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Assessing costs of reaching sustainable grazing levels for sheep in Alpine habitats

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Abstract. The study aims to estimate the effects on the sheep farm economy of reducing grazing levels necessitated due to possible overgrazing by sheep on two important mountainous range pastures in south-west Norway. The pasture range in Setesdal Vesthei is grazed by sheep from distant farms located at Jæren (south of Stavanger), while south-western Hardangervidda is grazed by sheep from local farms and distant farms located along the coast. Farmers utilizing the pasture areas combine sheep with dairy cows, off farm work or businesses, while the local farms combine it with orchards. A Linear Programming (LP) model for specialized sheep farms based on farm records has been developed to study effects of reaching various grazing capacity levels. Reducing the number of sheep in Setesdal Vesthei by 10% would lower farm income per breeding stock animal with € 15 to € 119 and with € 35 to € 211 for Hardangervidda. The decrease in annual income will range from € 15,00 to € 119,00 in total for the farms using Setesdal Vesthei. The economic effects depend much on meat production per ewe. Replacing unilateral sheep grazing with a mixed system involving suckling goats and heifers is discussed to deal with the problems of encroachment and increasing elevation of the alpine tree-line.

Keywords. Overgrazing – Sheep – Alpine pastures – Norway – Economic impact.

Evaluation des coûts pour mettre en place des niveaux durables de pâturage par les ovins dans les alpages

Résumé. *L'étude vise à estimer les effets sur l'économie de l'élevage ovin, de la réduction de la charge de pâturage qui a été proposée en raison d'un éventuel surpâturage des moutons sur deux importants pâturages de montagne dans le sud-ouest de la Norvège. Les pâturages dans Setesdal Vesthei sont pâturés par des moutons éloignés de leurs exploitations situées à Jæren (sud de Stavanger), tandis que le sud-ouest de Hardangervidda est pâturé par les moutons des éleveurs locaux proches et des fermes plus éloignées situées tout au long de la côte. Les éleveurs qui utilisent les pâturages associent les moutons avec des vaches laitières, avec le travail ou des activités à l'extérieur de l'exploitation, tandis que les fermes locales combinent les moutons avec des vergers. Un modèle de programmation linéaire (LP) pour des élevages ovins spécialisés, basé sur les enregistrements des agriculteurs, a été développé pour étudier les effets provoqués par les différentes charges de pâturage. La réduction de 10% du nombre de moutons dans Setesdal Vesthei diminuerait le revenu par animal reproducteur de 15 € à 119 € et de 35 € à 211 € pour Hardangervidda. La diminution des revenus annuels varie de 15 € à 119 € au total pour les exploitations qui utilisent Setesdal Vesthei. Les effets économiques sont très dépendants de la production de viande par les brebis. Le remplacement unilatéral du pâturage des moutons par un système mixte en utilisant des chèvres allaitantes et des génisses est discuté en liaison avec les problèmes d'embroussaillage et d'augmentation de l'élévation des lignes où se développent les arbres alpins.*

Mots-clés. *Surpâturage – Ovin – Alpages – Norvège – Impact économique.*

I – Introduction

Outfield grazing has a long tradition in Norway and feed intake amounted to 217 million feeding units (FEm) in 2004 with an estimated value of € 65 million (543 million NOK) (Asheim and Hegrenes, 2006). Sheep took up about 68% of the feed, cattle 29% while the share taken by goats and horses amounted to 3% percent. The use of outfield pasture by cattle and horses was substantially reduced during the 20th century making sheep the main husbandry animal

depending on access to outfield pastures. Roughly 2.1 million sheep graze outfield and 0.3 million graze farmland only. Sheep farming is often combined with off farm work or businesses. Overall number of farms with sheep has decreased while the number of sheep per farm has increased substantially. Currently there is a sheep meat deficit and demand in ethnic markets such as Muslim consumers is assumed to increase.

In 2004, roughly a third (32.1%) of the country's sheep was located in the Hordaland, Rogaland and Agder counties in the southwest corner of Norway. Summer grazing on farmland is common, particularly in Rogaland, but lack of farm or outfield pastures close to the farm forces farmers to rent distant pastures. Unfortunately the pastures hired sometimes have a poor quality and the question of overgrazing has repeatedly caused controversy in Setesdal Vesthei and Ryfylkeheiene (Mysterud and Mysterud, 1999) and in the vast alpine areas of the south-western Hardangervidda plateau (Warren and Mysterud, 1995).

