" is Norwegian spelling for "Guovdageaidnu".

Figure 7.1. Contemporary West Finnmark RPDs. Source: Reindriftsforvaltningen (1995).

Lyftingsmo (1965) conducted a sample survey of the lichen pastures of Finnmarksvidda (Guovdageaidnu and Karasjok[3]) in 1960-1962. Prestbakmo (1994) reports from a 1989/90 re-survey made to detect changes for the period 1960-1990. His results are clear:

1) *the winter pastures which in 1960 had a fully intact cover of lichen carpets were in 1990 clearly reduced due to intensive grazing,* and

2) *the autumn/spring pastures, which to some extent had reduced lichen already in 1960, were in 1990 heavily overgrazed.*

We should note that the grazing seems to have been more intense at the autumn/spring pastures (RPD 30) than at the winter pastures (RPD31), both in 1960 and 1990. Further, pasture biomass is generally reduced from 1960 to 1990.

These results are confirmed and specified by studies of time-series satellite-data by the Research Foundation the University in Tromsø (NORUT). Johansen and Karlsen (1998) substantiate how the standing lichen carpets of Finnmarksvidda gradually have been reduced in the period 1973 to 1996.

Figure 7.2, with panels for four chosen years, is illustrative for the development. We should

3 Karasjok is situated to the East of Guovdageaidnu (to the right in Figure 7.1) and has the same basic season pasture configuration.

note that the figure encompasses the Karasjok lichen pastures, which have a similar seasonal configuration.

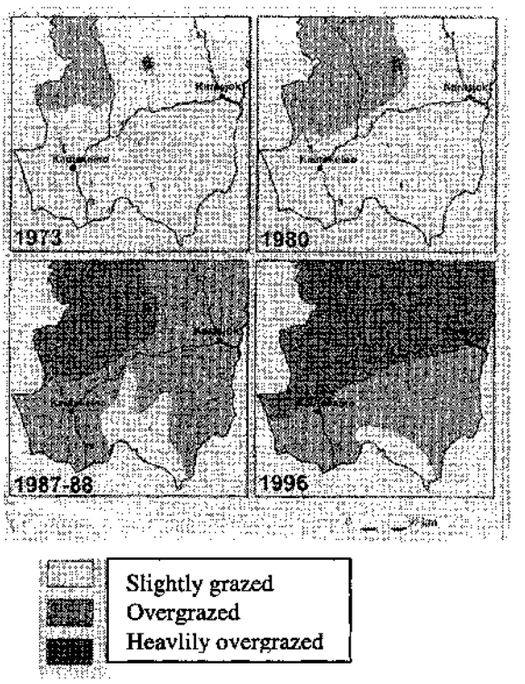


Figure 7.2. Changes in the lichen carpets of Finnmarksvidda 1973-1996 (Source: Johansen and Karlsen, 1998)

Starting considering the 1973 panel we note that the overgrazing starts in the northwest. If we compare with Figure 7.1, we note that only parts of the fall/spring pastures (RPD 30) are still affected. Turning to the 1980-panel most of the same district is affected. From 1980 to 1987/88, a rather dramatic shift seems to take place: 1) most of the fall/spring pastures become heavily overgrazed and 2) most of the winter pastures are also clearly affected. In 1996 RPD 30 is all heavily overgrazed, and only a minor part of RPD 31 has a fully intact lichen cover.

A special committee (Reinbeitekommisjonen, 1967) making an extensive survey and assessment of pasture found (ibid.: 204, 237) that Guovdageaidnu had summer pasture capacity[4] of about 37,000[5] reindeer, while the herd size was about 54000 in 1964-1965. *The summer pasture capacity was thus considered inadequate',* a clear *summer pasture limitation.*

Herd size and harvest

According to official statistics the total herd size of West Finnmark has been remarkably stable

4 This assessment is included in the summer capacity assessment of Figure 1.2.

5 Two additional Troms RPDs (Rendalen and Lakselvdal/Lyngsdal) included

varying basically within the range 30-50,000 animals for the whole period 1835-1974, cf. Figures 7.3 and 7.4.

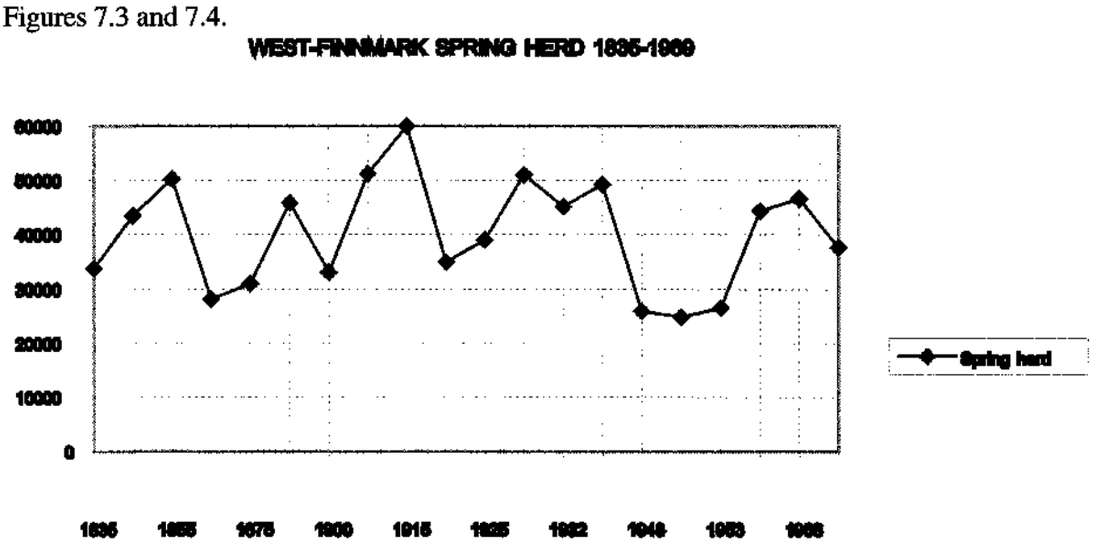


Figure 7.3. West Finnmark herd size 1835-1969. Source: Villmo (1969)

In Figure 7.4 we note that total herd size goes beyond 60,000 in the late 1970's. Comparing with Figure 7.3 we observe that this is a level reached only once before (1915). The further growth up to over 111,000 in 1990 is a new top over the double of "ordinary" top levels. This new increase is so great that some uncertainty of exact herd level hardly can question the relative magnitude of the increase. The registered lichen pasture overgrazing also is in full correspondence with such a conclusion.

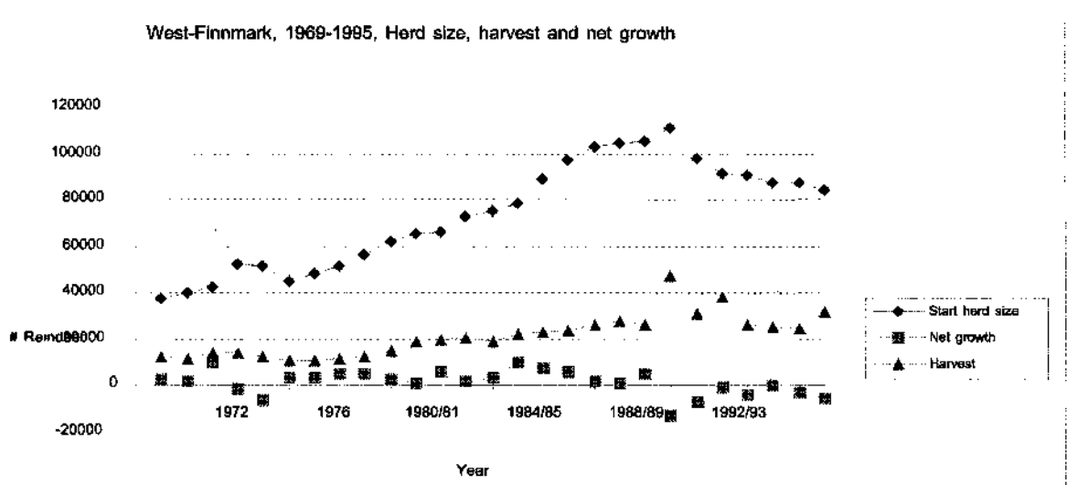


Figure 7.4. West Finnmark herd size, annual herd growth and annual harvest 1969-1995. Sources: Lappefogden i Vest-Finnmark, 1969-1979. Reindriftsadministrasjonen, 1980-1994. Reindriftsforvaltningen, 1995.

We note (cf. figure 7.4) that the herd size growth is relatively steady from the mid-1970's until the top year 1990. A drop in the early 1970's is due to epidemic disease. The extra top of 1990

can be explained by public counts and status corrections[6] (Reindriftsforvaltningen, 1995). The elevated harvest level around 1990 can be explained by extra subsidies with the objective of increasing slaughter.

Summing up we have established *a clear connection between a considerable herd increase from the mid-1970's till 1990 and a lichen pasture overgrazing*, starting at the fall and spring pastures and continuing at the winter pastures, becoming increasingly severe during the 1980's and the 1990's. We will go deeper into the development of West Finnmark, as a CPR externality, in the end of this chapter.

Øye (1996:45-51) has considered the average annual harvest rate for Finnmark (West Finnmark and East Finnmark) finding an average rate at about 0.3 for the period 1975-1994. In a regression between harvest rate and herd size, he finds that (1) only a minor part of the variation in harvest rate can be explained by variation in herd size (r^2=0.2145). Moreover he finds (2) that the influence of other factors increase (greater deviations from the regression line) with increasing herd size. Our data for West Finnmark seem to be in line with this.

7.1.1.3 South

Pastures

Pasture assessment surveys were conducted in several South RPDs in the 1960's and the 1970's. To provide an example, we can examine the results for the southernmost RPD in Norway, Elgå (Lyftingsmo, 1974), which was resurveyed a few years ago (Tømmervik and Johansen, 1992). In surveys conducted in 1948 to provide baseline date for regulating grazing of cattle and sheep (cf. Lyftingsmo, 1974), it was concluded that the lichen standing crop was heavily grazed and in danger of total overgrazing. A specific reindeer pasture survey was conducted in 1969, and the main conclusion was that in the period 1948-1969, all lichen growth was harvested. Some parts of the district were grazed so hard that they should "rest" for some years to regain optimal growth, while others should be grazed harder some years to improve the growth (Lyftingsmo, 1974). A 1991 re-survey substantiates that the more heavily grazed areas from 1969 now have regained much of their former capacity (Tømmervik and Johansen, 1992). Other parts of the South region surveyed in the 1960's and the 1970's (cf. Lyftingsmo, 1974) show a similar pattern. This indicates that the Elgå example may be representative for the whole region. The general pattern seems to be that parts of the areas in the 1960's and the 1970's are heavily grazed or overgrazed, while other parts seem hardly to have been grazed. This is consistent with the information (cf. 6.2) of insufficient herd control and suboptimal resource utilization, also provided in the administration annuals (see below).

Herd size

The quality of herd size statistics before 1980 is variable. The numbers are partly public

[6] The herders were given opportunity to correct their start-of the-year herd size in relation to their end-of the year herd size the previous year without additional explanations.

counting, partly aggregated herder statements, and partly Lapp Sheriff assessments. The data are mainly provided Lapp Sheriff annual reports. We distinguish between North Tr0ndelag and South Tr0ndelag/Hedmark and for this period, as the data are not fully commensurable, cf. Figures 7.5 and 7.6.

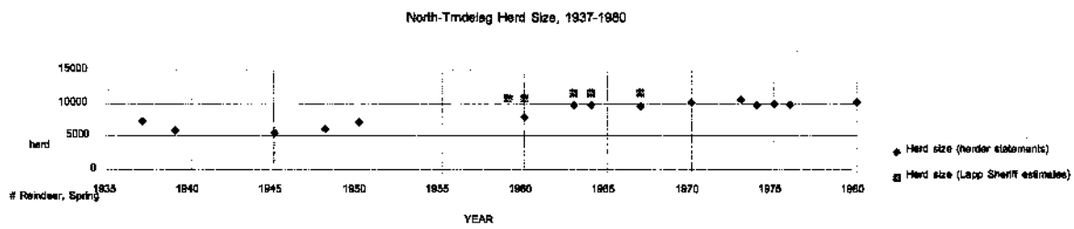


Figure 7.5. North Trendelag herd sizes, 1937-1980.
Sources: Lappefogden i Nord- Trondelag, 1937-1979. Reindriftsadministrasjonen, 1980.

Starting with North Tr0ndelag, Figure 7.5 indicates that the herd size levels from the 1960's and 1970's were around 10,000; clearly higher than around the Second World War. The annuals (Lappefogden i Nord-Tr0ndelag, 1960-1978) also indicate a standard harvest level for the region of about 2000 animals in the 1960's and 1970's; giving a harvest rate around 0.2. The South Tr0ndelag/Hedmark herd size pattern is similar, cf. Figure 7.6.

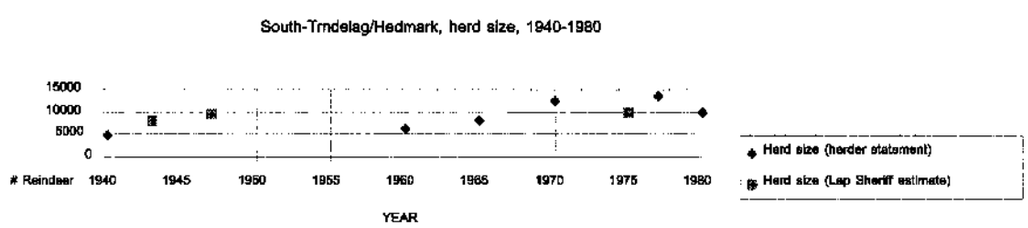


Figure 7.6 South Tmndelag/Hedmark herd size 1940-1980. Sources: Lappefogden i Sor-Trondelag/Hedmark 1940-1979. Reindriftsadministrasjonen, 1980.

The harvest numbers provided in the reports (Lappefogden i S0r-Trondelag/Hedmark, 1940-1979) are, however more variable than for North Tr0ndelag. In several of his annual reports, the Lapp Sheriff expresses uncertainty about the estimates given in Figure 7.6.

For both North Tr0ndelag and South Tr0ndelag/Hedmark an uncertain number of reindeer belonging to neighboring herders from the Swedish side of the border were exploiting the pastures more or less regularly during parts of the year. Most of this stopped in the early 1970's, due to erection of a convention border fence. This implies that the total pasture exploitation up to this time probably was higher than the numbers in Figures 7.5 and 7.6 indicate. A set of administration reports (Lappefogden i Nord-Trondelag, 1959-1967; Lappefogden i S0r-Tr0ndelag/Hedmark, 1939-65) point to cases of insufficient herding control and local overgrazing in some RPDs. The insufficient control also meant that not all parts of the pasture areas were in regular use.

The herd size and harvest for both regions, during the period 1980-1990, are provided in Figure 7.7.

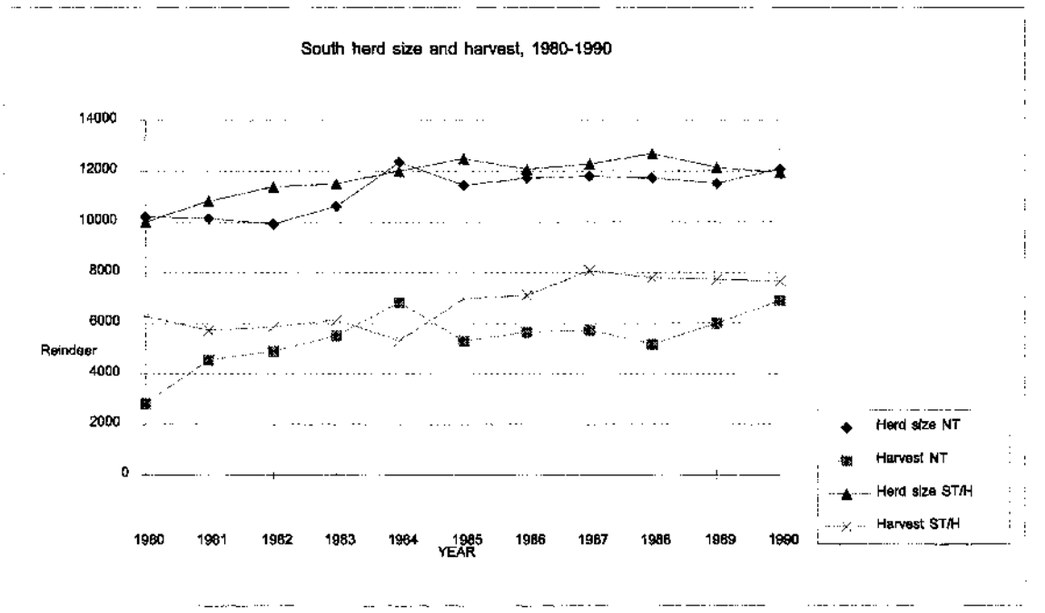


Figure 7.7. South herd size and harvest 1980-90. NT= North Trondelag ST/H= South-Trondelag/Hedmark.
Source: Reindriftsadministrasjonen 1980-90.

There is a moderate growth in herd size, to a level around 12,000, in both regions. This can be seen as a gradual adaptation to a full utilization of the current pasture capacity (Kosmo, pers.com.). Harvest levels increase to levels in the range from about 0.4 to more than 0.5during the 1980's; the increase being most pronounced in North Tr0ndelag.

0ye (1996:55-58) has, as for Finnmark totally, regressed harvest rate on herd size for South Trondelag/Hedmark for the period 1975-1994. The average harvest rate being 0.55, the author finds (1) a higher connection between harvest rate and herd size than for Finnmark (r^2= 0.39 vs. r^2 =0.2145), and (2) that the influence of other factors decrease with increasing herd size. This is the opposite of what is observed in Finnmark.

Summing up, the South development both herd size development, administration comments, and pasture surveys of the postwar period are indications that *there has been suboptimal resource use and insufficient herd control in the South area.* However, the stable development of the 1980's (see also 7.3) clearly demonstrates that the problems have been solved.

7.1.2. Income

The information about income levels some decades back is very sparse. A simple calculation of the average gross income[7] (e.g. operating income) per Guovdageaidnu herder household around 1960 (Lappefogden i Finnmark, 1959-1962) produces numbers of about NOK 70,000 (in 1990 prices) per year. Movinkel (1964:12) uses statistics of Finnmark herders' average net income

[7] Subsidies probably not included (if any they were very limited)

(return to labor and equity) estimates for taxation purposes for 1959 to show they in average earned NOK 35,000 (in 1990 prices) annually. This figure is slightly lower than the earnings of workers and peasant farmers, while officials' average wages were about three times higher.

The first extensive analysis of reindeer economics was conducted on the basis of 1976 production data (S0rland, 1978). Using standard assumptions of productivity and costs, the author constructed regional models for average net income per household.

Table 7.1. Production revenue and surplus 1976. Model calculations. In 1990 prices, NOK.

	Activity gross margin[1)], average per household	Return to labor and equity[2)], Average per household
West Finnmark	138,374	38,446
North Trøndelag	154,168	64,100
South Trøndelag/Hedmark	310,206	194,077

[1)]Operating income plus subsidies. [2)] Activity gross margin minus total operating costs.

Source: Sørland, 1978.

Comparing the Finnmark 1976 data with those of 1959-60, return to labor and equity are at the same level as the taxation data, while the gross numbers are nearly twice as high; indicating that both operating costs and subsidies have increased about similarly (in real prices) during these 16-17 years. In comparison between the regions, we note that the North Tr0ndelag gross margin are not so much higher than the Finnmark numbers, but have a clearly higher return. South Tr0ndelag/Hedmark have a gross margin the double of North Tr0ndelag and a return 3 times higher than its neighbor region.

Next we will consider the development in operating profit (operating income minus operating costs, subsidies not included) for the whole industry (Norway), presented in Table 7.2.

Table 7.2.Operating profit development for the whole reindeer industry 1976-1988. In 1990 prices, 1000 NOK.

Year	1976	1981	1982	1985	1987	1988
Operating income[1]	105,264	112,669	96,393	88,211	92,168	97,221
- Operating costs[2]	31,655	51,031	55,205	66,216	59,798	57,722
=Operating profit[3]	73,609	61,638	41,188	21,995	32,820	39,499
Op. Profit per management unit[4]	128	94	63	33	48	54

1)=Income from production, subsidies(except direct price support) not included, 2)fixed and variable costs, 3)=1 - 2, 4)=3) per MU (cf. 6.3.2)

Source: Karlstad, Hansen and Torvinen, 1990:133, cf. Økonomisk utvalg, 1976-1988.

For the 12-year period, we observe that total operating income decrease, but not much. The total

operating expenses seem to be established on a new level during the 1980's, though we should not rely too much on the single 1976 observation. As for total operating profit, the development is clearer: the trend is a very clear decrease.

Turning from totals to the allocated average to each household (management unit) we note that the reduction is even more considerable. The total numbers for the main measures, for the period 1975-94, are also depicted in Figure 7.8.

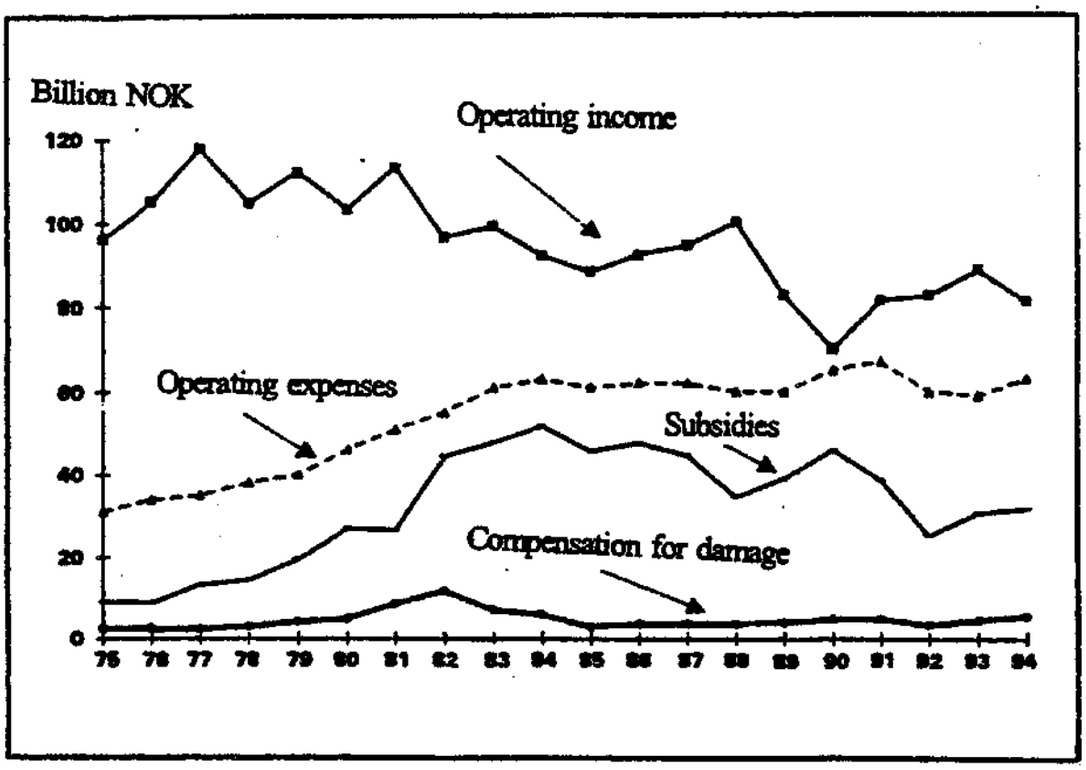


Figure 7.8. Main features of reindeer management total economy.In 1990prices, NOK. Source: Økonomisk utvalg, 1995:78.

Like in Table 7.2 we note, also in this figure, that as a result of decreasing operating income and increasing operating expenses; operating profit is generally decreasing.

Further the figure substantiates that subsidies increase considerably until the early 1980's and from then on perform a decreasing trend. The total effect of a simultaneous decrease in both operating profit and subsidies, from at least the late 1980's, is thus *a decreasing trend in return to labor and equity* for the rest of the period.

As we will see in the following, there were considerable differences in development between North and South during this period.

First, we look at the Finnmark development in Table 7.3.

Table 7.3. Total operating income, costs, profit, and per man-year operating profit for Finnmark (West Finnmark and East Finnmark) 1980-1992. In 1990-prices, 1000 NOK.

	1980	1982	1984	1986	1988	1990	1992
Operating income	71,019	56,837	59,688	57,523	55,367	35,077	47,893
-Operating costs	29,850	39,303	47,674	47,934	31,922	43,042	34,122
=Operating profit	41,169	17,533	12,014	9,589	23,445	-7,965	13,743
# man years[1]	473.5	475.1	529.6	565	580	937	885
Operating profit per man year	86.9	36.8	22.7	17.0	40.4	-8.5	15.5

1) a calculated standard man year of work contribution..

Source: 0konomisk utvalg (1980-1992).

Table 7.3 shows a decrease in operating income through the period, while operating expenses increase. The outcome is a clearly decreasing operating profit. A man-year, which is a computed measure for total workload, being positively correlated with total herd size, is doubled during the period. When *operating profit* is computed *per man-year,* the outcome is *a rather dramatic decline during the period.*

The corresponding numbers for Tr0ndelag are given in Table 7.4.

Table 7.4. Total operating income, expenses, profit, and per man-year operating profit for Trøndelag (North Trøndelag plus South Trøndelag/Hedmark) 1980-1992. In 1990-prices, 1000 NOK.

	1980	1982	1984	1986	1988	1990	1992
Operating income	14,356	18,563	14,563	15,325	12,395	20,762	20,396
-Operating costs	5,934	7,643	7,856	8,768	9,219	9,677	11,252
=Operating profits	8,422	10,920	6,707	6,577	3,176	11,085	9,144
# man-years	81.5	77.6	80.9	77	76	96	96
Operating profits per man-year	103.3	140.7	82.9	85.2	58.5	115.5	95.3

Source: Økonomisk utvalg (1980-1992).

The table shows a clearly contrasting pattern when compared to Table 7.3. Both operating income and operating expenses are increasing. The increases, however, level out each other, keeping operating profit on a relatively stable level. The man-years increase some during the period implying *a slight reduction in operating profit per man- year over time.* The direct comparable part of Tables 7.3 and 7.4 being the bottom line; we observe that *operating profit*

per man-year for the South is several times higher than for the North for most of the period.

In Table 7.5 we make a direct comparison of 1990 data for all Finnmark and Tr0ndelag regions, also including the subsidies and the return to labor and equity. In this table East Finnmark is divided into Karasjok (cf. Figure 7.2) and Polmak/Varanger which is to the East of Karasjok. This division is interesting because Polmak/Varanger has a pasture configuration unlike Guovdageaidnu and Karasjok, more alike Norway South of Finnmark; not having large second order commons.

Table 7.5 Totals for operating profit, subsidies, and returns. Returns per man year and management unit for Finnmark and Trondelag regions in 1990. In 1990-prices, 1000 NOK.

	Polmak/ Varanger	Karasjok	West Finnmark	North Trøndelag	South Trøndelag /Hedmark
Operating income	7,360	10,244	17,473	8,475	12,287
- Operating costs	6,780	9,927	26,335	4,464	5,213
=Operating profit	580	317	-8,862	4,011	7,074
+Subsidies	3,457	5,081	23,645	4,205	3,660
=Return to labor and equity	4,037	5,398	14,783	8,216	10,734
Per man-year	51.8	17.3	27.0	155.0	249.6
Per management unit	54.5	39	51.3	216.2	325.3

Source: Okonomisk utvalg, 1990.

The directly comparable part of Table 7.5 is the two lowest rows. *The returns both per man year and per management unit is many times lower for all three Finnmark (sub-) regions than for Trondelag.* While the Finnmark returns in average is low income, the Tr0ndelag herders in average earn good money.

With respect to the composition of the returns Tr0ndelag subsidies are at the same level as or lower than the operating profit, while in Finnmark the operating profits are many times higher than the low operating profits. We note that *NRL-chair Odd Erling Smuk's concern for zero operating profit* (cf. Chapter 1) seem to have good reasons, for all three Finnmark regions, both Tr0ndelag regions have high net surpluses.

A more extensive statistics would have made a more detailed analysis of the development patterns, sketched here, possible. However for making a general comparison of North and South development the above analysis is sufficient. Our general conclusion is that the data presented in this section indicate that *the Finnmark Sami on the average hardly can get a living of their industry, even heavily subsidized and that the South Sami on the average are well off.*

To consider how this CPR situation came into being we need to assess external factors.

7.2 External factors

We shall now turn to the external factors: market access, technological change and state regulations (cf. Figure 5.2).

7.2.1 Market access

It seems that self-sufficiency in Sámi society generally was very high up to at least about one century ago. There are several indications of increased meat sale and/or more used of purchased goods for various parts of Sapmi from that time on (Smith, 1938:293-294; Sara, 1993:67; Andresen, 1991; Falkenberg, 1985:21).

For the reindeer Sámi of Guovdageaidnu, the coastal market of Bossekop was important as a sales market of reindeer meat for a long time, up to the Second World War (Paine, 1994:110). The amount of meat delivered relative to herd size was limited by today's standards, about 1 1/2 kg per animal (Gjessing, 1954:62). In addition to markets, trading with private travelling merchants had become widespread.

In the post-war era, the first public undertaking for reindeer management as an industry was the building of a series of slaughterhouses, covering much of the Norwegian part of Sapmi. While these facilities in the South were simple sheds, the Guovdageaidnu (established 1954) and Karasjok ones were built as well-equipped cooperative firms. North herders probably faced better slaughter opportunities than South one's in the 1950-60's. It took time before the herders would use a slaughterhouse as their main option for slaughter.

One reason was that sales of reindeer on the hoof, which was a requirement, did not fit with most herders' own use of the meat and other reindeer products; sinews, fur, bone etc. for domestic and handicraft purposes. The herders preferred to sell parts of animals and keep some parts for own use (Paine, 1994).

The market access through slaughterhouses also involved cultural conflicts, as described by Paine (1994:131-138) for Guovdageaidnu in the 1960's. One example is complaints of reindeer being "butchered like a cow" and therefore of no uses for traditional handicrafts (because the furs then require a particular treatment) (op.cit: 138). This author has heard similar complaints in North Tr0ndelag as late as in the 1980's. Since 1959, public veterinarian control of reindeer meat has been compulsory, as for cattle. From 1967, the slaughterhouses in Karasjok and Guovdageaidnu established a cooperation with "Norges Kj0tt- og Fleskesentral" (The Norwegian Meat and Pork Central), NKF, which included marketing responsibility.

From 1968 on, NKF marketed 50 to 60 percent of all reindeer meat in Norway (S0rland, 1968). The long time trend is a clear increase in registered reindeer meat production and thus marketing in Norway, cf. Figure 7.9.

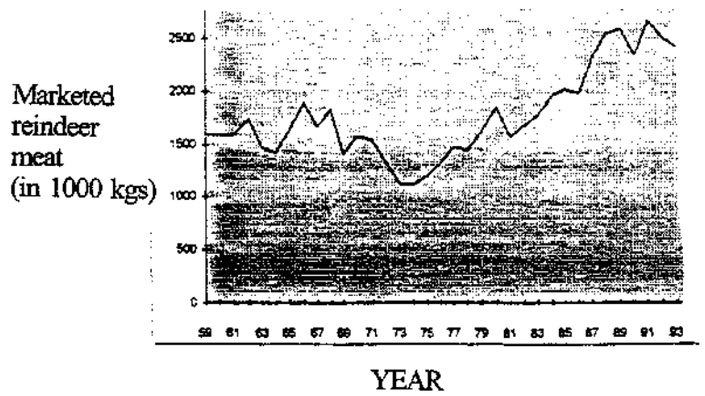


Figure 7.9. Marketed reindeer meat in Norway, 1959-1993.
Source: Holand, 1997.

The reason for the decline around 1970 is catastrophic losses of reindeer due to extreme climate and epidemic diseases (Kosmo, 1991:15).

The development of sales markets for meat provided the basis for an extensive use of imported technology. Generally we can consider market integration as a development process *from a subsistence production based on self-supply of most daily needs with limited cash sales to an industry oriented towards meat production and which purchases both production inputs and most everyday goods.* The Sámi reindeer management in Norway made major steps in this development process during the three decades we are studying.

7.2.2 Change in technological possibilities

In 3.3 we defined herding and husbandry technology and discussed how change in these technologies could influence the production system. Here we will introduce the relevant set of technologies imported from the 1960's and on.

7.2.2.1 Herding technology

Traditionally reindeer herding has been completely dependent on human and animal muscle power. The daily herding operations have been performed on foot - on skis during the winter - with the assistance of a trained dog and simple technology like binoculars and lasso. This continued down to the snowmobile revolution in the 1960's. Artificial borders like fences can assist herding, but use of such facilities did not become extensive before the postwar period, when the introduction of wire mesh and industrially produced poles gradually increased their use. In addition to "pure" herding technology, transportation technology is important, because these technologies overlap. It can also be difficult to distinguish clearly between herding and transportation tasks. Draft and pack reindeer, as well as castrated bulls, had important functions connected with shorter transportation, seasonal migrations, and transporting goods for trade (Ruong, 1982:77-81). Up to the Second World War draft reindeer were the only means of transport in the inner parts of Sapmi, and were also used by state officials.

The snowmobile introduced a revolution of both herding and transportation by means of motorization, implying extensive use of snowmobiles, motorcycles, cars, and other vehicles. The snowmobile typically used for herding (in winter) and also for light forms of transportation, became an option from the 1960's. Cars for person transportation became an option at about the same time (cf. Villmo, 1973). Around 1980 all-terrain-vehicles (ATVs) became another option, first as two-wheelers, but later also as four-wheelers. About at the same time, some herder groups started to use helicopters for collecting and steering animals into corrals.

In Finnmark and Troms, vessels of the Norwegian Navy have been used since the 1970's to transport reindeer herds to island and other summer pastures, which earlier required swimming the herd over fjords and sounds. Since the 1970's, trucks have to some extent been used for transportation of animals in specific cases, for instance, transport of yearlings during the spring move. Corrals are fence constructions where herds are gathered for particular purposes like calf marking or slaughtering. Corral construction has a long history, as they have been constructed from local natural materials. Corrals built with imported materials have expanded in the postwar period, particularly since the 1970's. In the South use of modern corral and fence constructions became particularly interesting relevant as they were relevant for a more intensive exploitation of the meat production potential of the reindeer herds; that is change in husbandry technology.

7.2.2.2. Husbandry technology

A part of the postwar external influence on Sámi reindeer management is the establishment of a bundle of *professional services:* research services, extension and planning services, and vocational school. From 1957 a research service, part of a State Veterinary Laboratory for North of Norway, had a contract with herders in L0dingen to conduct scientific research on their herd (Skjenneberg, 1960). Around 1960 also the question of *herd optimization* in reindeer herd management started to receive professional attention. According to consultant Wikman (1961:3) in the Swedish extension service, the first public discussion in Sweden of reindeer calf slaughter and herd optimization took place at course for herders in Jokkmokk, Northern Sweden in 1959. In 1960 a Sámi delegation went on a journey to Kola Peninsula, studying the conditions of the Sámi and their reindeer management. The editor of the herders journal, Anders Fjellheim (1960:3-4) reported that Russians were far ahead with respect to rational reindeer management and argued strongly for schooling, research, and extension services for reindeer management in Norway. One of the experiences from Kola was that one bull per 15-20 female reindeer was sufficient.

In 1968 the *State Reindeer Research* (SRR) was established with a research station in L0dingen and the veterinarian Sven Skjenneberg as its first leader. The list of young professionals working there in the late 1960's and early 1970's includes the husbandry scientist Dag Lenvik, the agricultural economist Ansgar Kosmo, and the veterinarian Paul Fjellheim. All three of them influenced the course of reindeer management considerably, particularly through the crucial 1970's, but also later, two of them mainly as advisers and the third mainly as an organization leader. Together with the adjacent *State School of Reindeer Management* (established in 1966) and the *State Consultant of Reindeer Management* in Troms0 (established 1969 and led by the former Lapp Sheriff of Nordland, the civil agronomist Loyd Villmo), the SRR became the *basis of biological research and extension service* for reindeer management in Norway until the establishment of the Agency of Reindeer Management in 1979.

7.2.3 State Regulation and Co-Management

Regulation encompasses both unilateral governmental regulation and bilateral relations between the governmental system and Sámi NGOs (non-governmental organizations). In this subchapter we continue the history of both, and also present the modern co-management arrangement founded in the 1970's and implemented in the 1980's. Before we focus the development of the institutional arrangement, we need a brief look at the herder organizations further history (cf. 6.3).

7.2.3.1 The herder organization

In the late 1960's, about 20 years after its foundation, NRL finally became well established with a relatively stable and well-functioning board and a paid secretary post (Berg, 1997). This took place under the chairmanship of Paul Fjellheim (1965-1973, deputy chairman 1973-1977). During this period, much of the organization work was "a silent diplomacy" directed towards the central government and supported by professionals in the research and extension service. From the 1970's on, protecting land and pastures from different kinds of modern societal encroachments, such as hydro-electricity development, military training fields, mining and modern mass tourism caused increasing problems for the reindeer management and the Sámi in general. These involved fundamental property rights issues. The late 1970's and the early 1980's became a very eventful time, with much focus on Sámi political and property rights as an indigenous people. The NRL found its role as an organization, on the one the hand, fighting for Sámi rights, and, on the other hand, working to develop reindeer management in cooperation with the State and its officials.

We proceed by studying how the 1978-act of reindeer management was derived.

7.2.3.2 Law regulation

As we mentioned in Chapter 6 a public committee had proposed reforms to improve the conditions for the Sámi. These included a revision of the Act of Reindeer Management from 1933, which was considered obsolete[8]. A special committee, established 1960, developed a proposal (Reindriftslovkomiteen, 1967), but Sámi property right claims were controversial in relation to agriculture, which was used to be superior in rights. It took a couple of decades before the new law, after many changes, finally was adopted (1978) and set in force (1979).

Constitutional-choice rights

Our presentation of the traditional Sámi Herder Society in 6.2 is a document of a livelihood with culturally inherent institutions mainly having a sufficient capacity of coordination. The governmental regulation efforts described in 6.3 had the interests of the expanding non-Sámi

[8] Most of the principles in the 1933 Act are found in its predecessors of 1883 and 1897.

population as motivation and thus had regulation of herder-farmer relations as their main concern. However, as we pointed to in 6.4; this created a major *de facto/de jure deviation.* As we will see below, the 1978-act had clear *ambitions of regulating internal herder relations;* in some respects this act would have more far-reaching implications than its predecessors. This clearly involves constitutional-choice questions (cf. Figure 2.10); what is the correct procedure for change in collective-choice rules? Moreover the ultimate question is; *who is in the position of defining the collective-choice rules for the Sami herder society?* For the Norwegian governmental authorities the answer was obvious; the 1978 law revision followed standard Norwegian legislative procedure, and the herders organization NRL was considered as nothing more than a party among others. The Sâmi were still weak politically; the Sâmi Parliament did not become established before 1989, and NRL then had to do its best to influence the outcome of the revision. For the Sâmi it nevertheless would be important that a new set of collective-choice rules of reindeer management had to be anchored in the traditional basic regulatory principles to earn legitimacy among the members of the society. If not, rules become rules-in-form instead of rules-in-use, and the governing system established will operate with a lower capacity for coordination than intended. Basic property rights became the main issues in the law preparation work.

Property rights for the group

The law committee[9] (Reindriftslovkomiteen, 1967:54) included a provision in their proposal of bill that the basis of the property rights was *long time use and customary rights.* The Ministry of Agriculture, however, asserted that Sâmi reindeer management did not have any other property rights than those expressed by law:

> "Which property rights that at any time should be ascribed to the reindeer industry, have to be decided on the basis of an assessment of the interests of contiguous industries and total social interests." (Landbruksdepartementet, 1976a: 42, my translation)

Unambiguously, the ministry considered *the dissemination of the property rights of the reindeer managing Sami in Norway to be a question which Norwegian political authorities had the full competence to decide.* NRL, protested energetically against both the Ministry's understanding of history and the view that their property rights had no basis outside legislation from Stortinget; using scientific evidence as support. As a compromise; the Act, in the end, did not take a stand on the basis of reindeer management property rights. On the arena of jurisprudence, the ministry's view on property rights dominated during the late 1950's, but in 1968 Sâmi RPDs won two cases in the Norwegian Supreme Court (Arnesen, 1978, cf. Bull, 1997). This became a turning point, as Sâmi reindeer management property rights from then have been fully recognized and herders can claim full compensation for encroachments. Table 7.6 gives an overview of regulations in the acts of 1933, included for comparison, and 1978. The table starts with property rights for the group (vs. other industries and users). The principle of reindeer pasture districts (RPDs)[10] is kept unchanged in both laws. A RPD may be the area of one or two siidas, or part of a siida, but there are also large RPDs, which encompass several siidas.

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[9] The before introduced Anders Fjellheim played an important role.

[10] introduced in the South by the 1883 law and in the North by the 1897 law (cf. 6.3.2)

Table 7.6. Property rights regulations in the Acts of Reindeer Management 1933 and 1978.

		1933 Act (also the Acts of 1883 and 1897)	1978 Act	
Property rights for the group	Outside RPDs	no property	No property	
	Inside RPDs	Authorized users	Authorized users vs. agriculture	
			(full co-owners vs. other industries[1])	
Operational choice rights	Access (entry)	Duty of marking animals.	Duty of marking animals	
			Management unit (MU)	
	Withdrawal	Seasonal pasture use regulations and allocation into RPDs	Seasonal pasture use regulations and allocation into RPDs	
		Authority of herd size limitations	Authority of herd size limitations	per RPD
				per MU
Collective choice rights	Management	(RPD trustee)	RPD Board and Annual meeting	
		Sheriff allocating pastures	Regional Board	
	Exclusion		Regional Board	

[1] not explicitly in the law regulations but determined by Supreme Court decisions from 1968 on

RPD= Reindeer Pasture District, MU= Management Unit

What is remarkable is that these acts[11] do not at all take siida into consideration as a notion (Bull, 1997). The original establishment of RPDs was due to the interests of farmers and their need of knowing where to address claims of alleged damage on agricultural lands from pasturing reindeer (Severinsen, 1979). However, in the two decades since 1980 much effort has been invested in adapting the framing of RPDs to the needs of the reindeer herders, and progress has been made.

Sámi reindeer managers have, even today, no rights outside the RPDs. All conduct of reindeer management outside *Sámi reindeer pasture area* (cf. Chapter 6) is (still) conditioned upon owner-allowances and governmental recognition in each case. Inside the RPDs, the laws did not provide reindeer management significant legal protection either. On the contrary the main purpose of legislation has been to protect agriculture against problems from reindeer management by imposing collective liability for damages to agricultural pasture[12]. Even agronomically the 1933 Act was outdated already at the time it was passed. During the 20th century the real resource competition between the two industries was reduced to a minimum up until the 1970's as the agriculture use of free range mountain pasturing decreased considerably (cf. Lenvik 1979:6). Bull (1997:122), however, establishes that these regulations in fact were made more rigorous by the 1978 Act.

Operational choice rights (Access and withdrawal)

Regulation of operational rights is extended from the 1933 to the 1978 Act. With respect to *access* conditions, the duty of marking animals is mainly a codification of an established customary practice. All earmarked reindeer must belong to an RPD. What is new in the 1978 Act is the establishment of the institution of *the Management Unit* [13](MU), a formalization of the *household* unit. The MU is a herd with a responsible leader. All reindeer must belong to a MU, which is the *de jure* institution responsible for the herd management. The intention was to establish *a formally responsible base unit in order to regulate both entry and withdrawal,* to provide opportunity for tightening the weak points in the traditional regime (cf. 6.2). NRL supported the MU establishment in its pronouncement to the act proposal. However, after implementation criticism has come from within the Sámi society; the institution deviates from tradition and is a copy of a similar institution in Norwegian agriculture (which both is correct).

Finnmark reindeer management became *seasonally regulated* in the second part of the 19th century, and a more extensive regulation of summer RPDs was implemented in Finnmark in 1934 on basis of the 1933 Act. Legal season regulations are implemented, but no further allocation of winter, spring, and fall pastures, that is they are kept as second-order commons, used by many groups in common. (Sara, Haetta, and Rushfeldt, 1994). For Norway south of Finnmark, RPDs with seasonal regulation had been established from before the turn of the century.

A clause of *herd size limitations* was included in the 1933 Act, but it hardly seems to have been used in practice. I have not found or heard of any examples. Sara (1996:37) provides this characteristics of the era the 1933 Act was in force: *"Reindeer management functions mostly*

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11 One minor exception is that the 1994-revison of the 1978-act mentions siida in one paragraph (cf. Bull, 1997)

12 since the 1883 Act(cf. 6.3.2)

13 No: driftsenhet

autonomously within the outer frame set by national borders and land use pattern" (my translation, JÅR).

In the preliminary works and statements about the 1978 Act (Landbruksdepartementet, 1976a) it is clear that *access and withdrawal limitations were considered necessary by many,* e.g., by governmental officials. Simplified, the picture of the situation in Finnmark in the 1960's and 1970's might be summarized under the headline: "Too much reindeer and too many herders - more regulations are necessary."

The herders' organization, NRL, which was critical to other aspects of the law, also supported access and herd size limitations (ibid.: 22). The law committee had recommended rules of herd size limitations both per RPD and per MU, but proposed that the authority be administered by a new internal board (cf. below), consisting of herder representatives only, covering a limited number of RPDs (Reindriftslovkomiteen, 1967:33). The 1978-act imposed a duty to regulate maximum herd size per RPD, and maximum herd size per MU also can be regulated (cf. Table 7.6). These regulation tasks became an important part of the responsibilities of the new administration and the new boards established (see below). The success of herd size regulations were regionally variable. Simplified; in the South the regulations mainly were accepted and adapted to, while in the North it became difficult to establish regulations that meant real herd size reductions.

Collective choice rights (Management and exclusion)

From Chapter 6 we remember that there was established a position as elected RPD *trustee* in the 1883 act to serve as an external go-between, for the government and, for example, farmers. This position did not compete with the functions of the traditional group leader, siida-isit, as the internal domain was not affected. The 1978 act introduced the RPD board elected by an annual meeting of active and registered herders within the RPD. The law committee (Reindriftslovkomiteen, 1967:19) argued that *the traditional institution of an authoritative siida-isit had disappeared and that there was a need for new collective bodies both for internal government and external representation.* The committee proposed to establish internal boards, altogether 10-15 boards, elected among the herders themselves, covering all Sámi reindeer management in Norway. *The motivation was to achieve a highest possible degree of self-governance in the reindeer industry* (op. cit: 31).

The ministry's answer to this challenge, which also became the final decision by the Parliament, deviated from the committee proposal and was rather far-reaching. *The reindeer pasture district (RPD) was reorganized and a double function was imposed: (1) to represent the local reindeer herder collective, partly replacing the siida, through an elected chairman and board, and (2) to administer control tasks for the state.* In practice the herders have found solutions adapted to their practical situation. Generally the regulatory principles of Chapter 6 is basis for herder interaction
In addition, *public boards with decisive authority were established on two levels, regionally and centrally.* The boards have had a majority of herder representatives, but all representatives were appointed by the respective county parliaments, i.e., for the central board, the ministry made the appointments (cf. Riseth, 1992:11: 21-24).

To consider the full impact of the establishment of this system of bodies, we also need to

inspect the *civil servant* side. The Lapp Sheriff position was a typical middleman role, leaving to the holder some freedom of choice to conduct their role as a patron or as a broker, though governmental directives clearly imposed them a guardian role. The new generation of Lapp Sheriffs from the 1960's and 1970's consisted of professional agronomists, not policemen. As a part of the 1978 law revision, a new administrative structure also was established. This included a change in the Lapp Sheriff position, to become an *agronomist of reindeer management* operating an extension service, in addition to serving as a secretary for the regional Area Board ("Områdestyret"). In addition, a new and central State Agency was established. The Agency of Reindeer Management (RA), which operates on behalf of the Ministry of Agriculture (LD) and supervised the agronomists, had both professional and administrative duties as a secretariat for the Central board ("Reindriftsstyret"). The professionals in the public reindeer management system serve double roles as advisers and government officers. The new institutions, cf. Table 7.7, were implemented in 1979 and 1980 and are still working.

Table 7.7 Political and administrative governing bodies based on the 1978 Act

POLITICAL RESPONSIBLE BODIES	ADMINISTRATIVE EXECUTIVE BODIES
The Cabinet of Norway	The Ministry of Agriculture (LD) The Office of Reindeer Management
The Central Board of Reindeer Management	The Central Agency of Reindeer Management (RA)
The Area Board of Reindeer Management	The Agronomist of Reindeer Management[1)]
The Reindeer Pasturing District Board	The Reindeer Pasturing District Executive[2)]

1) former Lapp Sheriff 2) under state instruction in state affairs, not as representative for the herders in his RPD. The political responsible bodies have authority to decide in cases, prepared by the administrative executive bodies at same level, specified by the law. The administrative bodies have power of instruction vertically.

In an overall comparison, the main goal of the 1933 Act and its predecessors was clearly the regulation of reindeer herd management versus external interests, mainly agriculture, while the 1978 Act had ambitions of regulating the internal relationships of reindeer management. Including a *de jure/de facto* perspective, we find that *while Sami reindeer herders in 1960 faced a rule by civil servants, having limited control and contact tasks. In the 1980's they faced collective choice arenas, participating as representatives in an integrated administrative and political governing system being a part of the total Norwegian State Hierarchy.*

Extensive external judicial regulation clearly affects the internal collective choice arenas of Sámi reindeer management. Recalling the intentions of the law committee, it is clear that the new institutional arrangement aimed to strengthen the governance of reindeer management, but whether the degree of *self-governance* increased is more ambiguous. The ministry said in its remarks to the law proposition (Landbruksdepartementet, 1976b: 55-56) that the establishment of the RPD Board would:

> "give a good starting point for increased activity and internal self-governance for the reindeer managers and, together with the proposed regional boards, give a basis for increased influence." My translation, JAR)

On the other hand, Paine (1994:139-200) uses the main heading "pastoralism by authorization"

to characterize the public policy of the 1980's, arguing that the key process "is the placing of an ethnically distinct livelihood under state license (op. cit; 141)".

We may let these two contradicting positions stand preliminarily uncommented and return to them at a later point. In the following section we will study the direct bilateral part of the government organization relation.

7.23.3 The Main Agreement for the Reindeer Industry

In 1976 the Ministry of Agriculture and NRL signed *The Main Agreement for the Reindeer Industry*. The parties agreed upon the following explicit political objectives for the Sámi reindeer management, cf. Table 7.8.

Table 7.8. Objectives of The Main Agreement for the Reindeer Industry

(1) Production	Optimizing meat production and sustaining the natural resource base
(2) Income	Securing the practitioners an income and a living standard at the same level as other occupational groups
(3) Allocation	Allocating total income in a way providing occupational security
(4) Culture	Developing reindeer management as a sustained basis for Sámi culture

Source: Landbruksdepartementet, 1976b.

The Main Agreement institutes negotiations on economic actions to promote industrial development. *The Main Agreement is thus the formal constitutional basis of a new co-management system.*

The concrete actions are decided in biannual short-time agreements, while the negotiations are conducted annually. *The Reindeer Management Negotiations were established as a new collective choice arena from 1977.* The Ministry of Agriculture (Landbruksdepartementet, LD) and the Association (Norske Reindriftssamers Landsforening, NRL) are the formal parts of the Agreement while the Agency (Reindriftsadministrasjonen, RA) is the Ministry's adviser and executor of the outcome of the annual negotiations. Based on the annual negotiations, rules for different subsidy arrangements are designed. The parties established a *development fund* governed by a board which administered funding for planned development actions both from individual herders and RPDs. Firms in the reindeer slaughter business, research and extension projects have also received considerable contributions. Specific subsidy arrangements were made to promote for example increased production, RPD cooperation; investments in necessary fencing facilities. To achieve some particular subsidies, general preconditions were included in the rules, e.g., to fulfil a so-called *slaughter requirement* equal to a calculated annual production. The rules of the Reindeer Management Agreements thus become *operational rules;* in the sense *"if you do not adapt to this rule you do not receive your intended portion of this pot of money ".*

The reindeer management agreement meant relative large amounts of money into a society that had lived rather close to self-sufficiency. In 1980 the agreement encompassed 10 mill NOK.

This increased during the 1980's to reach a level at about 80 mill NOK. Even though a considerable portion of this was used for research, extension services, slaughtering firms, marketing, fence and corral facilities, the amount of money transferred to families nevertheless have been relatively considerable, affecting about 2,000 people. Thus this money and the rules attached obviously had the potential of becoming a forceful factor influencing the herders' resource adaptations.

The implementation of the 1978 Act institutions and the development of The Agreement of Reindeer Management went on in parallel during the 1980's. Beyond the formal requirements of the agreement a pattern of extended organization-government cooperation was established.[14] The most important policy decisions within the sector were in reality made jointly by the leading state officials and the herders' elected leaders. Thus the reindeer herders during the 1980's managed to have considerable influence on public sector policy by means of their organization, NRL (Riseth, 1992). This author has been participating as a guest at a number of NRL's annual meetings during the 1980's. One interesting observation was a gradual change in the direction of much of the criticism expressed from the delegates; early in the period the criticism was clearly directed towards governmental authorities. Late in the period it was to a considerable degree directed towards the government and the organization leadership in common (cf. Riseth, 1992:II; 72,137). This is an indication that the members recognized the two parties, to an increasing degree, as *a common locus of power*. This is also in accordance with the Ministry view of the 1980's; LD and NRL should conduct a common policy (Arnesen, pers. comm.). This author also has observed clearly approaching general attitudes at the top level during the period. The total institutional arrangement facing the Sami reindeer herders in Norway from the 1980's on thus has three main elements: (1) the traditional, (2) the legally based, and (3) the Agreement based. The total pattern of rules is thus rather complex. Recalling Ostrom's (1990:90) design principles in Chapter 2 we remember that the creation of an *internal autonomous collective level* under the ultimate control of the appropriators themselves was an important aspect for long-enduring CPR-institutions.

We have during the 1980's observed a rapprochement between industry and government. *The crucial point seems to be whether this rapprochement has had a sufficient support in an internal collective level. If not, the new external rules would not have sufficient legitimacy, and would be in conflict with the traditional system.* The possibility is open that the new regulations more or less became rules-in-form; instead of rules-in-use. Also taking into consideration the different aspects of modernization and the requirement of a total fit between the attributes of the physical world and the institutional system, we would generally expect a diversity of outcomes for different regions of Sapmi with their diversity of geography and history.

7.3 Production systems

7.3.1 General

The history of reindeer production systems follow to some extent a common pattern from (1)

14 Note that this cooperation system was well established before the establishment of the Saami Parliament in 1989 took the first step towards Sámi autonomy within Norway.

decoy animals used to trap wild reindeer, to (2) an expansive reindeer pastoralism breaking up the hunting society, via (3) a more or less stable combined milk and meat pastoralism, then (4) abandoning the milking part exposed to external /internal pressure, (5) family winter settlement, and at last several steps of (6) motorization and (7) herd recomposing. Regional variance in sequence and significance of the different steps is important for our analysis.

In chapter 6 we followed the production system development up to the 1960's. Here we will focus two major transformations in the production system: (1) *the snowmobile revolution* and (2) *the revolution of herd productivity*.

7.3.2 The revolution of herd control

We have introduced the new devices of herding technology in Chapter 3. What created a particular dynamic impetus was the snowmobile as also focused in chapter 1.

7.3.2.1 The snowmobile revolution

The modern technical revolution of reindeer management started by the introduction of the snowmobile in the 1960's. We will now see how the increase in herd control ability developed.

Paine (1994:145) tells that in 1961 a salesman had to leave Guovdageaidnu without a sale of the first snowmobile. Nilsen and Mosli (1994:90-91) report that some of the first snowmobiles were bought in 1965, while in 1969 95% of the Guovdageaidnu herders purchased a snowmobile financed by conversion of animal capital. That is; they have found indications that total herd size were reduced for some years due to the major investment in the new vehicles. Their informants have a twofold explanation for the procurement: (1) facilitating the herding work and (2) the possibility of increasing the time together with the family at winter. Family winter settlement (cf. further in Chapter 8) meant that the adult men lived alone in their *lavvos* (herder tents) watching the herd. Paine (1994) explains that the advantage in mobility would leave any no-user without a competitive edge versus a user (cf. Riseth, 1987), for example when collecting the herd. In our terminology this is a *technological externality* (cf. Table 3.7).

Anders Fjellheim and partners (cf. Chapter 6) managed to solve their first challenge: keeping sufficient control over the united herd. By means of the snowmobiles they had procured in 1964, they managed the 1966 reunion with a much less controlled herd (Anders Fjellheim, pers. com.). Reading the annual reports of the Lapp Sheriff of North Tr0ndelag we get a glimpse of how the snowmobile use by herders on the Swedish side promote the introduction on the Norwegian side.

> "The Swedes (interpret: Swedish Sámi) to a large extent use snowmobiles in reindeer management. By this mechanized vehicle they also (they already had in summer) in winter-time have much greater opportunities to gather and bring back reindeer from Norwegian side, irrespective of how the herds are mixed ", (Lappefogden i Nord-Tr0ndelag, 1963:6), my translation JÅR.

Already next year we can note the response:

> "Most Swedish reindeer-owners have obtained snowmobiles. The Norwegian reindeer-owners have also

> realized that they in fact are helpless (becoming to slow) towards the Swedish reindeer -owners, if they do not have a snowmobile. It is therefore several who have obtained snowmobile, and others sure will follow suit", my translation, JÅR, (Lappefogden i Nord-Tr0ndelag, 1964:9).

My South informants also generally approved the two reasons for snowmobile procurement set forth by the North herders. Paine (1994:145) provides references to similar rapid introduction and expansion across Northern Fennoscandia, as Moran (1982:132) does for the whole circumpolar area. So far we generally note that *the snowmobile in the mid- to late- 1960's resolved both a dilemma of control and a social dilemma.*

Seen in relation to the need for coordination the snowmobile revolution had a double effect. The most apparent is the *considerable increase in control ability*. The other effect is a function of the first one: a *qualitatively new expansion potential* insofar as every herder now can control a herd, and a larger herd, much easier than before. The physical limitations on expansion possibility are thus considerably reduced. Whether expansion actually becomes realized depends on which strategy the herders choose to cover cost increase — if they managed. Reindeer management consultant Villmo (1968:5) asserted, for example, that for most small owners the annual operation costs of the snowmobiles were greater than the owners' annual income. This is in line with our theoretic assumption that winter herding technology does not increase revenue. The experience in Finland also was that increased cost by transition to snowmobiles among reindeer herding Sámi caused as well reduced total herd size and reduced number of herders (Pelto 1973, Moran 1982).

Moreover the general effect upon the need of coordination seems, in the first instance, to have been similar in both regions we are comparing. However, due to open landscapes, there were still control dilemmas left in both regions which left room for further increase in the use of new technology.

7.3.2.2 Fences and more vehicles

We have registered that both bar fences and corrals made their gradual appearance in the North reindeer management from the 1950's on. Openness towards Sweden was a case of concern for South Sámi during great parts of the 20th century. They are also widely reflected in the files of the local administrations (Lappefogden i Nord-Tr0ndelag, 1963). One of the outcomes of the Swedish-Norwegian Convention revision in 1972 was the erection of a National border bar fence on parts of the border where reindeer trespassing usually had taken place. Later in the 1980's some difficult internal South borders also have been improved. Generally, facilities as corrals for separation and harvest also became common, particularly as subsidies from the Agreement of Reindeer Management became extensive from the early 1980's.

Cars became increasingly usual during the 1970's in both regions. In addition to ordinary cars vans and trucks also became usual for particular purposes. In some Finnmark districts, weak animals as yearlings could travel by truck as an alternative to ordinary spring migrations. In the South, some districts started to conduct fall migrations by truck. The all-terrain-vehicles, ATVs, spread swiftly, mainly and first in Finnmark and other rather flat areas. In the Tr0ndelags some herders have started to use ATVs in the 1990's. Some districts from the 1980's on also started to hire helicopters for use under gathering of the herd for autumn harvest.

Generally the snowmobile revolution from the mid-1960's on started a process of increased use of technical and motorized facilities and during a couple of decades *eliminated the reindeer herders traditional dependence upon human and animal muscle power* to a baffling great extent. Even though the level of use of these facilities vary across Sapmi the process is the same and it has at least two major consequences: (1) a heavily increased capability to control the animals, and (2) a heavily increased cost level. These general features are characteristics for both regions we are studying (cf. Table 7.2 and Figure 7.8). In our next section, we will turn to the husbandry side and examine what the increased control in herding meant to the utilization of the herd growth potential.

7.3.3 The revolution of herd productivity

The snowmobile revolution encompassed that some of the traditional use of old bulls (draft and lead animal) became superfluous. Increased costs from the procurement and operation of snowmobiles introduced a drive to increase income. We have earlier focused on the questions of how to achieve a higher income. If the herders' choice was to increase meat production, one of the options was Strategy A, which is based upon herd restructuring.

Our most distinguished researcher on reindeer herd productivity, Dag Lenvik, have during three decades advanced an approach of combining traditional and scientific knowledge of herd composition (Lenvik and Trandem, 1991:191). He points out the L0dingen (South Troms) herder Trygve Andersen as a traditional master saying "Clear "useless reindeer" out of the herd" (Lenvik, 1991:42; my translation). By "useless reindeer" he meant animals, which had low propensity to survive and non-pregnant female reindeer. Consultant Sven Skjenneberg also advanced the similar point of view early (Skjenneberg, 1960).

Some Sámi herders discovered the potential of slaughtering young animals a long time before any professional gave their advice. My former colleague Mats Steinfjell, in his youth a herder of East Namdal, North Trondelag told me (Steinfjell, pers.com.) about the husbandry practice of his relatives Marja and Johan Bendiksen, Fosen RPD, North Tr0ndelag.

> "They were well-off and had a traditional herd structure with a high portion bulls. Getting older they had decreasing control and were starting to wind down their work as herders. They began slaughtering down old bulls and discovered that they received as much calves as before. They practiced this way for about a decade, probably in the 1930's and 1940's.The district has continued to have young animals as their main group of harvest up to modern time."

The Fosen practice seems to have been known, at least to some extent, over parts of the South. One herder from Riast/Hylling, explains to Elgvin (1993:125):

> "It is from Fosen the idea of calf slaughter first comes. In North Fosen they had slaughtered calves in a whole generation already" (my translation, JÅR).

In his 1950 annual report the Lapp Sheriff for South Tr0ndelag/Hedmark wrote (Hansen, 1997:137, my translation, JÅR):

> "From a reindeer management point of view it is senseless to slaughter calves, but that was actually done" (my translation, JÅR).

The interpretation of this is that the Lapp Sheriff actually did not understand the rationale of calf-slaughter (he was a policeman). In 1957 the same Lapp Sheriff wrote in his annual report (Hansen, 1997:137)

> "Castration of reindeer is not extensive in my district. The Sámi leave the bull calves until they are 1 1/2 year old, and then slaughter the bulk. The remaining bulls are used for breeding. The reindeer herds consist mostly of females and young animals, and the growth is thus very high"(my translation, JÅR).

Obviously the Lapp Sheriff now had finally understood what is all was about.

In an annual report from the State Reindeer Research (cf. 7.2) the preliminary result was that normal pregnancy was achieved by use of 1 1/2 year old bulls as stud animals conditioned good pastures (Skjenneberg, 1962). A few years later the veterinarian Sven Skjenneberg published a book (1965:300) reporting that female reindeer now constituted 74% of the research herd and *recommended calf slaughter to save winter pastures*. We should however note that the researchers took some reservations whether the growth potential in Finnmark reindeer management was high enough to recommend calf slaughter. A similar book published in Sweden gave corresponding recommendations (Persson, 1966;144-146).

Calf-slaughter was stimulated by a particular subsidy, from the first Reindeer Management Agreement implemented 1977. The development with respect to herd restructuring still became very different in the two regions we are comparing.

7.3.3.1 North - The stagnated revolution

There have been clear changes in the sex and age structure in Guovdageaidnu herds from the 1960's up to our time. The social scientist Johan Klemet H. Kalstad (1997:123-124) uses the Oarjebealli (Western zone)[15] herder Elian Ante as an example of a respected herder that in the 1960's followed a combined strategy; (1) keeping a productive herd, calf giving does in a good condition, (2) while slaughtering adult bulls. Kalstad (op. cit.) explains that this strategy was rational as long as pasture was in excess. In other words, he could afford a traditional strategy. Robert Paines (1994:99-102) observations of different Guovdageaidnu slaughter strategies in 1962 (cf. Table 6.1) are in line with this. In the 1970's and the 1980's Elian Ante changed to slaughtering young bulls (varit) thus exploiting more intensively the biological growth capacity of the herd. This is consistent with our theoretical point that when costs are increasing and pastures become scarcer, this type of development will be promoted. Elian Antes change in strategy seems to be typical of many Guovdageaidnu herders. Thus *in the 1980's, varit seem to have become the main animal category for slaughter*. However exceptions existed, I remember that my landlord in Alta, a Guovdajohtelitt (Medium zone) island herder in the early 1980's still stuck to traditional bull-slaughter as his main option.

Going further from Elian Antes strategy would mean to implement calf-slaughter. Both the State Consultant and the State Reindeer Research conducted extension and research service in Finnmark in the 1970's. Loyd Villmo's far-reaching contribution includes extension journal and extension projects for selected Finnmark siidas. The responsibility for the undertakings of these

[15] cf. Figure 7.1

two pioneering institutions was transferred to the Agency of Reindeer Management ("Reindriftsadministrasjonen") in Alta when it was established. However, calf slaughter became no success in West Finnmark. The statistics prove the failure of the extension services. In spite of the subsidy arrangement, the West Finnmark increase in the proportion of calf-slaughter to total-slaughters showed a very modest increase 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 level below 20% in 1993-1994, is the result of an extra herd reduction subsidy for the peak years (Reindriftsforvaltningen, 1995:25-27).

However, the general development in herd restructuring, which Elian Ante exemplified, continued. The number of does, about 55% in the period 1975-1980, increased during the 1980's and passed 60% in 1986 reaching a peak at 70.6% in 1991 and then decreasing down to 65% in 1996 (Lappefogden i Vest-Finnmark 1970-79, Reindriftsadministrasjonen 1980 and 1988; Reindriftsforvaltningen 1995 and 1996). *The rapid herd increase, from the midst of the l970's, seems; however, to have obstructed the potential for converting the increased doe percentage into increased productivity.* When we find no increased productivity that can be the result of a general decrease in physiological status due to poorer pasture conditions. Generally the meat production per animal in spring herd is a measure for herd productivity. Table 7.9 expresses that the productivity has been rather stable over two decades.

Table 7.9. Meat production per animal in spring herd (April, 1). West Finnmark

	1976	1984	1987/88	1993/94
West Finnmark	7.8 kg	8.9 kg	7.0 kg	8 kg

Source: Kosmo, 1991:20 and Reindriftsforvaltningen, 1995:38.

1976 1984 1987/88 1993/94
8.9" kg 7.0 kg 8 kg
Source: Kosmo, 1991:20 and Reindriftsforvaltningen, 1995:38.

Some of my personal experience may also illuminate the challenge for the extension service. From my first year in the Agency of Reindeer Management, 1980, I took part in an extension project which had the clear intention of promoting herd reduction in a particular siida, let us name it "Island siida". The Central Board («Reindriftsstyret») requested a considerable herd reduction. This was due to overgrazing and a conflict with external interests. A new fence and corral-system was built, funded by the Agreement of Reindeer Management. The herders conducted their fall-slaughter and, as a part of the contract agency people weighed the calves and provided a statistic to the herders. The rationale was that when the herders saw in writing the low weights of the calves they would realize that the herd size really was to high and that they would then decide to change their herd structure and cull the lightest calves.

The project went on for some years. One of my colleagues put much effort in counting the herd and its composition at winter too, and provided an excellent statistics and recommendations over how they could increase their output by a reduced herd size. However, making the decision about the sample for harvest belongs to the domain of every husbander as a principal. It became clear that the herd size was not decreasing significantly and calf-slaughter was limited. My colleague asked siida-isit why. His answer was clear enough: "We just cannot. Our siida would become nothing". In other words: *What really counted was keeping a large herd* (cf. Strategy B).

In retrospect it is easy to see that the Agency recommendation failed because it assumed that the herders of this particular siida wished to maximize income. Maybe the recommendations would

have been counter-productive - it is not difficult to imagine that another herd would have moved into the siida's area (on second order commons) if Island siida had decreased their herd size. In other words, knowledge of biology and economics is not always sufficient to provide relevant extension services. Broad knowledge and understanding of the institutional setting, or *time-and-place information* (von Hayek, 1945) may also be necessary.

The further increase in level of herd optimization seems to be blocked by the institutional setting as indicated by the above extension service example from Island siida. One part of this setting is expressed in the herders' traditional criteria for selection of life reindeer. Usually a Guovdageaidnu herder performs an assessment of two sets of attributes for a reindeer, which is either to live or to get slaughtered: (1) behavior as an individual and in the herd, and (2) appearance (different aspects of fur, size and antlers). For example, easy recognizable animals are important when collecting animals, since they can serve as indicators of whether different segments of an owners total herd is included in a herd considered at some distance (Oskal, 1997:159-162). This has two obvious implications: (a) that such types of selection criteria may conflict with increased productivity, considered for itself, and that (b) their importance will be relatively high for control in an open landscape.

In addition a potential transition to calf-slaughter may also have been blocked by arguments of biology and economics too. Recalling that enhanced productivity was conditioned upon the does' physiological status, which was negatively influenced by herd expansion. Thus high herd productivity will be conditioned both biologically on herd size limitation and institutionally upon a setting of efficient control. That is, it seems as the herders have had a too low level of control in the period with herd expansion to try to play the game of Assurance. Prisoner's Dilemma has probably looked safer, even though at the cost of the lichen pastures. In spite of this, we have to recognize that the diversity within West Finnmark is considerable; one of the neighboring districts of Island siida has in the 1990's established sufficient control to perform calf-slaughter as a profitable option, without the support of the specific subsidy.

7.3.3.2. South - The completed revolution

We provided elements of the prehistory of organized calf-slaughter, as we know it from Tr0ndelag. Another example is from is from the northernmost South Sámi at Helgeland. My interviewee "Aslak" (born 1945) from "Coastland" RPD started reindeer management in 1970. His district started to transport the herd to the islands for winter pasture by boat and had no need for the bulls under migration. The transportation costs were reduced when they had production animals (female and young animal) only. The gain in this adaptation was good without any special prices or subsidies and it was practiced over a number of years.

Mountain RPD regained control over their herd management in the early 1970's by technical means and by eliminating old bulls, in effect a beginning herd restructuring. The district went through a generation shift in these years, and the young, which now established were about same age and developed their strategy for the future through discussions over time. A pasture capacity assessment was conducted (Lyftingsmo, 1974) and they agreed upon that they wanted to be relatively many households and that they had to limit both total and individual herd size. In the early 1970's calf-slaughter was not discussed, but they made the same experience as at Fosen one generation earlier; the old bulls were not a precondition for a high calf birth rate. Thus to slaughter one-year-old animals was a possible option and became their strategy in the first years.

In Riast-Hylling Anders Fjellheim became executive for the reunited district, and faced the second challenge he described, how to enhance productivity. Being firmly convinced that a relatively similar herd size per household was a necessary condition for control, he advanced this view within the district. Many of his fellow herders were skeptical, but Anders was at that time the owner of the largest herd in the district. That was a position of power which he, according to his own narrative, used to get his way. In retrospect Fjellheim holds that without this means of power, he probably would not have been able to implement the changes he led during the 1970's.

In 1972 Fjellheim made a speech at the NRL annual meeting (Fjellheim, 1972) on the topic cooperation in reindeer management where he argued for collective ownership of the reindeer within a siida. The speech reflected the on-going process within the district. In practice they never went that far. Anders explained to me that the reason is that they developed a new method of calf marking which reduced the stress on the animals considerably, and that the collective ownership thus became less important (Fjellheim, pers.com.).

What is important to note, however, is that the strategy of efficient calf-slaughter required an extensive cooperation between the herders. The actions included: (1) the planning and building of a new and efficient fence and corral system, (2) complete annual herd counting, (3) extra marking of calves with plastic tags (carrying individual numbers for each animal with specific colors for each age class), and finally (4) weighing of all calves as a basis for sampling animals for life and slaughter. *This went much further than tradition. The cooperation was extended from herding and into, what is traditionally considered as a part of, the domain of each husbander. The production system established was in reality based on this extensive cooperation, and individual strategies of herd expansionism* (Strategy B) *was in practice excluded.* As early as 1973 the extension journal of the Swedish State Agency of Reindeer Management (Rennäringsnytt, 1973) focused the reindeer management of Riast-Hylling as progressive and profitable. When the calf-slaughter subsidy was implemented as a part of the first Agreement of Reindeer Management in 1977 several South RPD's were prepared to implement the new practice. Some of the immediate outcome is expressed in Table 7.10.

Table 7.10. South calf-slaughter in the two first years of the particular subsidy.

	1977		1978	
	# animals	Relative share	# animals	Relative share
Nordland	282	18.1%	302	20.4%
North Trøndelag	338	11.8%	557	15.6%
SouthTrøndelag/Hedmark	240	6.1%	1650	29.3%

Source: Ansgar Kosmo (personal files)

Some districts as Riast-Hylling and Mountain were particularly well prepared for this change in production system. They had already started to restructure their herds and were in search for new methods. The general impression is, however, that most herders were rather skeptical

towards this change. The counter-arguments were many, as for example the question of what about the doe, when suddenly losing its calf.[16] Nevertheless, by trying in a limited degree from the start, many herders in South found that this practice was possible and also profitable, even though they felt some unease about it in the beginning. Calf-slaughter spread in the Tr0ndelags during the 1980's and the herd productivity increased in most districts. Numbers for North Tr0ndelag demonstrate this clearly. The relative frequency of does increased from 59% in 1980 to 75% in 1988 and 79% in 1995 (Reindriftsadministrasjonen, 1980 and 1988; Reindriftsforvaltningen, 1995). These numbers are averages for the whole region. One indication of the development is that the *doe percentage* of North Tr0ndelag in the late 1980's and in the 1990's has become at the same level *as an average for the whole region (74.7%* in 1991, cf. Reindriftsadministarsjonen, 1991) as the L0dingen *research herd,* which was 74%, 20-25 years earlier.

The relative proportion of calf-slaughter increased gradually from 1977 leveling out at about 70-75% in the early 1990's. The South Trondelag/Hedmark development is similar, with even higher numbers (Reindriftsforvaltningen, 1995). However, some herders were skeptics a long time and some people argued strongly that this practice was against Sámi tradition. One siida of the outer districts continues still with traditional bull slaughter in the 1990's (Harald Sletten, pers. com.).

It seems, as when first starting by increasing herd productivity, herders will have a tendency to pursue this strategy further. One example may shed some light on the mechanisms working. The RPD Essand share winter pastures with Riast/Hylling and also has summer district neighboring Riast/Hylling. This means a high level of reciprocal knowledge in the two districts. In the late 1980's and into the 1990's Riast/ Hylling has worked for a further increase in productivity and implemented a program, which also encompass selection of does by weight. The rationale is that *heavier does have a strong tendency to produce heavy calves.* This is an important point in Dag Lenvik's Dr. agric. dissertation (1989). Essand herders have practiced calf-slaughter, but been skeptical about a more extensive program. However, traditionally they have had heavier animals for slaughter than their neighbors have, but over the years they noticed that this relation had changed to the opposite. That made them speculate. One of their youth conducted a structural analysis of their herd (Bergstr0m, 1993). Their district chairman Lars Age Brandsfjell (1995) made a speech at a seminar at a NRL annual meeting explaining how they had come to change their thinking and why their practice now became closer to that of their neighbors. In short: *When productivity is focused, people will be open for innovations and new advances will be made when people are ready for that.*

The general development in herd productivity of the South is reflected in Table 7.11.

Table 7.11. Meat production per animal in spring herd (April, 1). Trondelag.

	1976	1984	1987/88	1993/94
NorthTrøndelag	8.1 kg	10.5 kg	12.9 kg	14 kg
SouthTrøndelag/ Hedmark	12.5 kg	16.3 kg	14.8 kg	14 kg

Source: Kosmo, 1991:20 and Reindriftsforvaltningen, 1995:38

16 The calf normally follows the doe until next spring when the doe gives birth to a new calf.

Comparing with the North numbers in Table 7.9 we note while the average productivity is relatively stable in West Finnmark, both the South regions express an increase up to about the double level. North Tr0ndelag started at the same level as West Finnmark.

7.4 Regional comparison of performance

The development of the CPR situation is clearly different for our regions North and South. The North has experienced both heavily overgrazed lichen resources a negative development in income during the recent decades. It is remarkable that the problems do not seem to have been fully recognized before in the late 1980's. The South seems to have solved their problems of control and local overgrazing from early in the period, increasing their income and sustaining the resources. The external influences have mainly been the same. The opening of greater markets for reindeer products made imported herding technology an option. A public research and extension service was established. The law revision turned focus from reindeer management as an obstruction for agricultural development towards establishing a formal structure for regulating herd management as an industry, with herder representatives cooperating with officials. The co-management system initiated by the herders' organization NRL brought considerable additional income and was a contribution to develop reindeer management.

The outcome has been diverse. Generally the snowmobile revolution started a revolution in herding technique, which to a great extent solved the control problems of the postwar period, which had been more serious in South. On the other hand, the technological development put reindeer management in a potential cost-price squeeze which has two possible solutions: (1) herd expansion and/or (2) productivity increase. If the first option is chosen, this will at some stage confront resource limitation, which will lead to an increased resource competition. If the second option is chosen, the full utilization of the potential will also require a extension of cooperation which to some extent will break down the traditional division between herding and husbandry practices (cf. 7.3.4.2) as developed in the South. In North we have seen some productivity increase, but a much stronger increase in the level of herding technique, implying that main option exercised is herd expansionism. The total need of cooperation is therefore increased considerably during the period 1960-1990. In the South, the control problems are mainly solved, while the increase in productivity is sufficient to pay for the cost increase. The need of coordination obviously is increased by the new herding techniques, but that seems at least to some extent, to be balanced by the coordinating function inherent in the cooperation requirements of the production system itself. That is, a new intensity in husbandry seems to limit expansion through increasing the capacity of coordination. In a game theoretic understanding South development may be pictured as a game of Assurance (cf. 2.2.2).

In order to understand North development external comparison is not sufficient. We now turn to internal North comparison to study the development of the West Finnmark CPR problem.

7.5 The development of a complex technological externality in West Finnmark

We have above in subchapter 7.1 presented the pasture use and herd size development in

West Finnmark. As we pointed out in 5.2, the internal variation is considerable. We want to exploit this variation to understanding the process of change from the 1960's on. In this subchapter we will focus that the expansion in herd size made some herders to be winners and others to be losers. We will show that the winners were the herders that had the best opportunities of following Strategy B, while the herders following Strategy A became losers. As this developed over time the game played seems to resemble Prisoners Dilemma. We will show this by focusing how the increasing lichen pasture overgrazing can be understood by the externality terms derived in 3.4. We start with a description of the pasture use, continue by revealing the externality development through changes in pasture use and distribution as well as herd size distribution. Further we reveal variation in the production system and use this as a background for explaining the observed development.

7.5.1 Pasture configuration and exploitation

We need to consider further pasture configuration before we study the exploitation level.

7.5.1.1 Pasture configuration

The winter and fall/spring pastures are second order commons for a great number (varying over time from about 50 up to nearly 70) of *siida* groups of herder households. The winter area is a fully open landscape, while the fall/spring area is naturally divided into three zones (cf. 6.2). These zones have idiosyncratic migration systems, where the siidas follow a traditional pattern of annual movements. These systems include *a queue where the groups having their summer pastures nearest to the fall pasture have the same position versus the other districts as the users at the head of an irrigation system.* Though this makes up four types of summer pastures, we can, for the sake of discussion, divide them into two types: *inner* and *outer* areas, with some siidas going to the inner and some to the outer. The general pattern can be sketched as in Figure 7.10.

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*****************************************************
*      *      *      *      *      *      *      *      *   OUTER SUMMER
*      *      *      *      *      *      *      *      *   PASTURES
*      *      *      *      *      *      *      *      *   (Local commons)
*      *      *      *      *      *      *      *      *   [njarga, suolo]
*****************************************************
*      *      *      *      *      *      *      *      *   INNER SUMMER
*      *      *      *      *      *      *      *      *   PASTURES
*      *      *      *      *      *      *      *      *   (Local commons)
     *      *      *      *      *      *      *          [Nanne]
*****************************************************
*   Oarjebealli  |  Guovdajohttelit  |  Nuortabealli *   FALL AND SPRING
*     (West)     |     (Medium)      |     (East)    *   PASTURES
*                |                   |               *   (2nd order commons)
*****************************************************
*                                                   *   WINTER  PASTURES
*                                                   *   (2nd order commons)
*                                                       *
*                                                        *
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Suolo = island, *njarga* = peninsula, *nanne* is inland away from the coast, usually without natural borders towards the adjacent second order commons.

Figure 7.10. West Finnmark pasture configuration. Local and second order commons.

Each siida has traditional winter pastures. The winter pastures have no zones. In the spring, many herds are split up into male and female herds. In summer pasture regions, two or three siidas can share a pasture, but often each herd has its particular pasture (cf. Paine, 1994:38). In the autumn, several summer herds can be intermixed.

7.5.1.2 Pasture exploitation

The level of pasture exploitation has changed considerably during four decades. Vorren (1962) provides an extensive description of the annual cycles of all Finnmark siidas, as they were in the period 1953-1957, which is a decade before the technological revolution started. Vorren did not depict on his maps the extension of each siida's winter pasture, but the descriptions are accurate and reconstructed as a draft on a map[17] by the Reindeer Management Office of West-Finnmark (Gaup, 1997). Henrik Gaup kindly provided me a copy of this draft map, which is not published. Generally the map reveals that the winter pastures are not so heavily utilized in the late 1950's, which was a decade before the snowmobile revolution. There is good space between the siidas and some areas are not in regular use; law also protects some minor areas. I have measured *the sum of areas* indicated *not in regular use,* on the Gaup (op. cit.) map, by a planimeter; these add up to *about 16 % of the total winter area.*

This fact strengthens the assessment conclusion of West Finnmark as clearly summer pasture limited (cf. 7.1). Moreover this conclusion led to that in 1972, in accordance with the recommendations of the convention committee (Reinbeitekommisjonen, 1967), the summer pasture situation was eased by including several Troms RPDs, before used by Swedish Sámi, into the West-Finnmark system (Villmo, 1979). The pasture balance now moved from summer pasture limitation towards winter pasture limitation, but the situation with *not fully utilized winter-pastures lasted up til the late 1970's.* (J.I. Haetta, pers. com.) This is consistent with that the 1972 herd size level was not outnumbered until 1977 (cf. Figure 7.4). Further there is good correspondence between the continuos herd increase to 1990 and the lichen biomass reduction in the same period (cf. Figure 7.2). We will come back to an evaluation of the contemporary level of pasture exploitation, and pasture balance at the end of this subchapter.

7.5.2 The development in external effects

Recall Table 3.7 and the connected discussion of the notion *complex CPR problems*. The West Finnmark case may be considered an example of a complex externality with an assignment problem (due to summer pasture limitation) as the initial problem, and a technological externality as a dynamic force promoting an over-harvesting externality of lichen pastures.

The assignment problem is studied above in the preceding section. The basis for the technological externality is the general pattern of motorization (cf. 7.1); winter herding technology had become usual by 1970, cars became usual in the 1970's and ATV's in the 1980's, *mobility was radically improved year-around and herding techniques made more*

[17] I do not know the origin of Paine's map from the same period (cf. Figure 6.4), which however do not assign areas to named siidas.

effective. These changes gradually provided new possibilities of herd expansion (Strategy B) and pasture competition; also by grazing out of season. The open, relatively borderless, landscape on both spring/autumn and winter pastures, make this feasible.

The externality might be revealed by considering *changes in pasture use* reflected both in the administration annual reports and in more specific file data. Moreover it will also imply relative changes between siidas and districts in *winter area* and *herd size.* We start by considering pasture use.

7.5.2.1 Changes in pasture use pattern.

An survey of the West-Finnmark annual reports from 1972 (Beretning/Årsmelding, 1972-1995/1996) onwards give clear indications of *an increasing irregular use of the fall and spring pastures since the early 1970's and also for the winter pastures from the late 1980's* onwards.

Fall and spring pastures

The annual reports in the 1970's point to that herd size is too high for the summer pasture capacity; and grazing out of season by siidas not moving into their summer RPDs, but staying in the spring/fall area during summer (in 1975: 5,000; in 1978: 8,500). The specific cases of two particular siidas are commented in textbox 7.1.

Textbox 7.1 Illegal use of fall/spring pasture for summer pasturing becomes legalized

Recalling pasture configuration (cf. Figure 7.10) two siidas from the inner districts, RPD 40 Orda (Medium zone), and one siida from RPD 23 Seainnus/Navgastat (Eastern zone), have been revenants as irregular (partly legal, partly illegal) users of fall pastures during the summer. As early as 1973 the Lapp Sheriff wrote in his annual, regarding the former of the two siidas: *"The area is so heavily grazed down that further dispensations should not be recommended".* Nevertheless the use pattern was sustained, during the period and the officially registered herd size of the two siidas increased from 6878 in 1975 to 12306 in 1986. The most extreme example; one of these siidas, Baeskades, was accused of illegal pasture use every year 1974 to 1978 and in the 1978 the annual report expressed: *"The area is very heavily grazed down due to summer pasturing for many years."* However, the administration again gave dispensation and finally in 1991 the Central Board legally accepted Baeskades as a new summer pasture district, RPD 41, in the fall/spring area; *the illegal had become legal.*

A more general comment in the 1983 report is that *the capacity of the summer pastures are too limited and that several siidas use the spring and fall pastures far more than the given pasture time.* The 1985 report says that competition of the second order commons (both spring/fall and winter) is very great and that stipulated pasture times are not complied with. This is repeatedly stated as a situation description during the late 1980's and further into the 1990' s. The 1988 report states that the siidas belonging to outer RPDs are particularly harmed (since they are behind in the queue) by the irregular grazing in the spring/autumn pastures. The district board for RPDs 30 and 31 claim actions taken to stop irregular use (from 1986).

Winter pastures

The reports comment both upon the general use and exploitation level of the winter pastures and the changes in pasture use; cf. Textbox 7.2.

Textbox 7.2. Irregular use of winter pastures

> *In 1982 and 1983 the annual reports express that the northern (outer, cf Figure 7.10) part of the winter pastures* is heavily exploited causing the siidas having their pasture in these parts to move out early. The 1985 report express that *the winter pastures now are used several times during the winter and that the total herd size is all to great in relation to the winter pasture capacity.* This message is repeated annually, and the 1988 report states that herd size is increasing annually and the pressure on the winter pasture becomes even greater and may promote a catastrophe for reindeer management in the future.
>
> From 1988 on the western and inner district 35 Favrosorda changed their *pasture use pattern* by a rapid fall migration with an unseparated herd through a wide area used as winter pasture of several other siidas.

We should note that (1) at least by the mid-1980's also winter pastures seem to have become inadequate, and that (2) some siidas also start grazing out of season in winter pastures from the late 1980's, which is an action avoiding the effect of insufficient fall pastures. The rapid migration is made possible by motorization. We may widen our picture of the changes by studying *the change in winter pasture area over time.* For this purpose we may use the map for late 1950's winter siida areas (Gaup, 1997) and compare with the picture given by a similar map for the late 1990's (Gaup and Westlund, 1997), cf. Appendix H The rationale is that the relative size of the winter area is an indication of relative position when there is competition of basic pasture resources, winter pastures being fundamental. For the comparison we have divided West Finnmark summer RPDs into "inner" and "outer" ones as described in Figure 7.10. The division is in correspondence with an official division used in the Reindeer Management agreement, cf. Figure 7.11.

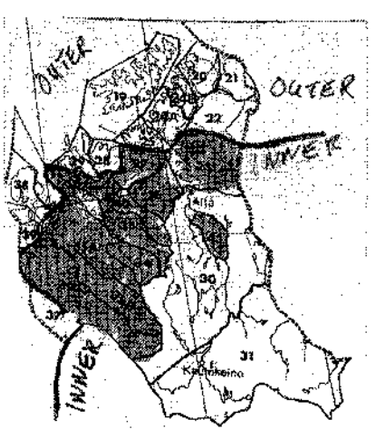

Figure 7.11. RPDs of West Finnmark "Inner" and "outer" summer RPDs.

I have used a planimeter and measured the area for each siida or RPD and summed for each RPD for the years of 1957 and 1997. Some siidas belonging to different summer districts have winter areas in common; this has required interpolation of for some of the results. For a couple of RPDs the outcome seems improbable (small and great siidas in common makes interpolation difficult), but generally the results seems reliable. Table 7.12 provides data of relative share of winter pastures 1957 and 1997, change in percent units and relative change.

Table 7.12. West Finnmark Summer RPDs. Relative size of winter pasture areas(share of RPD31) – 1957-1997

RPDs	Relative share of winter pasture (in percent)			Relative change
	1957	1997	Change	Percent
20	4.0	2.7	-1.3	-32.5
21	4.0	2.3	-1.7	-42.5
22	5.0	8.2	+3.2	+64
24A/24B	7.6	3.9	-3.7	-48.7
28	3.8	2.1	-1.7	-44.7
29	3.6	2.3	-1.3	-36.1
37	2.8	1.7	-1.1	-39.3
38	0.8	1.4*		
39	1.0	2.7*		
"Old" outer RPDs	**32.7**	**27.2**	**-5.5***	
19	-	2.4		
25	-	1.3		
T11	-	1.0		
T19-32	-	2.4		
T33	-	1.8		
"New" outer RPDs	**-**	**8.9**	**8.9**	
Sum outer RPDs	**32.7**	**36.1**	**3.3**	
23	6.4	8.2	+1.8	+28
26	7.7	7.6	-0.1	-1.3
27	8.6	2.5	-6.1	-70.9
32	11.1	2.3	-8.8	-80
33	5.4	4.7	-0.7	-13
34	7.5	11.0	+3.5	+46.7
35A/35B	11.8	12.2	+0.4	+3.4
36	2.9	8.2	+5.3	+182.8
40/41	5.8	7.2	1.4	+24.1
Sum inner RPDs	**67.2**	**63.9**	**-3.3**	
Total sum	**99.9**	**100.0**		

Source: Own planimeter measurement based on Gaup (1997) and Gaup and Westlund (1997)

The general pattern is that due to the new districts (outer ones)[18], on the winter pastures both the "old" outer RPDs and the inner RPDs as groups have lost in relative share. Further most old outer districts are losers (one exception only), while the majority of the inner districts are winners; however there are important deviations. Most of the outer ones have lost one to two thirds of their area, while the one winner has gained nearly two thirds. The losers are both *suolo* (island) and *njarga* (peninsula)RPDs, while the winner is also a njarga, but adjacent to

[18] Three Troms districts but also two West-Finnmark districts having had other winter pastures (19 is an island which have had all year pasturing until the 1980's, 25 has had winter pasture in an area of the spring/fall pasture,RPD 30).

a *nanne* (inland) - we may call it an *inner njarga.* For the inner RPDs the winners are all nanne RPDs; having direct access to the second order common of RPD 30. There are two very clear losers, by about three fourths each; both are inner njargas.

Summing up classifying by the Sámi summer district terms; we note that nearly all nanne districts are winners (the two exceptions are moderate losers). *All suolo districts are clear losers, so also most njargas.* We note, however, that what I have named inner njargas can either be clear winners or clear losers.

A preliminary conclusion might be that *the parallel to head and tail irrigators seems to be clear with reference to nanne and suolo herds.*

Let us then have a look at whether analyzing the geographical development of herd size can shed more light over who are the successful Strategy B followers.

7.5.2.2 Changes in Herd Size Distribution

While we for distribution of winter pasture have only start and end point values, for herd size and harvest we have numbers for the period 1980-1996, including the major growth period 1980-1990. Figure 7.12 is based on West Finnmark aggregated production data for the whole period, and, depicts herd size and harvest for inner and outer districts.

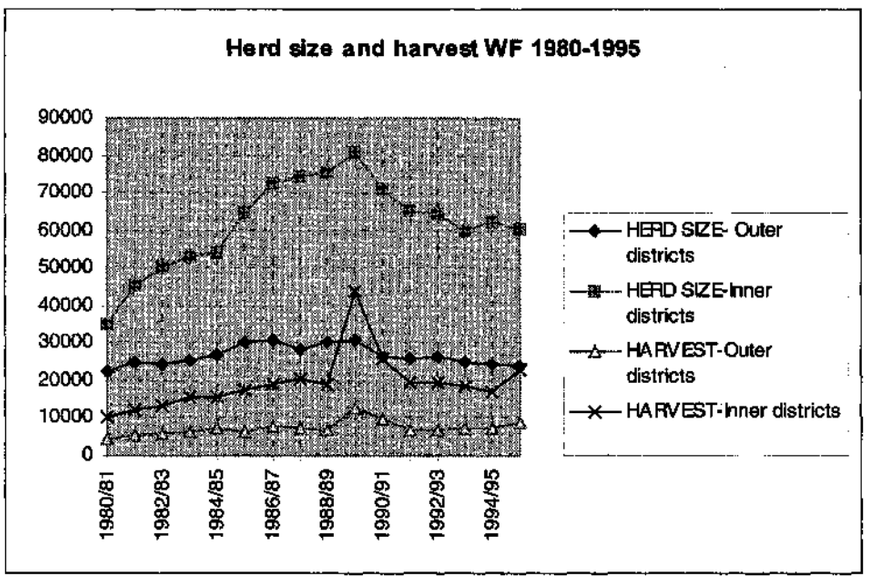

Figure 7.12. West Finnmark, herd size and harvest for inner and outer districts, 1980/81-1995/96. Own computation.
Sources: Reindrifisadministrasjonen, 1980-1993. Reindriftsforvaltningen, 1994-1996.

We note that while the herd size for the inner districts are more than doubled from 1980 to 1990 (+130%), for the outer ones, it is not increased by more than 38%. In Table 7.13 we have computed, for the same time period, average rates for gross growth; broken up into harvest and net growth, and present them for the groups; inner and outer RPDs, as well as for

West Finnmark total.

Table 7.13. West Finnmark average growth (annual increment in herd size) and harvest rates 1980-90, inner and outer RPDs.

	Gross growth rate	Harvest rate	Net growth rate
Inner RPDs	35.9	29.6	6.3
Outer RPDs	28.0	26.4	1.6
West Finnmark	33.2	28.5	4.7

Net growth rate(annual herd increment) = Gross growth rate – Harvest rate.
Own computation.
Sources: Reindriftsadministrasjonen, 1980-1990.

Net growth rate (annual herd increment) = Gross growth rate - Harvest rate.
Own computation.
Sources: Reindriftsadministrasjonen, 1980-1990.

The table indicates *clearly higher both gross and net growth (annual increment in herd size) as well as harvest rates,* when comparing inner and outer RPDs for the actual period. That is; the herds of inner RPDs grow faster than the outer even though the former has a higher harvest than the latter.

For the *net herd growth* we also have statistical analysis supporting our indication; Kosmo (1994) has conducted statistical analysis based on the material for all West Finnmark herders (management units) registered in the agency database for the two years 1981 and 1988, totally 206. In average the inner district herders have increased their herds by 234 reindeer, while the outer district herders have an average increase of 128 reindeer, which is statistically significant (t=3.2 df=173.42). However, the variation within each of the two groups is considerable, and linear regression reveal that membership in the groups inner vs. outer district do not explain more than about 5% of the variation in increase herd size (R^2 = 0.049). Further Kosmo (op.cit), dividing outer districts into two subgroups, found statistically significant difference in herd increase between herders in suolo (islands), and njarga (peninsula)[19]. *Between inner districts and njarga districts he found no significant difference* (t=-0.87 df= 150.48). *Regrouping into mainland districts* (njarga plus inner districts) *and island* (suolo) *districts he found statistically significant difference in herd increase* between herders in these two groups (average increase: suolo=26; mainland=219, difference = 193, t=6.76 df= 130.94). Linear regression analysis based on these two groups shows an explanation percentage of 12, clearly higher than the original grouping.

In evaluating Kosmo's analysis, we should note he has regressed on the increase in *absolute numbers.* This explains the relatively low values of R^2, regressing on absolute numbers obviously make initial herd size[20] the major factor of explanation. An alternative regression on *relative herd change* would have provided considerably higher values of R^2. Anyhow, his results are nevertheless interesting; as they show that based on herd increase *the main division between districts should be between mainland and island RPDs; instead of inner and outer ones.* Thus they adjusts our initial picture of Figure 7.11. We note that this also is in correspondence with our findings about area distribution with relation to suolo (island) and nanne (inland) RPDs, while there is a deviation for the njarga (peninsula) RPDs.

---

19 suolo (islands), average=26, and njarga (peninsula), average=201, districts (t=5. 0 df=115.1).

20 Also for regression on relative change in herd size, we would expect initial herd size to be an important factor explanatory factor as initial herd size is important in explaning harvest rate (cf. Kosmo, 1991).

The material presented in this subchapter, clearly establishes a development pattern which seems to be in accordance with our theory of a complex technological externality, and also identifies winners and losers in pasture competition. We might, however, reveal some more of the underlying development process by including some features of the production system (cf. Table 6.1 and comments). Considering our indications of externality development together with Paines (1994:99-102) characteristics of production system subtypes the essence of our findings is given in Table 7.14.

Table 7.14 Production system subtypes and externality indications

	Suolo (island)	Njarga (peninsula)	Nanne (inland)
Herding	Herded calving	Free calving	Summer herding
Husbandry	Intermediate	Extensive	Intensive
Strategy (probable)	A	B	A or B
Area-relative change	Decreasing	Increasing or decreasing	Increasing
Herd size-growth	Relatively low	Relatively high	Relatively high

We may connect the comments to the columns of the table. Generally the material discussed in this subchapter is consistent with that *suolo* herders, who early had chosen strategy A, became losers in competition over second order commons. Without additional data we do not know whether they changed their strategy later. Anyhow, they have been losing both in area and herd size[21].

The situation for *njarga* herders is more ambiguous. The choice of strategy B seems clear; this is supported by the low growth potential, a relatively high area in 1957 when winter pastures were in excess, and also by the relatively high herd growth rate. For change in area we observed a *difference of destiny the inner njargas* (cf. Table 7.12); on the one hand 27 and 32 (losers of area), on the other hand 22 (winner of area). Let us see how they perform for change in herd size. In Table 7.15 we have computed average growth rates for these three, following the pattern of Table 7.13.

Table 7.15.Three inner njarga RPDs. Average growth and harvest rates 1980-90

	Gross growth rate	Harvest rate	Net growth rate
22 – Fiettar	35.1	29.9	5.2
27- Joahkonnjarga	33.2	26.5	6.7
32- Silvetnjarga	26.1	25.2	0.9

We note that 22- Fiettar- has gross and net growth rates near up to the average of inner RPDs. Totally this district has expanded in both herd size and area and thus is a pasture competition winner.

For 27 Joahkonnjarga both gross rate is on West Finnmark medium level, while harvest rate at the level of outer RPDs, making the net growth rate relatively high; a clear B strategy; a winner in herd size competition, but though a loser of area.

[21] In so far as outer RPDs also are losers in average harvest rate (cf. Table 7.13) probably soulu RPDs also are. Whether this loss to some extent is compensated for by increase in productivity, we have not included data for.

32 Silvetnjarga has low rates through; it cannot manage to implement a B strategy and is a loser of both herd size competition and pasture area. Our material does not give indications to explain the difference in gross growth rate between these two districts; it might for example be related to the quality of calving area, difference in predation etc. For the difference between these two and 22 Fiettar the position of *being back in the queue,* can be important, as this limits the expansion possibilities of njarga RPDs in a situation of competition.

For the third group the inland *nanne* herders; we should note that, compared to njarga and suolo herders that did not practice summer herding, *the possible expansion of this group had been clearly limited by labor force at summer.* The possibility of summer and fall motorization removed this limitation. These herders, having the potential of strategy choice, acquired *an extra stimulus for choice of strategy B by motorization, as they now could gain advantage of their queue position.* So they did. We can ascertain that two siidas mentioned as irregular user of spring/fall pastures in textbox 7.1 also are among the winners of Table 7.12, so is also the irregular winter pasture use RPD of textbox 7.2. For the establishing the connection between winners of pasture area and winners in herd expansion, we have computed the growth rates for the two clearest winners of Table 7.12, cf. Table 7.16.

Table 7.16.Two nanne RPDs. Average growth and harvest rates 1980-90

	Gross growth rate	Harvest rate	Net growth rate
34-Aborassa	38.1	28.3	9.8
36-Cohkolat	28.7	21.8	5.9

We note a considerable difference in gross growth rate, which probably is due to natural variation between districts; the interesting feature is the high net growth rate; consistent with a B strategy.

Having complemented Table 7.14 with a some additional production data the picture of nanne herders accompanied by some njarga herders as competition winners and suolo and some njarga herders as losers seems clear enough. In an overall consideration our findings are consistent with that Strategy B from the mid-1970's and during the 1980's was dominating as total West Finnmark herd size was doubled in the period 1976-1988 (Riseth, 1988). Herd expansionism thus seem to be the over all dominant response to the new technological possibilities, leading to grazing out of season. For the winter pastures we have established that before 1960 winter pastures were in clear excess. Further as a result of the herd increase from the mid-1970's, and during the 1980's lichen pasture biomass have gradually reduced first on spring/autumn pastures and later on winter pastures. The situation of the 1990's seems to be one with deficit of pasture more or less year around.

Chapter 8
Explaining different North and South performances by comparative analysis of specific factors

Having focused on the "stem" of our research design (cf. Figure 5.2) in the preceding chapter, we now turn to the problem of explaining why North and South has adapted so differently to the same external pressure, i.e. we will look at the "branches" intermediate variables need and capacity of coordination and their understructure of explanatory variables. We will compare each factor and test every hypothesis against our empiric material. Comparing the effects of different factors we aim to discern possible differences of importance for the explanatory factors. Further we use the outcome to construct possible North and South development paths of as well, the intermediate factors need and capacity of cooperation, as the deeper community variable capacity of transformation. Using these development paths as a basis, we try to establish a best possible explanation of the observed West Finnmark development pattern.

The desired situation for a comparative study would be to have more units than explanatory variables. In this study we have eight principal factors and two composite units, the North and the South. However, there is internal variation within the composite units, and we can also acquire information from outside our principal study area to expand our basis for comparison. Nevertheless we may end in situations where we do not have enough data to infer which factors are necessary or sufficient to explain observed outcomes. For an exploratory study this /might notwithstanding be an acceptable result. As a second-best solution, it could be a basis for further studies of factors, which seem to be crucial. If the alternative were to reduce the number of hypotheses, the outcome would probably be worse; we would lose possible explanations and might end up with conclusions that easily could be proven false.

In or model presented in Figure 5.2 we focused on technological change as a *triggering factor* for change in the production system. The before mentioned example of the East Sámi (Skolt Lapps) of Sevettijärvi in East Finland (Pelto, 1972) indicates that the technological externality., starting with the introduction of the snowmobile, can lead to direct expelling of herders.

This has not been the case in Norway, at least so far. One major reason for that is probably the governmental subsidy via the Agreement of Reindeer Management (cf. 7.2) which has dampened the effect of the cost-increase. Further, the expansion potential both in herd productivity and herd size provided basis for increased revenue. The outcome was therefore different from the East Sámi case, and also more diverse. Both North and South had initially the same type of production system, and have broadly been through the same process of motorization; involving an over time shift in operating costs creating a demand for revenue increase. In 7.3 we documented that the herders of the two regions mainly met this challenge by different strategies, Strategy B and Strategy A, respectively. The herd size increase (cf. Figures 7.5 and 7.6 vs. 7.7) in Tr0ndelag was limited, while *the major increase in Finnmark* (cf. Figures 7.3 vs. 7.4), seems to be *a fundamental shift to a new level of herd size.* This shift is *difficult to imagine without the increased herd control abilities provided by the technological revolution* from the 1960's on.

Our focus on the connection between major herd increase and the technological revolution is also supported by the major development of Finland, for the same period. Following Kampala's (1998:111-112) description, the number of semi-domestic reindeer was relatively low and

undulating[1] until the early 1980's. From then on total herd size has risen to a historically new level[2], as in Finnmark. According to the author also the development in Finnish reindeer management is driven by needs to expand. The spread of supplementary winter feeding from the 1970's on has together with other factors[3] made the upward shift in herd size possible. Supplementary feeding belongs to the scientific field of husbandry science, as we know it for domestic animals, and it can also be included in the technological revolution of the period[4].

Based on general bio-economic theory we would ask whether the basic condition for the major Finnmark herd increases is more the *growth in governmental subsidies* than the technological revolution. A further comparison with Finland shows that governmental subsidies to reindeer owners there have been very limited all the time up to recent years[5], nevertheless Finland has experienced the major herd increase. Thus, the basic common feature for these two cases seems to be a technological revolution. Therefore, we could hardly imagine any of these two major herd increases to take place before 1960, because of insufficiency in control or forage. As a conclusion:

(Cl) *A major and permanent herd increase to a distinctly new and higher level is improbable without a major change in the production system as facilitated through a technological change.*

However, our basic North and South observations for the dependent variables when exposed to the external technological influence are connected to *the balance between need and capacity of coordination:*

(1) In contrast with the North, the South seems to have had deficit capacity of coordination in the early 1960's.
(2) Unlike the South, at least from the 1980's on the North has had a considerable deficit in capacity of coordination.

The most probable explanation is that:

a) *the South, which had an initial deficit capacity of coordination, through using its capacity of transformation, increased this enough to compensate for (the possible) increase in need of coordination, and*
b) *the North, which initially had sufficient capacity of coordination, did not increase its capacity of coordination sufficiently to compensate for the increase in need of coordination imposed by the technological change.*

Further throughout this chapter we will study *whether this really was the case* by inquiring each of the explanatory factors and testing the hypotheses connected to them as well as the two control variables of Figure 5.2. We start with the factors connected to the intermediate variable need of coordination.

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1 between 100,000 and 150,000 in the 1960's and the 1970's

2 over 200,000 with a top at about 280,000 in 1990

3 reduced mortalitity and increased reproduction rates due to parasite treatment, and calf slaughtering also increasing reproduction rates

4 Research on supplemantary feeding for reindeer has been an important task for the State Reindeer Research in the 1960-70's, and for the University of Tromsø in the 1980-90's, but in reindeer management its main use has been as crisis forage.

5 Governmental subsidies have been restricted to support for construction of fences, slaughterhouses etc. Direct support to owners was introduced when Finland joined the EU (1995), (cf. Päivi Soppela, pers. com.).

8.1 Factors influencing need for coordination

8.1.1 Pasture balance (H1)

Our hypothesis was:

(HI) *When winter pastures are the limiting factor in seasonal pasture balance, Strategy A and herd stabilization will be promoted.*

Conversely summer pasture limitation would be promoting Strategy B and herd expansion. We also listed some implications of this hypothesis connected to the possible effects of nutrition and degradability of bedrock, level and distribution of precipitation, on seasonal pastures (i.e. H1a-H1e). Keeping in mind the information provided in 6.1 and 7.1 we focus on the regions.

North

Much of the reason for the naturally high winter pasture capacity is that Finnmark inland winter pastures have poor and hard bedrock inhibiting most vascular plants, but promoting lichens. Further, the climate is very stable and continental (cf. Figure 6.2) with a relatively light snow-cover, and thus, high accessibility for the reindeer. As we showed in 7.1 the North was a clearly *summer pasture limited* region in the 1960s. The same subchapter also substantiated the gradual lichen pasture overgrazing in the following decades. The more detailed presentation in 7.5 indicated that the situation from the late 1980's on is deficit of pasture during great parts of the annual cycle. Following the situation into the 1990's, herd size has gradually decreased. A part of this may be explained by a more effective policy, but there are clear indications that *the conditions of the lichen pasture,* at least in some districts, *limits the herd size and reproduction* (Mel0y, 1996). For example, some districts have experienced calf birth percentages under thirty, and winter mortality also seems to be increased. That is, the lichen overgrazing seems to have made *lichen pastures a limiting factor, or at least are very close to being so*[6]. Going outside our primary area of study considering East Finnmark, Karasjok is also summer pasture limited (Utenriksdepartementet, 1967:204) and has a similar development as Guovdageaidnu, though with more moderate absolute numbers (for overgrazing cf. Figure 7.2).

South

As earlier shown in 6.2 the traditional use of the areas in the South was the double pattern of both inland and coastal winter pastures. However, the border convention regulations[7] reduced the utilization of continental winter pastures in Sweden from the Norwegian side to an insignificant level. *Most of the contemporary South area is thus typically winter pasture limited.* The inland winter pastures, today most significant in South Tr0ndelag and Hedmark, are stable, but have thicker snow cover, meaning a higher R (cf. 3.2) than the ones of the North; e.g. a relatively

[6] A closer analysis of that is beyond the scope of this study, but would be a challenging task.

[7] 1919 and 1972

lower pasture capacity than Finnmark winter pastures. The coastal winter pastures are normally free of snow, but limited. A third option is *sub-coastal winter pastures,* which have increased in significance due to the border conventions. They have a more unstable climate, with significant risk of both the sudden formation of a terrain-covering icecap (the outcome of heavy rain followed by rapid freezing) and heavy snowfall. The potential consequences of both are fatal; the winter pastures may become inaccessible and reindeer famine may take place. The availability of several options for winter grazing is thus a necessity. This attribute will limit the total safe herd size per winter pasture unit. One precaution is to have accessible winter pastures in different (local) climatic zones.

Some of the coastal districts having safe winter grazing are actually *summer pasture limited,* e.g. lack of "airing mountains"[8] or rather dry and poor areas with limited plant growth in late summer (Kosmo, pers.com.) For these, herd expansionism would be a possible strategy if not limited by other factors. Coastal winter pastures, however, are not mainly lichen pastures like inland winter pastures and thus not easily subject to overgrazing if grazed out of season. Practically, reindeer management in these districts has not expanded in herd size. This fact must be considered in relation to other factors below. Our main conclusion so far is, however, that *the South area is mainly winter pasture limited.*

Conclusion

There is a clear difference between the regions, and our hypothesis (H1) that winter pasture limitation will promote herd-stabilizing strategies cannot be rejected. Our material suggests that this may be an important factor of explanation. We conclude:

(C2) *Herd expansion (Strategy B) seems to be promoted by the existence of summer pasture limitation.*

8.1.2 Landscape structure (H2)

We have found landscape characteristics to be of particular interest insofar as natural borders can support human herd control and specified this in two hypotheses:

(H2a) *A landscape broken up by many natural borders, yielding relatively small-scale CPRs, will tend to promote Strategy A and herd stabilization*

(H2b) *In the case of big scale CPRs, lack of or insufficient borders between seasonal pastures would tend to favor Strategy B and herd expansion even more.*

The two of them are interconnected, as *H2b is a specification of H2a;* we discuss them together.

North

The landscape of the North is flat in a macro perspective, which requires long seasonal migrations. On a medium scale, the landscape can be described as *very open.* This is particularly the case for the winter pastures, but also the spring/fall pastures are fairly open with a natural trisection, while the summer pastures are predominantly of moderate scale. Most summer

[8] to escape mosquito harassment

districts have definite natural boundaries as suolo (islands) and njarga (peninsula) — as a rule being fenced at the isthmus/the forth side against the mainland, while nanne (inland) summer pastures do not have so clear borders. Some of these districts have established fences (some illegal, others legal) to protect their area against competitors. Thus the landscape allows for expansion and pasture competition at spring/fall and winter pastures, but to very limited degree on summer pastures.

In the North, there are no definite borders between winter and fall/spring pastures, or between summer and fall/spring pastures (except for islands). This makes *pulsating summer herd adaptations* (cf. 7.5) feasible for users of the inner summer pastures, as they are adjacent to fall/spring pastures, if they follow a strategy of moving before the traditional point of time at the expense of other siidas. *The problem of scarce summer pastures can thus be "solved" by moving "too early" into the fall pastures and "too late" from spring pastures into summer pastures.* On ground without a snow-cover, lichens are particularly vulnerable; their R-value (cf. 3.2) is very low, towards zero. *Pulsating summer herd practice will thus have a tendency to over exploit the fall and spring pastures. The logical "solution" to this problem will be to move into the winter pastures before they are snow-covered, though they are also particularly vulnerable at that time.* As we established in 7.5 this is exactly what has happened. The large scale and the open landscape of the fall/spring and winter pastures provide opportunities for possible followers of Strategy B. Combined with the lack of definite borders between pastures of different seasons, these conditions make the physical factors considered fully in favor of Strategy B for the North area. Strategy A is also feasible, but the institutional requirements are considerable. That is, the *physical factors create a high need for coordination,* and require institutional mechanisms at two levels (cf.4.1.2).

South

The South has a clearly more broken landscape than the North, and mainly small-scale local commons. There are a couple of second order commons, but they are of limited size. This is very different from the North. The pasture areas are also partly divided with wide spruce valleys, mainly not allowing long migrations. South winter pasture areas are in usually a part of the same district as the summer district or adjacent it (short seasonal migrations due to macro landscape features). Some districts however have fairly long seasonal migrations, a number of them move by trucks and trailers due to civilization encroachments in the pasture areas. The winter areas are also relatively broken areas. The winter areas of South Trondelag/Hedmark are more open areas than the North Tr0ndelag ones.

As for the summer grazing areas, inner districts are relatively open towards Sweden, and some of the local commons have had rather weak natural borders between themselves. This relative openness is a factor contributing to the feasibility of expansive strategies. In the first decades of the previous century, this promoted a transformation from combined milk and meat pastoralism to monoculture meat pastoralism in this part. Many of the inner districts experienced control problems and/or overgrazing problems in the postwar era. These problems were mainly local. The control problems were solved by means of new herding technology (vehicles and fences). When control was achieved, Strategy A with herd stabilization was a feasible option. Macro structures as a great valley has physically shielded the outer areas from the herd expansionism at the Swedish side and a relatively more broken landscape also provided the continued milk and meat pastoralism adaptation better terms. Most of these districts continued with the intensive milking down to the postwar era, some of them down to the mid-1960's (Fjellheim, 1991). As a consequence these districts still had an intensive reindeer management with good control,

intensive pasture use, and regular seasonal migrations in the late 1960's (Ramstad, 1967). Thus the landscape character here seems to have contributed to stabilization.

The South contrasts very clearly with the North. In the South control problems early in our period were solved by new herding technology, creating opportunity for pursuing stabilizing strategies. Though some of the outer South districts are summer pasture limited, the total pasture configuration of the South does not allow for expansive strategies like the pulsating summer herd adaptation.

Conclusion

The regions are clearly different both in landscape and performance and our hypotheses cannot be rejected. We conclude:

(C3) *Herd expansion (Strategy B) seems to be promoted by the existence of a relatively open and borderless landscape, in particular by lacking or insufficient borders between seasonal pastures.*

8.1.3 Missing markets (H3)

Our hypothesis was:

(H3) *When markets play a peripheral role in the economic life of a herding society we would expect a propensity to herd accumulation and also find Strategy B more usual than Strategy A.*

The development of the market for reindeer meat is described in Chapter 7. Though the supply of slaughterhouse services from the mid-1950's seem to have been high in the North, we do not have indications of a more rapid market growth in the North than in the South. In the South agricultural cooperative slaughtering firms slaughtered reindeer as well as a few private family firms. The cooperative firms were members of Norges Kj0tt- og Fleskesentral with which the Finnmark cooperative reindeer slaughter firms had established an agreement of delivery. Thus both South and North seem to have developed sufficient meat market possibilities from the late 1960's.

Other markets also expanded in this period. The public sector in Norway grew considerably from the late 1960's. One important implication was a considerable increase in female wage labor. Official statistics have registered that the number of woman in wage labor in Guovdageaidnu increased from 91 to 527 in the period 1960-1990 (cf. Nielsen and Mosli, 1994:101). In the 1960's female wage labor was not usual in the South either. One of my South interviewees speculates that the reason that he in 1966 did not receive a subsidy to buy life reindeer as some other herders did, was his marriage with a teacher; he was considered well-off (His friend who was the owner of a car, did not receive the subsidy either[9]). The public sector growth also includes general reforms in the system of social security and pensions and thus increase in public

9 The actual Lapp Sheriff annual report (Lappefogden i XT, 1967:4) lists 10 reindeer owners who had received the subsidy after a "close evaluation of the applicants" and with the objective of attending to not-so-well-off reindeer owners. My interviewee and his friend are not at the list. This seems to confirm that his judgement was correct.

contributions to retired and other low-income groups (Ustvedt, 1981: HI; 288-90). As a whole; during a couple of decades new groups of people increased their monetary income. This also affected Sámi households providing new possibilities for buying every day needs.

Income from external sources (wages, pensions and interest) is registered in the total accounting for the reindeer management industry from 1991 (0konomisk utvalg, 1992-1996) amounting to average levels from NOK 40,000 to 80,000 per household. For 1995 income from other industry (e.g.: handicraft, game, and fishing) is calculated to be an average of NOK 22,000 per household. The numbers for South Tr0ndelag/Hedmark is generally low, while North Tr0ndelag and Guovdageaidnu numbers are on the average level. Kalstad (1992:72) provides Guovdageaidnu examples of this type of income at the level of NOK 60,000 to 70,000. Even though these numbers are from the 1990's, they give an indication of the levels of the 1980's, which probably have been on levels not so far below these numbers.

In addition to availability of markets, the general attitudes to both sale and capital conversion will affect market behavior significantly. From his fieldwork in Guovdageaidnu in the 1960's Paine (1994:135) provides stories about small fortunes of cash and jewelry buried in the tundra. The demand of bank and financial services seems still to be limited in the early 1960's, but generally bank services became gradually more common. The first snowmobiles were bought by conversion of animal capital (Nilsen and Mosli, 1994:64). At that time investment in other objects than the herd was not extensive. For whole Norway the early 1980's were a period of vigorous bank loan increase. Many reindeer managers used this opportunity making investments in new technologies.

In this section we have not discussed the situation in North and South divided insofar as the processes seem, roughly seen, to be similar. We cannot test our hypothesis, due to lack of observed differences, and conclude:

(C4) *We do not have any indications that market relations influence herders' choices between the Strategies A andB.*

Having tested our hypotheses connected to the need of coordination we also have a look at the control variable of demography.

8.1.4 Demography

In 4.1 we found that resource dependence and demographic conditions can work as an *entry pressure* of would-be resource users and as such had *a potential of increasing the need of coordination.* However, we found that this pressure was independent of the strategy choices of the already established herders. Let us then have a look at some demographic data, starting with the North.

Public statistics for the whole Finnmark (cf. Movinkel, 1964:10) show that herder families around 1960 in average had 3,8 children while the Norwegian population had 2,4. That is a good basis for population increase in the following decades. To what extent the increase in households and persons is a result of recruitment from within herder households or from the surrounding Sámi society we do not fully know, but we know that both contribute. One report (Karlstad et al., 1990:101) states that a considerable portion of the population increase in Karasjok and Guovdageaidnu have been absorbed by reindeer management. In Gouvdageaidnu the reindeer

management population has increased more than the general population increase, the reason being lack of employment in other industries. During the period studied, Table 8.1 demonstrates that there is increase both in number of herder households and number of persons in these households from 1960 to 1990.

Table 8.1. Development in # of herder households and persons in herder households within North region from 1950 to 1990.

		1950	1960	1970	1980	1990
Finnmark total	# households or management units[1)]	260	310	390	430	514
	# persons	1200	1423	1500	1556	2139
Guovdageaidnu	# households or management units[1)]	2)	174	2)	241	334
	# persons	2)	850	2)	1034	1330

1) from 1980 on, some households contain more MU's (in most cases household= MU); counting MUs as households thus imply a slight overestimation
2) lacking data

Sources: Reindriftsadministrasjonen (1980-1990), Lappefogden i Finnmark (1961).

We should note that the net 1980-90 increase in Gouvdageaidnu MU's (91) is greater than the Finnmark total (84), while the population increase is more as we would expect from the increase up to 1980. The table more reflects the outcome of the entry pressure than the pressure itself.

A part of the explanation for the considerable Gouvdageaidnu MU-increase may to a considerable extent be explained by the so-called "Critical assessment of MU-status"[10]. The background for this assessment was that when the new Act of Reindeer Management was set in force in 1979, a first time registration as MU was done quite simply by assigning MU status to the herders submitting trading statements as reindeer mangers with their tax return. What turned out were many of those adult herders still living in the parental household had not submitted own tax returns (probably implying reduced tax), but acted as household members. During the early 1980's the amount of personal subsidies connected to MU-status increased, and "grey establishment" became clearly unfavorable. Nilsen and Mosli (1994) found that in West Finnmark many households had registered two, and some even three, units, while the intention in the regulations clearly was one. In so far as there was a possibility of herders not being registered that should have been, when NRL claimed, the critical assessment was conducted, and the number of MUs in Guovdageaidnu was increased considerably; East Finnmark MU numbers was not increased so much.

A committees report (Mel0y, Eira and Riseth, 1985) focusing East Finnmark, with altogether 22 summer siida; found a pattern where 4 siidas, in the west of the region, were overpopulated in relation to the resource base[11], while 7 other siidas, mainly in the east of the region, was under-populated; they had a problem of recruitment. A similar formal analysis was not conducted for West Finnmark, but the judgement from one of the committee members (Ole Mathis Eira) having detailed insight in the herder population, was that the relative overpopulation was clearly higher than in East Finnmark. A contemporary report (Generasjonsutvalget, 1997) finds that

[10] No: "Kritisk gjennomgang av hvem som skal være driftsenhet", file material, Reindriftsadministrasjonen

[11] Reindeer quotas (according to Ministry decision) assigned to MUs

West Finnmark has still a sufficient number of children per MU (1.5), while East Finnmark has to few children (0.8 per MU) to sustain all the MUs by internal recruitment.

For the South we have old data only for herder households and further only for North Tr0ndelag, cf. Table 8.2.

Table 8.2. Registered persons i herder households, Nord-Trodelag 1945-1990

YEAR	1945	1960	1970	1980	1990
# Persons	125	121	128	126	132

Sources: Reinbeitekommisjonen (1966), Lappefogden i Nord-Tmndelag (1970) and Reindriftsadministrasjonen (1980-1990)

The number of persons is remarkably stable. So is also the South Tr0ndelag/Hedmark numbers for the 1980's. The South faced a recruitment problem a couple of decades ago, the child number per family not being greater than for the average Norwegian population (Kosmo, pers. com.), today the recruitment is sufficient[12] and stable (Generasjonsutvalget, 1997).

The material presented in this section can, at least indirectly, give indications of the pressure from would-be herders. For West Finnmark we have established both high numbers of children in 1960, clear increase in population and relative overpopulation in the industry. These features are to a considerable extent also contrasting as well the South and East Finnmark. Even though the extra MU-registrations by the "Critical assessment" meant formalizing already grey establishment, the registrations themselves included access to the subsidy money of the Reindeer Management Agreement and thus better economic conditions and possibility to herd increase.

We thus have *indications that West Finnmark has had a clearly higher recruitment pressure than both the South and East Finnmark* (Karasjok included). As both Karasjok and Guovdageaidnu seem to have had a considerably increase in need of coordination, we might infer that the recruitment pressure is *not a necessary condition* for this increase. As the difference in recruitment pressure between Karasjok and Guovdageaidnu also seem to be distinct, it seems as it has been a contributing factor in Guovdageaidnu. As a conclusion:

(C5) *Internal recruitment pressure could contribute, though not being necessary factor, to a upward shift in need of coordination.*

Another factor with possibility of influencing the need of coordination is the connection to markets.

8.1.5 Summing up need factors

In 8.1 so far we have studied three variables with hypotheses connected and one control variable. In Table 8.3, we sum up our findings how regional difference and possible contribution to the explanation of the development in North. We note that South contrasts North very clearly both when it comes to demography and the physical factors of pasture and landscape.

12 1.2 and 1.6 children per MU for the South and North subregions, respectively

Table 8.3. South vs. North contrasts in need factors

H#	Factor	Regional difference	C#	Possible contribution
(H1)	Pasture balance	Clear contrast	C2	Seems important
(H2)	Landscape structure	Clear contrast	C3	Seems important
(H3)	Missing market	No difference observed	C4	No test possible
	Demography	Clear contrast	C5	Probably contributing

The table says that we have no indications that market relations influence herders' strategy choices. The clearest findings in our material is that pasture balance (H1) and landscape structure (H2) both seem to be important for the explanation of herders' strategy choices. These choices influence the development of the production system and thus indirectly need of coordination. From the arrows of Figure 5.2 the factors above in the table also influence need of coordination directly (cf. 3.5). In addition we have found that the control variable demography (in North) probably also contribute to the increase in need of coordination. We will now focus the interaction of (H1) and (H2)

For the variables *pasture balance* and *landscape* we have found the main pattern that *in the South both are such that the choice of stabilizing strategies becomes easier, while in the North both work in favor of expanding strategies.* Thus, both or only one of them may be necessary for the choice of strategy. Let us see if we can distinguish between the importance of these two factors. Analytically we can show this as a two-by- two-matrix depicting pasture balance on one axis and landscape character on the other as in Figure 8.1.

Pasture balance	**Winter pasture limited**	**Summer pasture limited**
Landscape structure		
OPEN	Stable North 2000 (?)/Finland 1970	Expansive North 1960-1970
BROKEN	Stable South –main pattern	Stable South- coastal

Figure 8.1. Possible combinations of Landscape and Pasture Balance. Stable' and expansive' combinations.

For pasture balance, on the horizontal axis, we recall that a winter pasture limitation restricts the herd expansion potential. If the winter herd zero-isocline is transgressed her size cannot expand due to increased mortality. Landscape structure is depicted on the vertical axis. We note that the strictest condition on each of the axes is the Southwest corner.

Going into the matrix we start with the combination winter pasture limitation and a broken landscape, which is the South main pattern, Here we have a double limitation. The opposite situation is the combination summer pasture limitation and open landscape, which was the North situation at the start of the technological revolution; a double low level of physical limitation.

The combination *summer pasture limitation and broken landscape* is the example in our material, we have registered as breaking with the main pattern; the South coastal summer pasture limited districts where herds do not expand. In this setting it is only the landscape that limits the expansion potential. The landscape has natural borders and a moderate scale; there is no place to

expand. Thus Strategy B is not feasible. It seems, as winter *pasture limitation is not a necessary condition for limiting herd expansion since the landscape can set the limits.* This indicates that *an overgrazing of the observed West Finnmark magnitude is not especially probable in an area with the South configuration.* This conclusion also include the coastal areas having summer pasture limitation.

The other possible deviating combination is *open landscape and winter pasture limitation.* Assuming that the contemporary North in fact has become winter pasture limited, North 2000 is an example of this combination. The Finland total example referred to in the introduction of this chapter, is another example (cf. Kumpala, 1998); as *going from ordinary pasture use to supplementary winter feeding is parallel to abolishing a winter pasture limitation.* We can imagine a West Finnmark 1960-situation of abundant summer pasture resources and scarce winter pastures. How would the herders then have adapted during the technological revolution? It seems improbable to graze out of season pasture at summer when there is abundant summer pasture resources. Herd size would probably adjust to lichen pasture capacity (the possibility of some grazing at fall/spring pastures would not be dramatic when there is snow-cover). In the West Finnmark 2000-situation the total herd size is not increasing; the empirical test of whether this is due to winter pasture limitation, is to start supplementary feeding and observe whether total herd size will increase in the future, similarly to Finland in the 1970s and the 1980s.

As we have found empirical examples of all four possible combinations, we can suggest that *the observed North herd increase is dependent upon both the features of summer pasture limitation and open landscape.* As a conclusion:

(RC2&3) *Successful implementation of Strategy B seems to be dependent on the co-existence of (a)summer pasture limitation and (b) a relatively open and borderless landscape, in particular by lacking or insufficient borders between seasonal pastures.*

Pursuit of Strategy B increases the need of coordination via the production system as well as factors summer pasture limitation and open landscape have a similar effect directly (cf. Figure 5.2). Considering need of coordination in an overall perspective, we have found three factors that we will consider necessary for a major increase in need of coordination. Of the three necessary, but not sufficient factors, the technological revolution itself (C1) is in the position of being the triggering factor of the whole process. The factor works both the increase herd control abilities and through a cost-drive that create a need of increase in revenue. The two ecological factors co-work as the summer pasture limitation (C2) is necessary for creating the need of grazing out of season, while the pasture scale and border-condition (C3) is necessary to make grazing out of season feasible. The recruitment pressure (C5) has probably speeded up the whole development process, but we find that the process would most probably have gone on also without this pressure.

The rapid development in herding technology from the middle of the 1960's thus represents a strong challenge to the North capacity of coordination. In other words, a considerable increase in the capacity for coordination would have been *a necessary condition if North herd size had stabilized during the 1970's and the 1980's.*

We now will inquire the development in capacity of coordination.

8.2 Factors influencing capacity of coordination

The capacity of coordination will depend on both general features of society and more specific institutional properties. We start with the features of the traditional CPR institutions.

8.2.1 Traditional CPRs (H4)

The traditional institutions to be found are both on community level as regulatory principles, and at the level of rules-in-use as a concrete regime. Our hypothesis, including both levels, was:

(H4) *Herding CPRs, which (a) belong to a society stressing collective responsibility in its set of regulatory principles, and (b) have a strong common-property regime with effective monitoring and sanctioning, will have a higher probability to pursue Strategy A and herd stabilization than herding CPRs having the opposite features.*

8.2.1.1 Regulatory principles (H4a)

The first part of the hypothesis (H4a) stresses the supposed connection between collective responsibility in regulatory principles and stabilizing strategies. In Chapter 7 we noticed clear differences in North and South performance. To the extent that choice of main strategy is a question of basic values and ideology, it is important to sort out whether the differences we can observe today have old roots or a rather new origin. I will in this subsection inquire the value of being a large herder as an indication of strong individuality. In a lecture on reindeer management history, the culture historian Bj0rn Aarseth (1989:21) states:

> The South Sámi also seem to have been very reluctant to increase their herds more than the pastures had capacity to carry. Perhaps this attitude is based in the ancient religious ideas of connections to the spirits of nature (saivo) in the family areas (cf. Bergsland, 1985). In the North, the ownership of as many reindeer as possible has been a definite objective of the reindeer owners (my translation, JÅR).

I have previously been inclined to support a stand that there is a clear difference between North and South Sámi herders in their thinking about herd size and expansion. Looking more in depth of the material I am not convinced that the difference in traditional regulatory principles of the North and the South is so clear as the impression we can receive by reading Aarseth's statement. Let us elaborate a bit on this problem.

In the North, *to be a large herder* is held as a basic pastoral value (cf. Paine, 1970:65, 1971:169, 1994:109, Ingold, 1980). This is also in accordance with some of my own observations (cf. my example "Island siida" in 7.3). However, when we interpret this material, we should note that Paine's primary fieldwork is from Guovdajohttelit (middle zone); where the herders according to Paine's (1994:115-130, cf. 6.2) own examination maximize relative herd size. The total pattern brought forward by Paine (op.cit), however, reveals a *diversity of objectives* where an adaptation typical for two of three zones in Guovdageaidnu can be expected to *balance herd size to pasture resources.* That is, variation in basic conditions provides a basis for variation in ideology, also in the North.

This is line with the findings of Johan Klemet H. Kalstad (1997:104, 158-163, cf. 1995:5), from Oarjebealli (western zone), who focuses on herders who pursue *birget,* meaning the ability to manage even with very limited resources. This implies an adaptation relying on several sources

of income and a production system with *an intensive herding of relatively small herds,* presupposing that there is a relatively broken landscape and that the herd control is sufficient to limit herding technology development. These herders have as a basic value to *maintain the herd size* and to "stay in business" (op. cit, 166-168). The contrast in pronounced main objectives seems very clear and seen as a whole I conclude that *thinking in Guovdageaidnu seems to be rather varying with respect to herd maximization as an objective.*

Principle 5 (responsibility towards the land and the spirits) has obviously played a role, not only in the South, but also in the North (cf., Oskal 1995). The concrete implications of this is expressed in the general terms of appropriate reindeer management conduct, which seems to play an important role in both North and South resource management.

Quite opposite of our expectations from Aarseth's statement above, South Sámi tradition encompasses narratives of rich Sámi. Martha Jåma (1985:61) explains that her great-great-grandfather Lars Paalsen (1791-1859) was honored by the nickname "Fjellkongen" (Mountain King). She holds that the probable reason for his nickname was his reindeer wealth; a public committee (Lappekommisjonen, 1891) states that Mountain King had been the owner of about 4000-5000 reindeer. The culture historian Sverre Fjellheim (pers. com.) holds that there are several similar narratives from the South area. As we have seen in 6.2 and 7.1 overgrazing has also has taken place in the South in the periods up to the 1960's. Such incidents of overgrazing are well known by the South Sámi, but they usually do not seem to be focused on.

During my fieldwork I have become struck by the diversity also of South ideology. History and tradition for each local common seems to produce important premises for the thought of contemporary herders. Sigbj0rn Dunfjeld (pers. com.), leader of Saemien Sijte, the regional Sárni Museum, has a hypothesis that *the strength of collectivism in today's South can be explained by the experiences of the parental generation* (of today's middle-aged). This is also in line with the personal narrative of Anders Fjellheim (cf. 6.2).

Another example is the districts "Mountain" and "Valley" (cf. subchapter 7.3) whose current production systems are fairly alike, though they are different in landscape. They both have experienced success during the 1980's, but during the 1990's they have faced increasing problems due to government policy of predator conservation. However, there seems to be clear ideological differences between them. Mountain herders are relatively many, the RPD having many households even before the Second World War. In the early 1970's the young herders took control and during two decades re-intensified their reindeer management as a collective effort. Today their representatives emphasize that their basic objectives are to be many and to have a close cooperation in their work.

In contrast, Valley herders have been relatively few, and they have been well off. One of my informants in Valley, "Per" (born in the late 1940's), presented some of his thoughts, reflecting on the development from the 1980's, in an interview I made with him:

> We have established some of the most productive reindeer management in the country, but we are nowadays facing serious predation problems. I must consider; what is really important to me? It is not to have a nice statistics with many kilograms produced per spring herd animal. What really counts is to have enough animals to survive the winter when the predators have taken their share. The situation is the same as my grandfather faced.

Thus Per carries with him an ideology of *the large herder,* even though his district have in practice limited herd size during the 1980's. This example is in line with Sigbjorn Dunfjeld's

hypothesis that the experience of the paternal generation seems to influence the values of their successors.

The important is that *even though expansionism is not a focused ideology of the contemporary South, its existence can be revealed both as ideology and as historical events.* In spite that *South adaptations of the last decades are relatively uniform and herd stabilizing, the traditional regulatory principles do not seem be different from those if the North.* In both regions, the balance between individuality and collectivity seems to be able to tilt either way. Thus I do not find sufficient empirical support to maintain a stand of a significant difference in the North and the South regulatory principles. As a conclusion:

(C6) *We do not have clear indications that regional differences in traditional regulatory principles have contributed to regional differences in herders' choices between the Strategies A and B.*

Thus we did not find support for the first part of our hypothesis (H4) and now turn to the second part.

8.2.1.2 Internal strength of the regime (H4b)

The second part of our hypothesis was related to the strength of the common-property regime with effective monitoring and sanctioning. We recall that the strength of the regime (cf. Table 2.5) is dependent on its bundle of connected property rights. In 6.2 we found that entry and withdrawal conditions were both interconnected and crucial for the regime's coordinating capacity. In my interviews, I have focused on the role of internal recruitment; asking whether there exists a traditional rule that allows access to be denied somebody. The answers given sum up to *a uniform rule for both regions: Every male youth from a herder household has the right to try his ability to earn his living as a reindeer husbander* (some would say his reindeer fortune). If it had not been for indirect withdrawal limitations, this would, in practice, have been a common property regime for the group, but open access for those within the group (Bromley, 1991:32, cf. 2.5).

Even though the rule is uniform, the contrasting demographic situation, cf. Tables 8.1-8.3. leads to different effects. Having considered the potential weak point of the property rights within the group, we thus have two findings. (1) The entry rule is uniform for North and South and has no potential of explaining difference in behavior (2) The higher entry of the North may thus be explained by demography and entry-pressure (C5), not by difference in rules.

In 6.2 we also provided some examples of sanctions which suggest the existence of a ladder of graduated sanctions (Ostrom, 1990:90, cf. 2.1.2). We have made one clear observation of regional deviation: the evaluation of reindeer theft is clearly different in the two regions. As Paine (1970:62-64) asserts, in the North, reindeer theft can include a multitude of meanings, while in the South reindeer theft is always considered a crime (Aarseth, 1989). Another point is that smaller CPRs with fewer households would usually mean that closer social relations limit individualistic behavior through closer monitoring. Generally the siidas of the North consist of more households than in the South, but we do not know how far-reaching implications this fact has.

Generally we have not found enough or clear enough differences between the two regions we are comparing to ascribe them explanatory power for differences in capacity of coordination. As a conclusion:

(C7) *We do not have clear indications that regional differences in traditional regime have contributed to regional differences in herders' choices between the Strategies A and B.*

Thus we did not find empirical support for any of the parts of (H4). Next we turn to the modern regime.

8.2.2 Co-Management system (H6)

Our hypothesis was:

(H6) *The following characteristics of a co-management system can promote that its effectiveness:*
(a) mutual trust between the parties,
(b) the appropriateness of both the local and central institutional system, and
(c) economical and political gains for both parties.

The Main Agreement of Reindeer Herd Management (1976) introduced an era of herder - government cooperation. If the system was to work successfully, a number of conditions had to be fulfilled. The first one is related to trust.

8.2.2.1 Mutual trust (H6a)

The establishment of mutual trust was in reality a considerable challenge two both parties, mostly locally, but to some extent also within the central system of boards and agreement negotiations (cf. 7.2). This may be illustrated by a pinpoint statement from a South Sámi leader (anonymous pers. comm.), commenting on the new conditions for herder cooperation with extension workers in this statement:

> *Yesterday, the key to herder success was to fool the Lapp Sheriff. Today the key to success is to cooperate with the Agronomist of Reindeer Management. (My translation, JAR)*

North

The regional administration (Lapp Sheriffs office) was clearly understaffed already in the 1960's (Paine, 1970). Compared to the regional offices south of Finnmark, it still has a considerably higher number of "customers" per employee. The formal training of the leaders also have been on a lower level than usual further south. The employee's have been, and are, mainly Sámi from the local area, most of them with a background in herder families; the administration workers and the herders know each other well, in all relevant respects. However, elements of distrust can be found, insofar as the administration represents the government, and their motives may thus deviate from those of the herders.

Because of the understaffing and some lack of formal competence, much of the extension tasks were left to non-Sámi professionals on project basis. While successful extension workers need

both professional and cultural competence, my personal experience, documented in Chapter 7, is that non-Sámi professionals in the North lacked sufficient time-and-place information to develop the necessary dialogue with the herders. Sámi professionals are relatively few and have also to some degree been reluctant to go into the state reindeer management service. Probably one of the reasons for this is the extra burden of having to take responsibility for complex problems related to their own folks.

Both in the 1970's and 1980's extension projects were conducted in the North; with limited success, cf. the "Island" siida case in 7.3. In short *the demand for the services of the extension workers from the outside were limited.* In many cases both the problems were posed and the solutions suggested by outsiders. If the herders had found Strategy B to be the best response to their situation, they were often not very interested when extension workers tried to convince them to change to Strategy A. (Einar Aarak, pers. com.). Further; if they did not themselves "own the problem", they hardly would "own the solutions" either and thus the extension workers may join a cultural imperialist role trying to imposing values on unwilling receivers. It is obvious that this type of situation do not promote trust and cooperation.

With respect to the relation to central governmental authorities North Sámi came in as NRL organization leaders from the mid-1970's on (see details in 8.3 below). Even though some of the political incidents of the period[13] represented challenges to the building of trust, my observation, as a participant in the negotiating system between the herder organization and the government, is clearly that mutual trust generally grew during the 1980's.

South

South herder leaders have historically been active promoting various proposals towards the governmental authorities (cf. 6.3). As a follower of this tradition, Anders Fjellheim has given his account to this author of how the Minister of Agriculture asked his opinion about the applicants for the vacant South Tr0ndelag/Hedmark Lapp Sheriff position. The applicant he recommended, Dag Lenvik, received the position (1969). In 1973 another professionally trained agronomist, Ansgar Kosmo, was employed in North Tr0ndelag. An extensive cooperation between herders and professionals was developed during the 1970's and the 1980's to support the productivity increase described in Chapter 7.

The basis of the trust between herders and professionals was *a perceived need for change,* and a *demand for professional assistance* in the transformation process. The perception was not, however, universal. South entrepreneurs, which can be labeled "occupationalists" (cf. Snell and Snell, 1975) established a dominance over industry policy, governing the development since the 1970's and actively promoting alliances with the extension service. Their counterpart, called "culturalists" in the same terminology, played a more modest role in the South.

Conclusion

Locally the South contrasts the North very clearly in general attitude towards the extension service. In the South many herders actively sought cooperation, while in the North the main attitude seems to be that the work of the extension service did not seem very relevant. In the

[13] e.g. the Alta-Guovdageaidnu river regulation case, translation to Sâmi of the Act of Reindeer Management

negotiation system of reindeer management and in the governing system of boards (cf. Table 7.7), particularly on the top level (cf. Riseth, 1992) trust seems to have been built during the period, regardless of the regional background of the parties. We may conclude:

(C8a) *When mutual trust between herders and extension workers exists, this seems to have been a factor contributing to strengthening the capacity of coordination.*

(C8b) *We do not have indications of regional differences with respect to mutual trust between government and herder representatives, and cannot infer whether this is a factor that has contributed to regional differences in the capacity of coordination.*

822.2 Appropriate institutional systems (H6b)

The second part of our hypothesis was related the appropriateness of both the local and central institutional system.

Whether the new institutional system was felt appropriate involves, as we have mentioned, both constitutional choices and cultural questions, and it concerns central as well as local matters. Seen from a governmental perspective, the NRL claim of stronger property rights for the group challenged agriculture. This can explain both the long time from committee proposition to enacted legislation (12 years) and the weak outcome for the herders at this point. As for the implemented system, the user influence through the board structure was more like the system in the agricultural sector, and therefore more familiar for the Ministry of Agriculture. The same was true for the the Main Agreement and the biannual/annual negotiations, which from the start was nearly a carbon copy of the similar system for the agricultural sector.

The evaluation of the appropriateness was diverse on the herder side. Even though NRL had supported the principles of management units and of herd quotas, North herders were very reluctant to see them implemented. For example, in the North, herd size limitations per management unit (formal household unit, cf. 7.3.) were not implemented during the 1980's. In the South, formal decisions according to the law are made in three of ten reindeer pasture districts (RPDs), while in the other seven, the RPDs have made internal decisions which are implemented successfully (Reindriftssjefen, 1994:15). For the North, this is consistent with a result from a survey by Sara and Karlstad (1993), where *60 percent of the herders asked had plans to increase their herd size.* On the other hand, a survey of RPD executives detected that for West Finnmark most of them held the opinion that other RPDs slaughtered too little, while their own districts slaughtered enough (Kosmo, 1987:281).

Karlstad (1998) has studied functionality of the new local institutions; the Reindeer Pasture Districts Board (cf. Table 7.7) through herder interviews. A main finding was that *the boards and the governing system seems to function best when there is some balance of power and interests in the area in question.* Not surprising he also found that powerful family groups in large Finnmark districts advancing a status quo opinion, being happy with a situation where neither the local nor regional board intervened. Resistance in the North to implementing the regulations of the 1978 Act is also reflected in the boards on different levels. In 1984, the Guovdageaidnu herder Johan Mathis Turi, then a NRL Board member and a member of the Central Board of Reindeer Management ("Reindriftsstyret"), probably speaks for many herders when he says that *the regulations were an infringement upon reindeer management and Sami culture* (Turi, 1984).

Even though not everybody in the South was entirely positive to the regulations, I have not detected any public protest. On the contrary, the regulations mainly seem to have been accepted. Even so we have not found traditional cultural South-North differences. However, there are clear *historical differences',* South herders have had a dialogue with governmental representatives for a longer time, and there was *a widespread wish for changes due to the situation* (cf. 6.2). Thus during the period of our study, *South herders seem to some extent having changed their mind from traditional attitudes towards being in favor of regulations; because they felt the regulations to be necessary.* As we were not able to document significant regional differences in traditional regulatory principles and regimes (C7), *ideological differences between the regions seem to have developed in the period 1960-1990.* The outcome from this was that *while in the South the new institutional system mainly was felt to be appropriate, it was to a significant degree felt inappropriate in the North.* As a consequence of this; in the North the system was considered fully legitimate, and the regulations to a considerable degree became rules-in-form. We can conclude:

(C9) *When the institutional system was felt to be appropriate and thus legitimate, the new co-management system seems clearly to have contributed to increase in capacity of coordination.*

8.2.2.3 Economical and political gain (H6c)

The last part of our hypothesis focused economical and political gains for the parties.

The Ministry of Agriculture had experience with institutionalized co-management systems from the agricultural sector. However, it seems, as *the Ministry did not understand the difference between agriculture and reindeer management.* To be more precise, agriculture in Norway is private property and in addition firmly regulated. Reindeer management is common property for the pastures and at least for the North in the 1980's definitely not a well-regulated industry, *De jure* internal regulations in reindeer herd management were implemented from 1979/1980. In the South de jure regulations and *de facto* regulations corresponded rather well, while in the North they did not. However, the Ministry did not take much notice, and *subsidies were allocated to North herders as if North reindeer management was de facto regulated.*

A calf slaughter subsidy, designed to promote Strategy A was one of the first actions implemented (Landbruksdepartementet, 1976). NRL had their annual meeting in 1977 decided that all objectives in the Main Agreement (cf. 7.2) were of equal importance (cf. Kosmo, 1991). In practice, the organization gave priority to increased income through subsidy increase (Riseth 1992:II: 99). The government accepted as the outcome of negotiations subsidies with that were compatible with Strategy B; the system was rather ambiguous in most of the 1980's. There is a clear connection between Karlstad's (1998) description of some herders' interest of ineffective governing bodies and our description of expansive grazing out of season in subchapter 7.5. The herders he describes are some of the winners of the pasture competition.

The first public criticism against the subsidy practice was a journal article from Kosmo and Lenvik (1985) asserting that the subsidy system promoted North herd increases. The article initiated a debate in the sector, and a report was made (Reindriftsadministrasjonen, 1987). The final outcome was change in policy including that *subsidies were conditioned upon a*

minimum harvest rate (not less than annual growth); that is followers of Strategy B could not gain any more.

Politically both the government and NRL gained from the system, in the early 1980's; before the public became aware of the malfunction for Finnmark. The government was under pressure for its general Sámi policy, and NRL was in need of results. The change in policy in the late 1980's obviously was necessary for the trustworthiness of the parties. The implications of the malfunctions can be concluded:

(C10) *As (a) the government had defective understanding of the real function of the regulation system, and (b) followers of Strategy B interest in its malfunction, this seems to have constrained capacity of coordination.*

8.2.3 Overall system consistence (H7)

Our hypothesis was:

(H7) *The higher the overall consistency of a regulatory system, the higher will the capacity of coordination for the operating regime, tend to be.*

Seeing institutions as successive layers of structuring, the overall institutional system of the 1980's consists of three layers; the traditional system, the law-based regulations and the agreement-based regulations. For an effective total system these layers should reinforce each other. The intention of the law regulations was thus to mend "holes" in the traditional system. However, this was not an easy task. As we found above, many North herders did not find the regulations very legitimate. This impeded both their implementation and their effects.

Mark Fjellheim (1986) has studied the subsidy system of the Reindeer Management Agreement and has found a high degree of inconsistency in the subsidy system itself. The inconsistency meant that efforts to solve one problem the one year created new problems the subsequent year. Reforms of the subsidy system in the late 1980's (see above) included cleared standard requirements for receiving subsidies; as to slaughter the annual herd increment.

The coordination between Act and Agreement was also improved. The system at the beginning of the 1990's thus had considerably fewer holes than the one during the 1980's. The inconsistencies of the system clearly had a more important impact in the North than in the South, which mainly had adapted to the system, e.g. by developing the quota system by local design of quotas based on household size by reallocation (without increasing the total quota.

In addition there were not full correspondence with the law- and the agreement system. In the early 1980's it was not a requirement for receiving subsidies to have adapted to law regulations. This "hole" was also mended by the "tidying" in the late 1980's. We can conclude:

(C11) *When imperfect overall system consistence, this seems to have been a constraint upon the capacity of coordination.*

Having discussed the hypotheses connected to the capacity factors we now turn to the control variable for this side of our model.

8.2.4 External Resource Pressures

In 4.2 we found that external pressures from resource competitors could promote undermining of the regime, seen as property rights for the group, independent of the husbandry strategies performed by the herders. We will thus consider whether there are regional differences in the strength of the pressure from external competitors of the pasture resources. This factor needs to be seen in some perspective. Generally reindeer management are exposed to some principle challenges (cf. Torp, 1999) as (1) continuos reduction of available land area, (2) restrictions on management due to external encroachments, and (3) the herders' experiences of problems and restrictions by encroachments are not recognized by the government. This is a contemporary standard situation, our question is whether the regions differ in degree of external pressure imposed on them, and how such pressure may have influenced the herders resource adaptation.

North

Guovdageaidnu belongs to the central parts of Sapmi. The late cultural historian Guttorm Gjessing (1954:53) named it "the stronghold of reindeer nomadism", and, as such, the property rights of reindeer pastoralists have remained relatively unchallenged by competing users up to the postwar era. Recalling the history of regulations, the rights for the group were first challenged only in the South. The reasons for this were that the government in the last part of the nineteenth century considered the North reindeer herd management to be of greater economic importance than the South counterpart and that there were no significant conflicts with expanding agriculture (cf. S0rum, 1984; Pedersen, 1994:66, 71).

In 6.2 we included guest friendship *(verde)* as part of the social bonds of the extensive kinship system (principle 2). In the North, this type of relationship has been important through the whole annual cycle, but weakened during the last decades. Paine (1964) compares *the relation between pastoralists and sedentary peasants* in Guovdageaidnu and Karesuando (North Sweden)[14]. The sedantaries of Karesuando are Swedish or Finnish in language and culture, while *dalon,* the sedentary peasants of Guovdageaidnu (cf. Kalstad, 1997), are Sámi in language and culture. One implication of this difference is that if a herder has to abandon reindeer herd management; in Gouvdageaidnu he has the possibility of becoming a dalon. In Karesuando he probably has to emigrate and move to urban and industrial centers, insofar as it is difficult to find another livelihood as a Sámi in Karesuando. Thus in Guovdageaidnu, the pastoralists are surrounded by other Sámi who are a reservoir both for transactions (within a cultural repertoire) and for recruitment of new pastoralists. Paine (1981) has studied the school protocols of Maze (a local community of Guovdageaidnu) and tracked extensive movements over several generations between reindeer management and agriculture/combined primary industries. Thus, traditionally, reindeer pastoralists are on good terms with sedentary peasants because they are relatives, friends, and verde (guest-friendship). *The practice of regulatory principle 2 here ensures property rights for the group.*

However, this is not the full picture; there are also observed some pasture conflicts with farmers in the North; particularly with sheep farmers (cf. Elgvin, 1998a). These conflicts seem to be more pronounced in Karasjok than in Guovdageaidnu.

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14 distance by road 140 kms

South

In the South, the relationships are quite different, with a Norwegian farmer population as close neighbors. The conflicts have been clearest in South Trøndelag/Hedmark, with the Røros area as its center. Historically this has been a border area, towards the South and the West, between Sapmi and the advancing Norwegian farmer society. The situation has been more relaxed in North Trøndelag, partly because the reindeer pastures are further from central agricultural areas. However, the old conflicts with the farmers are still kept alive through litigation processes over pasture rights. In recent decades, farmers also have questioned the property rights of reindeer herd management within the RPDs. In South Trøndelag/Hedmark farmers, during the period 1981-1998 have advanced litigation on pasture rights five times. Two of these were finally decided in Supreme Court (1988 and 1997); the Sámi lost both and were deprived of winter pastureland within the defined RPDs (Elgvin, 1998b). The external property rights in this area are thus still rather uncertain. As well the Central Board of Reindeer Management as the Sámi Parliament have taken an active stand to protect these right and Stortinget approved in 1995 changes in the Act of Reindeer Management giving a authorization for expropriation of pasture rights on behalf of the reindeer management.

The contemporary leader of Riast/Hylling[15] RPD, Jarle Jonassen, explains in an interview with the extension journal Reindriftsnytt (Fjellheim, 1996) his view[16] on the background for the high productivity in his district. Jonassen points to that (1) lack of natural borders towards external interests creating conflicts towards agriculture and "wild reindeer"[17], (2) their experience with insufficient herd control and that (3) pressure form agriculture made it necessary to cooperate internally and stick together towards the external pressure. As a consequence of these reasons, in the 1970's they found it necessary to regulate total herd size and further, both to assign quotas to households and increase productivity by herd restructuring and calf-slaughtering.

Conclusion

In comparing North and South, the external pressure towards the Sámi reindeer management has been clearly greater in parts of the South than the North. The South Sámi, particularly in the Røros area, are still exposed to a considerable external pressure. Other parts of the South, as North Trøndelag are more in a medium position; neither very much pronounced conflicts nor close relations. Our expectation in 4.1 was that strong external pressure would promote undermining of the regime. The experience of Riast/Hylling is, on the contrary; *strong external pressure strengthened the regime and promoted stabilizing strategies*. One reason for the failure of our expectation may be that we did not imagine concretely the relation between resource competition and border conditions. However, North Trøndelag, which has not been exposed to this strong external pressures also pursued stabilizing strategies. This fact is an argument against strong external pressures being a necessary factor for the revolution of herd productivity. We need to consider this in a broader context of internal South comparison. Preliminarily we can make the following proposal:

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15 Røros, South Trøndelag/Hedmark

16 which is in full correspondance with Anders Fjellheim (cf.6.2 and 7.2)

17 Gauldalsvidda, cf. 6.2

(C12) *When strong external pressures from resource competitors, this has contributed to strengthening of the internal management regime, and thereby increased the capacity of coordination.*

8.2.5 Summing up capacity factors

Our results in subchapter 8.2 can be summed up in table 8.4.

Table 8.4. Observed differences with respect to capacity of coordination development

H#	Factor	Regional difference	C#	Possible contribution
H4a	Regulatory principles	Not different	C6	No clear indications
H4b	Internal strength of regime	Not different	C7	No clear indications
H6a	Mutual trust-herders vs. extension service	Clearly different	C8a	Probably contributing
H6a	Mutual trust- organization vs. government	Not different	C8b	No clear indications
H6b	Appropriate institutional systems	Clearly different	C9	Probably contributing
H6c	Economical and political gain-government defective understanding	Clearly different	C10a	Probably contributing (negatively)
H6c	Economical and political gain-Str.B-followers interest of malfunction	Clearly different	C10b	Probably contributing (negatively)
H7	Overall system consistence	Clearly different	C11	Probably contributing (negatively)
	External resource pressures	Clearly different for Str0ndelag/Hedmark	C12	Probably increasing capacity

From the table we can sum up four major findings related to the capacity of coordination: (1) no clear indications of difference in effect of traditional regime (C6 and C7), (2) no clear indications of difference in effect of the co-management system on organization – government level, (3) clear indications of difference in effect of co-management system for the herders (C8a, C9-11), and (4) effects of external resource pressures for South Trondelag/Hedmark (C12).

On interpreting, (1) means that our material does not provide us information making it possible to conclude whether differences in traditional regimes contributes differently to changes in capacity of coordination, and (2) similarly about possible differences connected to the top level of the co-management system.

Our findings, (3) and (4), are connected to factors where we have material that can be a basis for inference. Finding (3) is based on a cluster of four registered factors connected with the co-management system and its adaptation to the traditional system. They are also to some extent interconnected; however not enough to consider them as a composite factor.

Let us try to reveal their relations by comparison of the effects of the findings. Both *mutual trust* (C8a) and *appropriate institutional systems* (C9) seem to be related as the both are connected to

the herders' dialogue with the majority society and efforts to increase the capacity of coordination. The distinct regional differences seem to express a basic feature.

Governmental understanding (Cl0a) was clearly improved during the 1980's, but overgrazing problem is still not solved.

As for herders' interest in malfunction of the governing system (ClOb), winners of the pasture competition (cf. 7.5) still are rather happy with the situation (cf. Karlstad, 1998).

The lack of overall system consistence, C11, had a clearly negative effect in the North, which was reduced during the late 1980, but that has not solved the overgrazing problem.

Seeing the cluster (C8a and C9-C11) as a whole, our findings seem to fall into two groups; *temporal* and *more permanent* effects. It seems as two of the factors, lack of governmental understanding (Cl0a) and system inconsistence (Cl1), have had only a temporal effect, and that the solutions of these partial problems not have solved the fundamental overgrazing problem.

This may give reason to see them as not so important as the remainder of the cluster; mutual trust (C8a), appropriate institutional systems (C9) and strategy B-followers' interest in malfunction (Cl0b). These effects seem to be more permanent.

Above we found an interrelation between C8a and C9. We may also see a relation between appropriate institutional systems (C9) and strategy B-followers' interest in malfunction (Cl0b). We would not expect pasture competition winners (ClOb) to feel the regulation efforts appropriate (C9), but what about the losers? The externality described in 7.5 involve that followers of Strategy A will become losers, so why should they support the regulation efforts, if they do not believe that they will work.

In game theoretic terms the watershed is between games as Assurance and games as Prisoners Dilemma (cf. 2.2). The game may become like Assurance if many enough find cooperation as a possible option (cf. Runge, 1992). Regulations might be a support for herders with the intention of playing Assurance. The cooperation situation developed in the South seems to be in accordance with a conditioned strategy like Assurance.

On the contrary, Prisoners Dilemma is a dominant strategy, Assurance players would lose if they meet a player of Prisoners Dilemma; therefore they may as well play Prisoners Dilemma, too. In our North setting, Strategy A and regulations do not seem feasible. There is thus no reason to support regulations. As a conclusion, we cannot expect the losers in the North pasture competition to feel very enthusiastic about the regulations.

Probably *all the factors mutual trust (C8a), appropriate institutional systems (C9) and strategy B-followers' interest in malfunction (ClOb) seem to be important, and influencing the capacity of coordination.*

The evaluation of the external resource pressure for South Tr0ndelag/Hedmark (C12) is not straightforward either. On comparing history of the two Tr0ndelag sub-regions (cf. Figure 7.7, cf. Table 7.10), we register that South Tr0ndelag/Hedmark seems to have been more *pioneering* on Strategy A than North Tr0ndelag. Could we by this infer that the development among North Tr0ndelag herder has been dependent on the development among their southern fellow -herders? Digging a bit deeper in North Tr0ndelag history, we find several indications of an ongoing

change (cf. 6.2 and 7.2), and I do not find enough evidence to infer that it is dependent on South development; i. e., the external resource pressure may be a contributing, but not a necessary factor.

Let us then draw some formal conclusions (potential necessary factors with bold types):

(RC8a) ***When mutual trust between herders and extension workers exists, this seems to have been a factor contributing to, and potentially being necessary for, strengthening the capacity of coordination.***

(RC9) ***When the institutional system was felt to be appropriate and thus legitimate, the new co-management system seems clearly to have contributed to, and potentially being necessary for, increase in capacity of coordination.***

(RClOb) When followers of Strategy B had interest in the malfunction of the regulation system, this seems to have contributed to, and potentially being necessary for, constraining the capacity of coordination.

(RC10a) When the government had defective understanding of the real function of the regulation system, this seems to have contributed to, but not being necessary for, constraining the capacity of coordination.

(RC11) *When imperfect overall system consistence, this seems to have been a constraint upon, but not being necessary for, the capacity of coordination.*

(RC12) When strong external pressures from resource competitors, this seems to have contributed to, but not being necessary for, strengthening of the internal management regime, and thereby increased the capacity of coordination.

In this subchapter we were not able to detect differences in the traditional regimes" contribution to the development of capacity of coordination (C6 and C7). However, we have detected three factors that probably have contributed to the influence of the capacity of coordination (RCl0a, RC11, and RC12), while three others (RC8a, RC9, and RCl0b) seem to have not only been contributing, but may also have been necessary factors for increasing or decreasing the capacity of coordination.

As the South adapted positively to the new regulations while the North adapted negatively, our findings above give reason to think that the regional differences with respect to the three factors that might be necessary for influencing capacity of coordination (RC8a, RC9, and RCl0b); might have some deeper connection. They seem to be connected with the capacity for transformation, that is, the society's ability to create new capacity for coordination when in deficit. We will discuss this ability further in the following subchapter.

8.3 Factors influencing capacity of transformation

A society's capacity of transformation becomes relevant when there is deficit in capacity of coordination, in particular when there is large and rapid changes. This includes both "pure" internal processes and processes that involve cooperation with government representatives. The

former is generally dependent on leadership and social capital, while the latter involves middleman roles. We remember that in a long-run process of State-minority encounters both state officials and minority representatives may act in different middleman roles. In our hypotheses we have focused on one relevant aspect of the physical world and two aspects of the minority society as well as one aspect of the majority society.

8.3.1 Landscape structure (H2c)

Our hypothesis was:

(H2c) *An open landscape with relatively large scale CPRs will promote a community with a lower capacity of transformation than the converse.*

This was due to a greater complexity and thus greater transactional costs. The South areas clearly are smaller than the North, with closer overall social relations (cf. Kappfjell, 1998). The relative closeness to Norwegian farmer societies also had made the South Sámi more used to responding to external changes (cf. 6.2). For Guovdageaidnu, Paine (1994) holds that each of the three parts of the autumn/fall pastures, are distinct social systems. Within a weaker overall system, rapid changes might have been difficult to assess and handle as a collective.

This can become even clearer comparing with Karasjok, as geographically it is clear that Gouvdageaidnu has "deeper" winter pasture areas than Karasjok, and historically that the sedentarization also was particularly slower in Guovdageaidnu than Karasjok (Vorren 1960, cf. Solem, 1970). Much of the traditional society was still intact in 1960. This might have made Guovdageaidnu less prepared to take up the challenges when the changes started during the 1960's. Though this seems to be in line with our hypothesis we should be a bit prudent in concluding:

(C13) *An open landscape and great scale CPRs, this might contribute to a lower capacity of transformation than the converse.*

8.3.2 Understanding Need of Change (H5a)

Our hypothesis was:

(H5a) *The more developed is the general understanding of the need for implementing change is, the higher will the capacity for transformation be.*

Kappfjell (1998:41) asserts that more efficient christening in the North than in the South had contributed to a higher degree of dissolution of traditional society. Given that this is correct, this clearly would contribute to a lower ability to react as a society towards external challenges. What, however, is beyond discussion, is that the South Sámi has a longer and deeper tradition of organization and dialogue with the government, than the North Sámi (cf. 6.3).

Already in the mid-1960's professionals asserted that the total Finnmark herd size was at or exceeded summer pasture capacity (Lyftingsmo, 1965; Movinkel, 1964). The bilateral pasture commission agreed (Reinbeitekommisjonen, 1967, cf. 7.1). State consultant Villmo (1974) found

indications that the major loss of animals from a series of epidemic diseases in 1972-1973 could be a result of overgrazing. In the extension service magazine Reindriftsnytt, Villmo advanced a warning to the Finnmark herders in 1978, asserting that the herd size was then at a level which historically had caused serious herd size declines (cf. Figure 7.3). I have not found indications on that North herders found the total grazing pressure as a problem in the 1970's. Maybe it is no wonder; total herd size did not become higher than it had been before the end of the 1970' s. The development was incremental, and who could see into the future of the 1980's and the 1990's. There were probably not clear enough signs of any crisis.

When a new governing structure was established in 1979/80, a main task was to limit Finnmark herd size through implementing herd quota regulations. Prestbakmo (1984) refers as *main viewpoints among West Finnmark herders; total herd size is too large at all season,* particularly at fall/spring and winter pastures. *Herder representatives were nevertheless skeptical to extensive regulations in herd size,* and the decisions made by the boards (with a herder majority)[18] which had the authority to decide the limits, were 25-30 % higher than professional proposals (Reindriftsstyret, sak 32/87). This seems contradictory. How can we explain the deviation between herder viewpoints and their acting in the governing boards?

Above in 8.2.5 we have considered the possible situation of a Prisoners Dilemma situation in the North. *Maybe many herders knew that they really were overgrazing, but felt the situation impossible to do anything.* In addition, basic values (the ideology of becoming a big herder, cf. 8.2), the consensus principle (cf. 6.2), personal relations as well as the physical power of the large herd, obviously provided followers of Strategy B with political power exceeding their number. This probably influenced the general opinion on perceived need of change.

The South situation was clearly different. In the 1960's and early 1970's there was a crisis felt among a wide circle of persons in the South area and a growing demand for new solutions among the herders. The role of the South leaders is consistent with this (cf. 6.2). There are several examples of herders trying to find new opportunities and new ways of practicing reindeer management (Ramstad 1967, cf Fjellheim, 1996). The general understanding or opinion in a society is not easy to assess in retrospect. I have used statements in written and oral sources. The sources could be more extensive, but are nevertheless clear.

(C14) A *general understanding of a need of internal change seems to have had effect upon the capacity of transformation.*

8.3.3 Leaders capability of introducing solutions (H5b)

(H5b) *The existence of leaders who can find and implement solutions that are considered culturally appropriate will tend to enhance the capacity for transformation.*

Leaders' actions are clearly dependent on the general understanding in the community they live in. Nevertheless, also in acephalous societies, there have to be individuals taking the lead to find and implement the actions required by the situation faced.

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[18] Regional Board (for West Finnmark) and Central Board (for Norway) both with herder representatives in majority.

North

Focussing internal roles Paine (1970) found a link between individualistic goals and attitudes towards leadership during his Guovdageaidnu fieldwork of the early 1960's, concluding:

> "No Kautokeino owner wants to be a leader any more than he wants to be led. What he wants is successful herd management, and this is accomplished through manipulating opportunities (Paine, 1970:66)."

I would be somewhat reluctant in inferring that this attitude is representative for the whole region of West Finnmark without more data (Paine's fieldwork is mainly from one of three zones), but it is nevertheless a useful starting point. What is clear empirically, is that Guovdageaidnu herders have not been very pronounced in prehistory (from early in the last century up to World War II) and the early history of the organization NRL. In the 1950's, there were problems to make Finnmark Sámi take part in the annual organization meetings (Berg, 1997:92). Their participation has been limited, absolutely, but particularly relative to their magnitude, both as members and leaders. Even though Guovdageaidnu and other North Sámi leaders have been very important for NRL from the 1970's, organization percentage in West Finnmark seems to be clearly lower than in the South and also in Karasjok. Guovdageaidnu has probably the lowest in the country, but numbers are not public.

The activities both through NRL and BES (cf. below) in the 1970's and the 1980's are a testimony of social capital and to some extent contradicts Paine's statement above. However, it can be useful to focus the orientation of North leaders. The anthropologists Snell and Snell (1975) have, when characterizing persons orientation, made a distinction between *occupationalists* meaning that their main concern was reindeer management as a way to support themselves, and *culturalists* having ethnic identity and preservation of traditional culture as their main concern. If we study both the organization history (Berg, 1997) and relevant issues of the extension journal (Reindriftsnytt, 1968-1990), we can find support to the impression that internal development problems of reindeer management were not a pronounced concern for North leaders in the 1970's (as Anders Oskal from Troms) and the early 1980's (as Johan J. Eira from Guovdageaidnu). Working both with the Agreement and the Act property right claims, the general position of the Sámi towards the Norwegian society and sustaining traditional culture seems to have been important engagement fields. Following the Snell and Snell (op. cit) terminology they should rather be characterized as culturalists.

The North has also had occupationalist leaders. The most prominent example is Ole K. Sara. Coming from a herder family, but not active as a herder himself, after training and service as a military officer, he became Lapp Sheriff in West Finnmark and also made a political carrier through the Social Democratic Party. Sara was concerned about low income and living standard in the North herder society (Sara, pers.com.). He was appointed Secretary of State for the Ministry of Agriculture in 1973. There he played a key role in developing the new institutional structure implemented the 1980's. From 1980 he became the first leader of the new Agency of Reindeer Management ("Reindriftsadministrasjonen"). In the late 1980's and the early 1990's NRL had a leader with a business school diploma, Odd Erling Smuk, from Varanger, East Finnmark. In the late 1980's Smuk and Sara shared a concern about the low income of the North and agreed upon a policy to reduce the number of Finnmark herders and increase the income of the remaining. In the late 1980's the State and organization cooperation headed by Sara and Smuk was rather close and the Finnmark policy seemed to become more effective than before. In this situation a competing organization (to NRL), BES emerged. BES managed in 1987 to gather about 300 members in Guovdageaidnu and Karasjok (Paine, 1994). This organization strongly criticized NRL and its cooperation with state authorities in the creation of regulations (Paine,

1994), What is particularly interesting is that this organization emerged at a time when the parties agreed to increase their mutual efforts to get the Finnmark herd increase under control.

Summing up the development in the 1970's and 1980 does clearly demonstrate that *the North had leaders with capability of implementing changes.* However, we have not clear indications that North herders generally felt it necessary to take action against the herd growth in the 1970's and the early 1980's. Further when the North occupationalists in the late 1980's implemented changes these met opposition. Obviously the regulations then implemented by the State and supported by the NRL were felt as a threat towards traditional North reindeer management practice. BES leader Mathis M. Sara could be characterized as a typical culturalist as his arguments focus the value of traditional culture and livelihood.

South

Historically the South dominated the Sámi ethnopolitical activity. As early as the 1920's, South herders managed to get consulted by the government (Berg, 1994). Berg (1997) also finds a clear line from this period to the postwar area. The NRL leaders of the 1950's Lars and Paul Danielsen were the sons of Daniel Mortenson, who (together with Elsa Laula Renberg) pioneered the meetings of 1917 and 1921. Like their father, they worked for a more rational reindeer management which focused on meat production (op.cit.:42).We could label them occupationalists. In the late 1950's, Anders Fjellheim became NRL's secretary and editor of the organization magazine Reindriftsbladet. During the period 1960-1966, he also played an important role in the committee preparing the proposal for the revision of the act of reindeer management (Fjellheim, pers. com., cf. Berg, 1997:81-85). As mentioned earlier, Paul Fjellheim was in charge of the organization when NRL became firmly established and the basis for the cooperation with the government was laid. Thus, these South Sámi leaders played a central role in the design of the resource control system introduced in the 1978 Act, including both RPD and household herd quotas, and also in the development of the Main Agreement.

Conclusion

I find that the South contrasts clearly with the North with respect to: (1) perceived crisis in the 1960's and 1970's, (2) organizational tradition, and (3) the leaders' focus on internal change. On considering these attributes we note that (1) is basic, since problem recognition is the foundation for problem resolution. The feature (3) is connected with (1), and (2) is a vehicle increasing the possibility of problem resolution. Thus, for the North, we can conclude that as there were no strong and general understanding of a need for implementing institutional changes, *the potential transformation capacity for the society probably was not fully utilized in the 1960's and the 1970's.* The real challenge of action seems not to have been taken up by this society before late 1980's. For the South society we have found three important and interconnected contributing features; of which is difficult to distinguish the relative importance of. Incorporating (C14) and summing this up in one conclusion we have:

(C14/l5)Where there is: (a) a general societal understanding of a need of internal change, and (b) an orientation of herder leaders towards finding solutions, this seems to have been contributing to the development of a society's capacity of transformation. Where(c) the society has a strong organization tradition the capacity of transformation is enhanced further.

8.3.4 Cross-cultural understanding (H8)

Our hypothesis was:

(H8) *The higher the level of cross-cultural understanding among the responsible state actors is, the higher will the capacity of transformation tend to be.*

Though we here have focused the herder side, the State side in a co-management system is important. Though Scandinavian Sámi are far better off than their fellows in Russia (cf. Robinson and Kassam, 1998:89-101), the Scandinavian countries should not be proud of its historical treatment of the indigenous people of the North (cf. 6.2). In Norway many people feel there has been a fundamental change in State minority policy during the four decades from 1960. The Sámi have established democratic assemblies in Finland, Norway and Sweden. In Norway the Prime Minister in his New Year speech two weeks ago asked the Sámi forgiveness for historical oppression.

Let us have look at an outsider characteristic of Scandinavian Sámi Policy. The Australian expert of comparative minority policy Peter Ml (1995) asserts: 1) that the main achievement of government policy in Sapmi is the high living standards including high quality public services and infrastructure shared by Sámi and non-Sámi. 2) On the other hand the great failure of Scandinavian policy is that governments and their experts have been unable to recognize the plain fact of Sámi life: that the Sámi have lived and been the principal occupants of large tracts of Northern Europe since the Ice Age. 3) Further when the Sámi in rich and democratic Scandinavia achieve so little recognition of their rights, and Sámi leaders silently accept this, how can indigenous peoples in other parts of the world take Scandinavia as model of minority policy? The paradox behind this critique is that the poor Inuits and Native Americans of Canada has achieved far more extensive land rights than the Sámi, e.g. the autonomous area Nunavut and also extensive rights in other traditional areas.

We should note that this is a characteristic of General Sámi Policy, not Policy of Reindeer Management. The critic is harsh, but it is neither unfair nor incorrect. For reindeer management, the crux of the matter is that the main achievements of the herding Sámi is not through Sámi Politics, but through Industrial Politics (cf. the distinction culturalist/occupationalist, above). The reindeer managing Sámi have been rather reluctant to support the Sámi Parliament, a new central institution. They have their reasons; what they have achieved is through their own organization, NRL. The problem of Reindeer Management Policy in this respect is that its political basis is rather narrow. It started around 1970 with a few herder leaders, some professionals and a few positive politicians (Villmo, pers. com., cf. NOU1975:5). This basis of course has been broadened somewhat, but not really much. During the 1990's much of the achievements of the South reindeer management is lost or at least reduced as conservation of big carnivores according to the Bern convention is given priority before the conservation of the resource base of the indigenous people (Sletten, pers. com.).The achievements of the reindeer managing Sámi is mainly as Industrial Policy and not so much through Minority Policy. This developed a capacity of transformation for the 1970's and the 1980's. This is a narrow basis and it is probably not sustainable when exposed to hard external pressure. However, this does not seem to have influenced the two regions we inquire differently in the period of our study. As a conclusion:

(C16) *We cannot conclude whether the level of cross-cultural understanding among state actors seems have influenced the capacity of transformation.*

8.3.5 Summing up capacity of transformation

Our findings in 8.3 are:

(C13) *An open landscape and great scale CPRs, this might contribute to a lower capacity of transformation than the converse.*

(C14/15)*Where there is: (a) a general societal understanding of a need of internal change, and (b) an orientation of herder leaders towards finding solutions, this seems to have been contributing to the development of a society's capacity of transformation. Where(c) the society has a strong organization tradition the capacity of transformation is enhanced further.*

(C16) *We cannot conclude whether the level of cross-cultural understanding among state actors seems have influenced the capacity of transformation.*

In evaluating the relative importance of these factors the landscape (C13) seems to be of lower importance than the C14/C15 as the 1987 BES action indicates that North herders took action when they really felt it necessary. However, this can be an indication that *the problem maybe was not lack of capacity of transformation.* Seeing this in connection with the possible Prisoners Dilemma situation, the situation could be to difficult that action was considered a realistic alternative.

Chapter 9
Discussion and conclusion

In this study we started out with posing a question of how to explain overgrazing and low income in the Sámi region we have denoted as North. We continued with developing a resource economic theory for reindeer management and placed this theory into a relevant institutional context by applying the IAD Framework. To handle the dynamics between resources and regimes we defined the concepts *need of* and *capacity of coordination* as well as *capacity of transformation.* We discussed how possible changes in *herding* and *husbandry technologies* influence the production system and also may create CPR problems. We have focused how diverse physical and institutional factors could influence the herders' choice between expansive and stabilizing strategies.

Empirically we have conducted a comparative study bringing attention to the differences in performance between the geographical area North with the one we have called the South. The South contrasts with the North in that it has stabilized pasture utilization and developed high income. External influence, public policy included, has mainly been the same for both the North and the South. We have inquired the development of the production systems in the two regions. Generally the snowmobile introduction started a fundamental change in herding technique which to a great extent solved the control problems of the postwar period, which had been most serious in the South. On the other hand, the technological development put reindeer management in a potential cost-price squeeze which led to two possible responses: (1) *herd expansion* or (2) *productivity increase.*

If the first option were chosen, herd size would at some stage confront resource limitations, leading to an increased resource competition. If the second option were chosen, the full utilization of the potential would require a change in cooperation which to some extent would break down the traditional division between herding and husbandry practice. Empirically we found a distinctly different development pattern in the North and South regions where the main choice of the North was *herd expansionism,* and the main one of the South was *productivity increase.*

In our analysis of how different factors could explain the contrasting North and South development patterns, we have in Chapter 8 we have analyzed three independent sets of factors, related to need and capacity of coordination and capacity of transformation, *within* each of these three sets. We will now bring all this knowledge together - i.e. we will discuss relative importance and try to illuminate possible interrelations.

9.1 Deficit coordination capacity

At the start of Chapter 8, we found basal condition for the a major increase in total herd size as such:

(Cl) *A major and permanent herd increase to a distinctly new and higher level is improbable without a major change in the production system as facilitated through a technological change.*

In 8.1 we concluded by finding two physical features that seemed to be important for the major increase in the need of coordination:

(RC2&3) *Successful implementation of Strategy B seems to be dependent on the co-existence of summer pasture limitation and a relatively open and borderless landscape, in particular by lacking or insufficient borders between seasonal pastures.*

Of these factors, the technological change itself (Cl) is in the position of being the triggering factor of the whole process. The factor works both via an increase in herd control abilities, and through a cost-drive that creates a need of increase in revenue. The two ecological factors co-work as the summer pasture limitation (RC2) is necessary for creating the need of grazing out of season, while the pasture scale and border-condition (RC3) is necessary to make grazing out of season easier.

If the total increase in need of coordination created by these (and other) factors is not met by a corresponding increase in capacity of coordination, there may emerge a deficit of coordination capacity, and the complex over-harvesting externality described theoretically in 3.4 will take place with overgrazing of lichen pastures.

For the potential necessary capacity factors we concluded (cf. 8.2):

(RC8a) *When mutual trust between herders and extension workers exists, this seems to have been a factor contributing to, and potentially being necessary for, strengthening the capacity of coordination.*

(RC9) *When the institutional system was felt to be appropriate and thus legitimate, the new co-management system seems clearly to have contributed to, and potentially being necessary for, increase in capacity of coordination.*

(RC10b)When followers of Strategy B had interest in the malfunction of the regulation system, this seems to have contributed to, and potentially being necessary for, constraining the capacity of coordination.

When observing an empirical CPR problem as a deficit of coordination capacity, the problem can have different possible origins (cf. Figure 2.5). To find which is the most probable in our North case, we first have to track, so far as possible, the development of both need and capacity of coordination. We start with the need side and the main conditions for increased need (Cl and RC2&3). The technological revolution itself is a clearly observable process; that is *the need of coordination has obviously gone through an upward shift,* in both regions, however clearly *greatest in the North.*

It is more difficult to assess the development of the capacity of coordination. However another comparison with the South can be useful. Even though the South do not meet either of the other physical conditions (C3, C4) for promoting Strategy B, obviously the need of coordination increased clearly also in the South. Since South did not develop a deficit of coordination capacity in the 1970's and the 1980, the South either had sufficient capacity of coordination or increased its capacity during the same period.

Going back to our North South comparison of traditional regimes, we did not find clear differences, while the differences were very clear for the functionality of the co-management

regime of the 1980's. As the South experienced control problems up to the 1960's and these were solved, the functionality of the co-management system is consistent with an increase in the capacity of coordination. As the traditional regimes seem to have been fairly alike in the North and the South, *the North capacity of coordination probably also was low in the 1960's,* however sufficient though.

It seems as the main features are like this:

1) Need of coordination (NOC) has increased clearly both in the North and the South.
2) The NOC increase is undoubtedly much higher in the North than the South
3) The capacity of coordination (COC) of 1960 was rather low and fairly alike in the North and the South
4) The COC of 1960 was sufficient in the North and insufficient in the South
5) In the South the COC has increased clearly and sufficient
6) In the North the COC has not increased sufficient to cope with the increase in NOC, and there is a deficit of COC

If we sketch this as in Figure 2.5 the development pattern of the two regions may look like this:

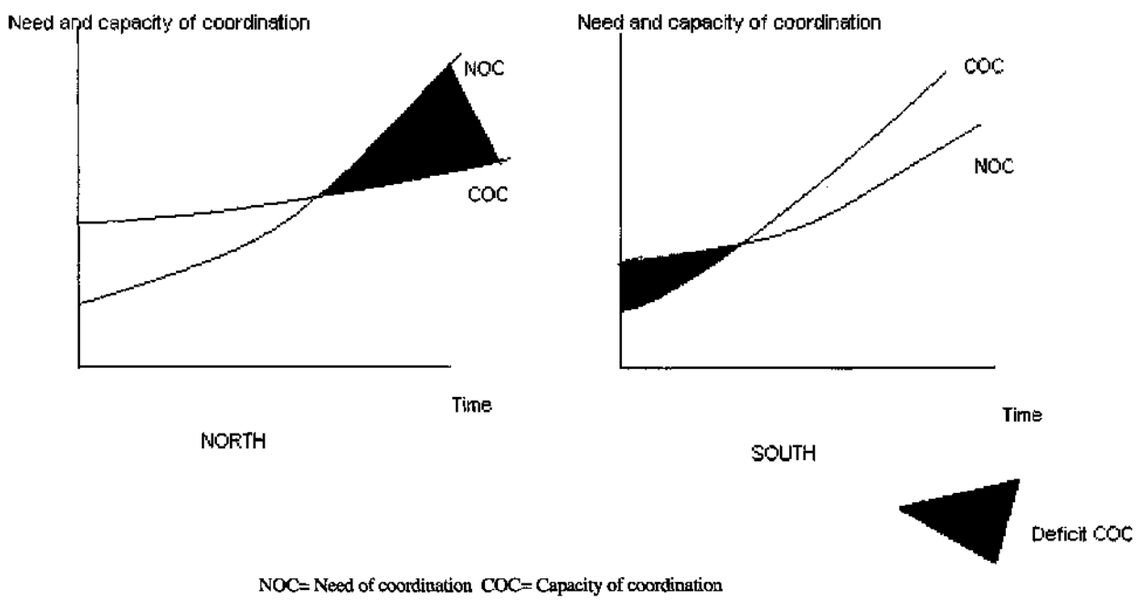

Figure 9.1. Development trends in North and South needs and capacities of coordination.

Deficit capacity of coordination within a regime calls for the society's capacity of transformation.

9.2. Capacity of transformation

Our main findings in 8.3 were:

(C14/l5)Where there is: (a) a general societal understanding of a need of internal change, and (b) an orientation of herder leaders towards finding solutions, this seems to have been contributing to the development of a society's capacity of transformation. Where(c) the

society has a strong organization tradition the capacity of transformation is enhanced further.

I find that C14/15 gives a good explanation for how the South managed to create new capacity of coordination. For the South all three points (a), (b) and (c) seem important.

For the North I find it more difficult to draw a certain conclusion. For the capacity of transformation, point (a) the need of understanding, probably was the most important. However, as I pointed to in 8.3.5, maybe lack in capacity of transformation was not the main problem. Maybe existing capacity of transformation was underutilized, as the problem, when perceived became too overwhelming to recognize?

9.3 Conclusion

In Chapter 8 we tested all our hypotheses and sorted out the factors we found to be the most probable as important to explain the North development in contrast with the one of the South. Above we have connected our main findings for need and capacity of coordination as well as capacity of transformation.

We singled out a pair of physical features on the need side and three institutional factors on the capacity side, all three of them connected to the functionality of the co-management system established. The presence of the two institutional factors, mutual trust herders-extension workers (RC8a) and appropriateness of the institutional system (RC9) seem to be the outcome of societal use of capacity of transformation; which seem to have been used in the South. This seems to have contributed to a situation based on conditioned strategies.

The third institutional factor; interest in the malfunction of the co-management system (RCl0b) may have restricted the use of capacity of transformation in the North. Thus, while the South seems to have created new capacity of coordination, while the North has not, at least not in a sufficient degree. It may be the case that dominant strategies have made existing capacity of transformation more or less irrelevant.

The most important factors seem to be the physical features of the pastures and the capacity for transformation and its use. We may summarize (1) *The natural conditions for adapting to the technological change were more in favor of stabilizing strategies in the South, and (2) the South Sami were also better prepared than their fellows in the North In addition (3) winners of the North pasture competition and the setting itself might have influenced the remainder of the herding society to not take actions.*

9.4 Alternative Perspectives and Explanations

The problem studied is complex and also controversial. To be successfully explored a broad perspective seems necessary. The one chosen in this study is not the only possible. Nilsen and Mosli (1994) have conducted an analysis of the changing adaptations of the households within a West Finnmark siida for the period 1960-1993. Their analysis is interesting, focusing the economic interaction between the household and its surroundings. Their conclusion is that the direct cause for herd size expansion from the end of the 1970's is can be explained by the State subsidy increase and the new availability of external wage labor money for women. Using a

comparative perspective we found that exposed to broadly the same external influence, South reindeer management households did not invest these additional revenue in herd size expansion.

Robert Paine is one of the anthropologists that have conducted the most extensive studies of reindeer management. His concepts herding and husbandry is basic for my understanding of reindeer management as a production system. His analysis of the interaction between landscape features and strategies within herding and husbandry (cf. 6.2) is an excellent entry to an understanding the dynamics of further change in the production system. Paine presents his analysis of West Finnmark and the 1980's both in a journal debate (Paine,1992; 1993) with Ottar Brox (Brox,1993), who had conducted comparative analysis (Brox,1989), and a book (Paine, 1994). The debate I have commented extensively on elsewhere (Riseth, 1998), so just a few points here.

Paine's main thesis is that the (alleged[19]) crisis in Finnmark is the outcome of the State's actions to prevent the same crisis; mainly pointing to regulation efforts and subsidy policy[20]. Further, Paine condemns State actions as misguided, and both morally and legally questionable. However, his analysis of the relation between the pastoral society and the herders' organization is wanting. Putting all blame on the State, we do not receive an explanation of how the organized reindeer herding Sámi influenced public policy, e.g. connected to his analysis of North herders attitudes on leadership.

In order to restore pastoral responsibility Paine (1994:196) advances the idea of *flexible self-adjustment to pasture as a limiting factor* for the future development. In admitting that Paine's has a very good point in that the State never had analyzed what would be the outcome if the herders did not adapt as expected, I find his vision a bit paradoxical. Probably adjustment to pasture is the factor that really has worked in the 1990's (cf. 8.1). Further, whatsoever verdict can be put on State regulations of the 1980's, the most important fact about them in the North probably is that they did not function, and the main reason for that was herder resistance.

A part of Paine's critique of the government is, that when the State take the responsibility from the herders for their own industry this will undermine the herders responsibihty and promote asocial tendencies:

> "With such erosion of the pastoralists' responsibilities, "irresponsibility" in the form of asocial individualism likely follows" (Paine, 1994:195).

I cannot disagree in such a statement. However, I am suspicious that there is another source of asocial individualism that is at least as important as State interference; the tough situations of competition over ever more scanty pasture resources.

Nevertheless, being critical to others' contributions I do not think I have found all the answers. More, I find some of my answers to be rather sketchy. This is in line with the ambition of this study, to be exploratory more than to provide a full test of theories. Some of the factors and explanations involved might have been examined more thoroughly and systematic, and in future studies, they should. I find my approach to be of no less importance as a contribution, than my results. I think both the IAD Framework and comparative analysis has much to offer for analysis of complex CPR problems.

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[19] Like Bjørklund (1990) Paine asserts that overgrazing is exaggerated or not well documented.

[20] Kosmo and Lenvik criticized the subsidy system already in 1985 and corrections were implemented from 1987/88, cf. 8.1.

9.5 In retrospect

In the end we could ask whether the explanation given here seems reasonable in a broader perspective. The physical differences are clear, and the development is well documented. The technological externalities we have described are also in line with common-property theory. The relation between landscape structure and pasture balance is, however, not fully discerned. More examples would have given a better basis for more far-reaching inference. A systematically comparative analysis of both summer and winter pasture limited CPRs of different size would be a challenging task (if there are sufficient variation of cases) to achieve more complete explanations. Nevertheless, this is question of how precise our explanations could be, not so much their general validity for explanation.

Our second main conclusion is more to discuss. Why did South herders, cooperating with the State, take action to regulate herd size, while North herders not? South herders hade experienced problems during the postwar period, and they had a tradition for government cooperation. South herders therefore obviously have managed to utilize the new co-management system to their long-term advantage, though the system deviated from Sámi traditions.

The Guovdageaidnu society seems not to have been so prepared. The North Sámi have a shorter organization tradition. As we have seen, the biological and economical thought basis of the new institutional system was mainly developed between professionals and South herder pioneers (through an "occupationalist" approach). In the North property rights and reindeer management as a Sámi way of life was the main concern (a "culturalists" approach). Both approaches united in NRL from the late 1960 and it seems as nobody considered these different approaches as contradictory.

We should recognize that the situation of a major lichen pasture overgrazing probably is a new situation in Guovdageaidnu. Further, it seems as all parties underestimated, or did not understand, the seriousness of a couple of circumstances. The first is the development of the technological externality started by the snowmobile revolution and the dynamics where a competitive game of the second order commons during a couple of decades implied a serious overgrazing. The second is the one of *system* and *goal correspondence.* If all parties in a multilevel system, which is officially based upon stabilizing strategies, not really agree in these strategies, but may continue with off-record strategies, then the system cannot function.

Many explanations could be found. One is humans' limited capacity of cognition; how could anyone imagine the aggregated long-term consequences of a series of actions. Another is politics; probably parties going into alliances and compromises during the 1970's used the room of flexibility, which was available. Probably nobody would have been able to achieve support for advancing, e.g., an idea of different regional solutions for the North and the South. Maybe the overgrazing was necessary due to path dependence. What we can learn from the South example is that the internal problem recognition is the basic. External persons can serve as supporters, but the drive for problem resolution must be internal.

In the late 1990' s supplementary feeding have become increasingly more relevant, as the lichen pasture biomass steadily decreased; the North famine winter 1996-1997 has pinpointed this question. The North situation at the turn of the Millenium is maybe closer to the Finland situation than most people that are concerned about the development of North reindeer management would like to admit. Kumpala's (1998) article has its main focus on mainstream reindeer

management in Finland, which is the rather stationary Finnish (farmer-related) reindeer management. Particularly interesting is his visit to the reindeer management of Northern Finland, which is Sámi reindeer management as in Finnmark, and just on the other side of the national border. The author explains than in recent years, also this reindeer management, has taken up supplementary feeding, and might become dependent on it, and thus have to adapt to higher costs. If West Finnmark lichen overgrazing continues, which is not unlikely, North herders may end in a similar situation as their colleagues across the border, within a number of years. Who can then afford to stay in business?

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Appendix I

INTERVJUGUIDE (in Norwegian only)
Intervju av en eldre reindriftssame

1. **Målsetting:**
Få fram data om endringer og endringsprosesser i reindrifta i overgangen fra tradisjonell nomadisk reindrift til moderne bofast og markedsorientert reindrift ut fra informantens egne erfaringer og opplevelser.

2. Metode - Det kvalitative forskningsintervju (Kvale 1995)
Emnet for intervjuet er informantens **livsverden**. Det er temaorientert . Intervjuene skal analyseres med henblikk på en felles sosial situasjon . Hovedoppgaven med intervjuet er å forstå **meningen** i sentrale tema i subjektets livsverden , dvs. i tillegg til fakta også prøve å få tak i underliggende budskap hos informanten . Presisjon i beskrivelse og stringens i meningstolking korresponederer i **kvalitative** intervju med eksakthet i kvantitativ måling. Målet er å oppnå utolkede **beskrivelser** gjennom at informantene gir så fullstendige beskrivelser de kan av sin forståelse og opplevelse, mens tolkningen tilligger forskeren. Beskrivelsene skal være **spesifikke** for handlinger og situasjoner (OBS -Fenomenologisk tilnærming Giorgio 1975)).

Intervjueren skal selv være **veloverveid naiv** for å ivareta åpenhet til nye og uventede fenomen og bevare en kritisk avstand til sine egne hypoteser /kritisk bevissthet til sine egne forutforståelse. Intervjuet skal være **fokusert** på visse teamaer i subjektes livsverden. Informanten skal bringe fram dimensjoner som han oppfatter som viktige. Intervjuerens oppgave er å lede subjektet mot temaet, ikke mot bestemte meninger om temaet. I den grad informantens utsagn er **tvetydige** er det intervjuerens oppgave å så vidt mulig klargjøre om de skyldes komminikasjonssvikt i intervjusituasjonen, relle inkonsistenser, ambivalens eller motsigelser hos informanten. Evt. motsigelser kan være adekvate refleksjoner av objektive motsigelser i deres verden.
Intervjueeren forutforståelse om emnet skal benyttes **sensitivt** for å oppfange nyanser og dybde i temaet.

Et intervju er samhandling mellom to personer hvor intervjuerens person er et instrument i en deltakende observasjon . Som en **mellommenneskelig situasjon** må en være oppmerksom på den gjensidge dynamikken mellom personene både på kognitivt og emosjonelt nivå . Intervjuprosessen kan få informanten til å **endre** mening om noe fordi han oppdager nye aspekter. Et kvalitativt forskningsintervju kan være en **positiv erfaring** for informanten da folk sjelden får oppleve en slik åpen og positiv interesse for et emne fra sin livsverden.

Metoden bygger på åpne tematiske spørsmål, dvs. et halvstrukturert intervju. Jeg har laget en spørsmålsrekke som er nokså spesfikk på de punktene jeg gjerne vil innom (dvs. ligner litt mer på et spørreskjema). Problemet er å finne de riktige overordnede tematiske spørsmålene som åpner for presise beskrivelser innenfor et tema.

Det er laget en dobbel spørsmålsrekke med **forskningsspørsmål** relatert til prosjektets hypoteser og **intervjuspørsmål** som forutsettes brukt direkte under intevjuene.

3. Grunnlag/Forutforståelse

Intervjuopplegget er en videreføring av de hypotesene som er drøftet i Riseth& Vatn (1995). Det bygger på noe videre lesning av kildemateriale og skal også suppleres med noe arkivstudier.

Det er tatt utgangspunkt i de punktene i artikkelen hvor kildene er sparsomme /manglende og lagt vekt på å bringe fram materiale som kan knyttes til teoriene om Property Rights-systemer og Design Principles for Longenduring CPR-Institutions (Ostrom 1990).

4. Før intervjuet:

Informant og intervjuer må bli trygg på hverandre.Generelt /nøytralt prat.
Informert samtykke. Informantens rettigheter. Oppbevaring og bruk av materialet.
Notere navn og fødselsdato-føre liste med nummerering av intervjuene
Briefing om selve intervjusituasjonen. Båndopptaker. Har informanten noen spørsmål før vi starter ?

5. Oppstart

OBS: De første minuttene er avgjørende. Det er viktig å etablere god kontakt med aktiv lytting, å utvise interesse forståelse og respekt for hva subjektet forteller samtidig som intervjueren må være sikker og klar på hva det er han vil vite.

Få informanten til å begynne og fortelle - informantens personlige rammebetingelser

Hvor er du født og oppvokst?
Hvor var familiens driftsområder ?
Hvor bodde dere?
Når begynte du å delta i reindriftsarbeidet?/Hva var barnas oppgaver?
Har du drevet med reindrift hele ditt liv eller har du også hatt annet levebrød?
(Hvor gikk du på skole?)

6. Før og nå
Du begynner å bli gammel nå. Det har skjedd store endringer med reindrifta i løpet av din levetid.

Jeg kan tenke meg at du begynner å fortelle om hvordan det var i reindrifta når du var ung og at vi kommer inn på endringene etterhvert.

7.DET INTERNE SYSTEMET

FORSKNINGSSPØRSMÅL

Intensiv/ekstensiv drift (Beach 1981) Tilknytning mellom flokk og familie.
Har det vært klare interne regler for hvem som kunne etablere seg med eget hushold? (Ostrom 1b)
Hvilken mix av Common Property og Individual Property var det?
Var det klare interne regler for ressursbruken / ressursbelastningen ? Fungerte disse godt ? Tilsvarende for arbeidsfordelingen?
appropriation & provision rules - Ostrom 2)

Hvordan ble beslutninger om endring av interne regler tatt? (Collective choice arr.- Ostrom 3) Hvem tok beslutningene (autoritetssystemet, Bromley)?

Fantes det et internt kontrollsystem og hvordan fungerte det?(Monitoring - Ostrom 4)

Hvilke sanksjoner risikerte de som brøt reglene ? Var det de graderte ? (Ostrom 5)
Fantes det interne konfliktsløsningsareanaer ?(Ostrom 6)
Var det behov for slike? Hvis ikke -skyldes det at det ikke var konflikter- eller at **normer** hindret konfliktene å komme til overflata?

Har disse systemene/mekanismene endret seg over tid- feks. 1930-60-90 eller 1940-60-80 ?

Hvilke grunnleggende normer og verdier har reindriftssamene? (Selvstendighet/Sikkerhet/Samarbeid/Konkurranse?)

INTERVJUSPØRSMÅL

Kan du prøve å beskrive selve måten dreiv på når du var ung. Var dere mye i lag med reinen? Hvor mye flytta familien i lag med flokken?
..over til noe annet..
Kjenner du til fra din ungdomstid tilfeller av at unge som ønsket å starte opp med reindrift for egen regning ikke kom igang ? Hvordan ble han i så fall hindret? Hvem tok beslutningen ?

Kan du fortelle om hva det var som avgjorde hvem som brukte hvilke områder? (Konkrete oppfølgingsspørsmål:
-Har det vært personlige områder eller har alt vært gruppens /sijtens?
-Har der også vært områder som har vært ansett som fellesområder for flere grupper/ distrikter ? Hvor mye betyr "naturlige grenser"- hindrer de konflikter?)

Kan du fortelle om hvordan det ble avgjort hvor mye rein som kunne føres på ulike beiter til ulike tider? Hvem avgjorde ?

Husker du om det noen gang oppsto problemer med ressursbelastningen?
Ble de løst ? Hvordan ?

Husker du noen tilfeller av at enkeltpersoner brukte områdene på en måte som de fleste mente var feil? Ble det oppdaget? Hva skjedde etterpå ?

Kan du beskrive et tilfelle av konflikt mellom enkeltreinere -Hvordan ble det løst? (Fantes det konflikter som ikke kom til overflaten? Hvorfor ?)
Var det viktig hvem som var distriktsformann? Hvorfor ?

Husker du noe tilfelle av konflikter mellom sijter /driftsgrupper /distrikt - Hvordan ble det løst ? Fantes det personer som "alle" hørte på og rettet seg etter?

Kan du fortelle om **hva som har vært det viktigste for deg i ditt liv som reineier?**
Hva har vært viktig med reinflokken? Hva har vært viktig med driftsområdene ?
Vet du om andre ser dette på samme måte som deg?
Husker du på **om synspunktene på dette har endret seg** fra du var ung- middelaldrende- gammel? Har konfliktløsninsmekanismene endret seg i dette tidsrommet ?

8.YTRE PRESSFAKTORER

FORSKNINGSSPØRSMÅL	INTERVJUSPØRSMÅL
Teknologi Hvilke konsekvenser har introduksjon av ny teknologi (motorisering) fått for reindrifta?	Kan du beskrive hva som skjedde da snøscooteren kom inn i reindrifta? Hva mener du om bruk av helikopter som driftsmiddel i reindrifta?
Marked Hvilke virkninger har den gradvise tiltakende tilknytningen til markeder både når det gjelder forbruksvarer, driftsmidler og produkter fått?	Kan du beskrive hva som skjedde med driftsmåten/opplegget når dere begynte å levere rein til slakteri?
Konkurrerende arealbruk I hvilket omfang er reindrifta blitt utsatt for press fra andre arealbrukere - og hvilke virkninger har det fått?	Kan du fortelle om tilfeller hvor andre næringers og interessers bruk av utmarka har hatt konsekvenser for reindrifta? Kan du fortelle om tilfeller hvor andres fritidsbruk av utmarka har fått konsekvenser for reindrifta?
Myndigheter Hvilken innflytelse hadde myndighetenes lovregulering på forholdet(ene) - mellom reindrifta og omgivelsene - internt i reindrifta	Hvordan har du opplevd reindriftsloven(e) når det gjelder å beskytte reindrifta mot press fra andre arealbrukere? Hvordan har du opplevd driftsenhetssystemet i reindriftsloven i forhold til rekrutteringen (hvem og hvor mange) til reindrifta ?
Hvilken innflytelse har tjenestemennene i reindriftsetaten hatt på reindriftas ressurstilpasning ? Lappefogdrollen. Reindriftsagronomen.	Hva kunne lappefogden gjøre for reineierne ? Hva kan reindriftsagronomen gjøre for reineierne ? Hva oppfatter du som det viktigste ved disse tjenestemennenes arbeid?
Hvilke effekter har reindriftsavtalenes tilskuddsordninger hatt for reindrifta?	Har reindriftsavtalen bidratt til å forandre reindrifta - i tilfelle hvordan? Hvilke positive og negative sider ser du ved disse endringene?

9. SPØRSMÅLSTYPER

Introduserende spørsmål
-Kan du fortelle meg om.. ?
-Husker du et tilfelle hvor ....?
-Kan du beskrive så detaljert som mulig en situasjon hvor ....?

Oppfølging
-direkte spørsmål, nikk , pause
- gjenta viktige ord
- legg merke til uvanlige ord, sterk intonasjon, andre signaler for noe som er viktig for subjektet
OBS - Lytt etter hva som er viktig for subjektet - og hold in mente forskningspørsmålene

Undersøkende spørsmål
Kunne du si litt mer om det ?
Kan du beskrive litt mer detaljert hva som skjedde ?
Har du flere eksempler på det?

Spesifisering
Hvordan reagerte du på det ? Hva tenkte /følte du da ? Er det andre situasjoner hvor du har følt på samme måte?

Direkte
Har du noengang.., Hva mener du med ...?

Strukturering
Jeg vil gjerne over til et annet emne...

Indirekte
Hvordan tror du andre... ?

Tolkende spørsmål
Mener du at...? Er det slik at du...? Kan uttrykket... dekke det du mener /har sagt ?
Er det sånn å forstå at ....? Ser du noen forbindelse mellom ...?

Stillhet/Pauser
Gi informanten anledning til å reflektere kan bety ny informasjon

10. OPPSUMMERING/AVSLUTNING

Når du nå ser tilbake på ditt liv i reindrifta og de endringene som har skjedd i dine levedager Hvilke endringer synes du er de viktigste ?

Hvilken betydning har de for livsformen/måten å leve på? Positive og negative(Kulturelle kostnader) sider ved endringene?

(Er det noen av endringene som du synes er vanskelige følelesesmessig?)

Intervjueren kan avrunde med noen hovedpunkter av hva han har lært fra intervjuet. Informanten får anledning til å kommentere det.

Intervjuet kan så avsluttes med : *Jeg har ikke flere spørsmål- er det noe mer du vil si eller spørre om før vi avslutter?*

11. Etter intervjuet

Debriefing. Intervjuet kan ha vært en sterk opplevelse, informanten kan føle seg tom , kan kanskje synes han har sagt for mye.

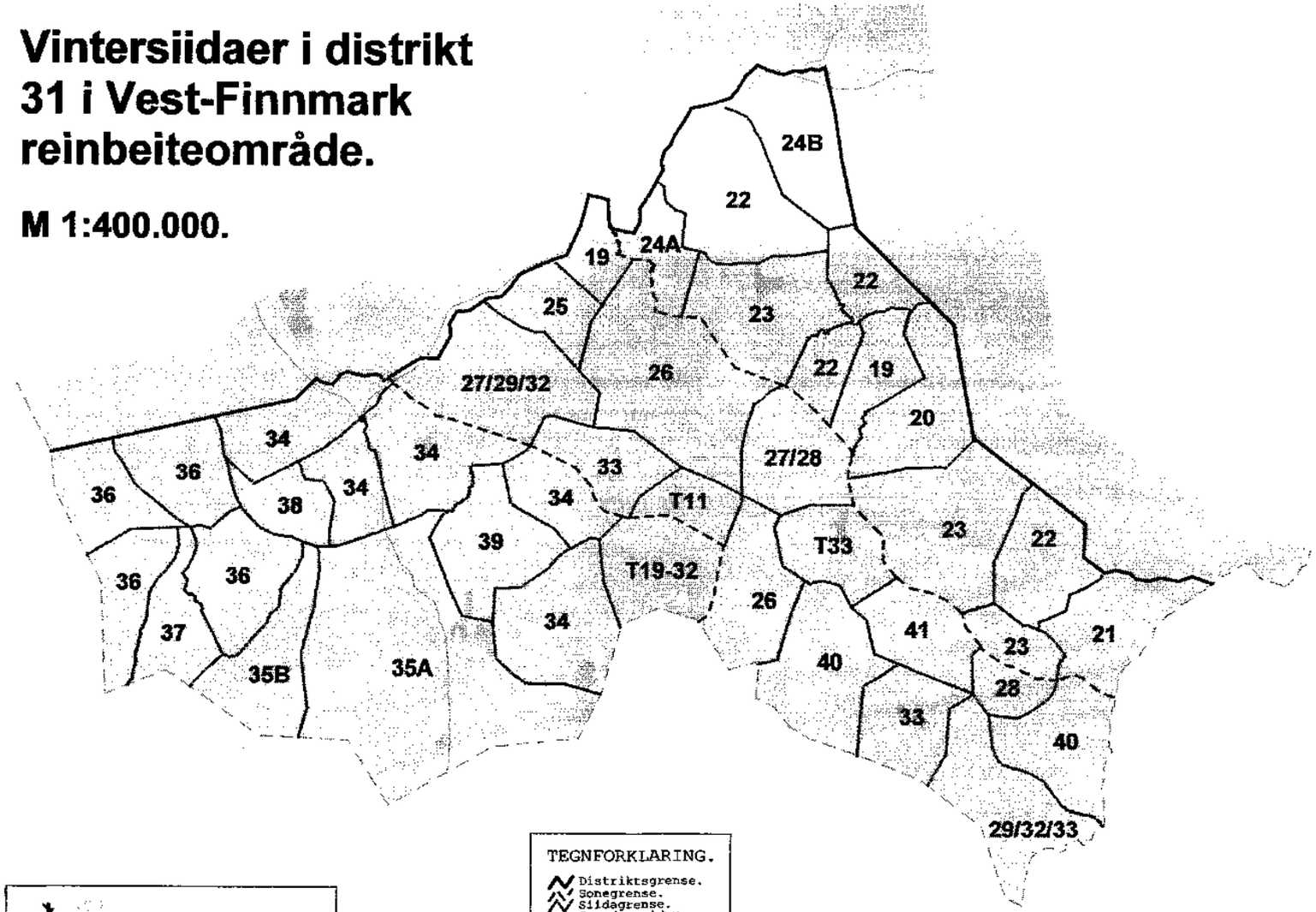
Det kan også være en anledning for informanten til å komme fram med tema som han ikke følte seg trygg nok på mens opptakeren sto på.

Intervjueren kan nå også gi en videre info om hnsikt og utforming av intervjuundersøkelsen.

Intervjueren kan også notere ned eller diktere inn sine umiddelbare inntrykk fra intervjuet etter å ha reflektert litt over det.

Vintersiidaer i distrikt 31 i Vest-Finnmark reinbeiteområde.

M 1:400.000.



Boazodoallohálddahus
Reindriftsforvaltningen
Báatsoe-burrtej reereme

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TEGNFORKLARING.

- Distriktsgrense.
- Sonegrense.
- Siidagrense.
- Guovdageaidnu.
- Vei.
- Kommunegrense.
- Fylkesgrense.
- Riksgrense.
- Elv.
- Vann/innsjø.

Ref: Henrik Gaup og Anders Westlund.
Utgitt: 08.07.1997.
Utgitt med tillatelse fra Statens kartverk.

TRØKKERIET
Hustrykkeriet ved Høgskolen i Narvik