The study aims to provide managers with a tool to assess the economic effects on a farm and local community level of lowering sheep numbers, determine to what degree the overall costs depend on management regime, and examine alternative grazing systems. The study does not assess whether sheep numbers should be altered to reach specific management goals.

II – Material and methods

1. Grazing regime, capacity and alternatives

The Setesdal Vesthei pasture consists of 9 grazing areas totalling roughly 1200 km^2. A responsible grazing manager is keeping the sheep under surveillance in each area. The sheep are not herded rather they are encouraged by the manager to spread out since the forage resources are scattered. The utilization is organized through Jæren Smalelag whose member farmers are mainly from the municipalities around Stavanger. The Hardangervidda area is grazed by sheep from coastal and fjord municipalities in Hordaland and Rogaland in addition to sheep from local farms. There is no responsible grazing manager on Hardangervidda, but the farmers patrol the area.

A common definition of overgrazing in range ecology is "*when the grazing plants are unable to maintain themselves over time due to too much grazing or related processes*" (Mysterud, 2006). It is also possible to define under-grazing as a decrease in carrying capacity due to too little grazing. Grazing capacity or sustainability of grazing levels can only be assessed relative to specific management aims (Mysterud, 2006). There is currently no clear grazing management aim in the pasture areas, apart from expectations that grazing levels should be sustainable. Recent ecological studies in the Setesdal Vesthei area (Austrheim, *et al*., 2007) showed that exclusion of sheep brought about a recovery of an important forage plant (*Deschampsia flexuosa*) in the area. The resource levels available to sheep depend to a large degree on vegetation type.

The grazing capacity of most of Setesdal Vesthei in a "vegetation for sheep" forage production perspective has recently been investigated by Rekdal and Angeloff (2007) using satellite-imagery combined with extensive field surveys to determine the grazing capacity (Table 1). The satellite photos were interpreted into four broad categories of vegetative land; bogs, moors, snow-beds, and natural meadows or pastures; which were further subdivided into several vegetation types each with an associated grazing value. The share of vegetative land ranged from 30 to 56% and the grazing value from 44 to 60 sheep per km^2 of vegetative land among the vegetation types.

It is in the interest of farmers to avoid extensive overstocking as that would affect sheep yield (Asheim, 1978). Farmers and grazing managers are able to change grazing area and could for example move about 400 sheep from Svanes to Nomeland/Brokke. The total number of sheep in 2006 was only slightly lower than the maximum and 9 or 17.5% reduction is needed to reach the low or average capacity levels. According to the owner of the grazing rights in Setesdal

Vesthei (Statskog), there are few or no alternative outfield pastures in the region. The region is under pressure for extensive cabin development as a popular area for both winter and summer recreation. We also regard fertilizing or adding lime (whitening) to increase pasture productivity as an unlikely alternative. Coarse scale fertilization of mountain pastures was tried in Setesdal Vesthei, but led to increased coverage of Nardus stricta, a grazing resistant plant (Mysterud and Mysterud, 1999). In addition to the ethical concerns, costs would probably also be high since one might have to use aeroplanes or helicopters.

Table 1. Number of grazing sheep and lambs in 2006 for the eight main grazing areas in Setesdal Vesthei compared with recommended number of animals by Rekdal and Angeloff (2007)

	Sheep	**Sheep grazing capacity level**		
Grazing area†	2006	Lower	Average	Upper
Nomeland/Brokke	6,087	5,800	6,470	7,100
RYsstadheia	3,610	2,800	3,058	3,400
Suleskardheia	4,663	3,700	4,090	4,500
Fidjelandsheia	3,809	2,500	2,725	3,000
Holmevassheia	2,907	2,500	2,768	3,000
Svanes	839	400	422	500
Kviheia	2,219	2,000	2,230	2,500
Langeidheia	5,810	5,000	5,539	6,100
Totals	29,944	24,700	27,302	30,100

†*Dynjanheia, a small partly forested border area with 890 sheep in 2005 has not been investigated.*

The grazing period in Setesdal Vesthei usually lasts from the 20th of June to the 5th of September or 77 days. Overall, for the country, the outfield grazing was 95 days in 1992 (Asheim and Hegrenes, 2006) which compares to 106 days in 1974 and 129 days in 1949 (Central Bureau of Statistics, 1975, 1951). Pasture plants not utilized will deteriorate so altering the grazing period would not affect the computed capacities. However, more pasture on farmland would be made available on the farm if the outfield grazing period could be extended. The opportunities for increasing the length of the outfield grazing period may be limited by hunting in the autumn and also affect sheep productivity.

More pasture on farmland would also become available if farmers with dairy cows replaced (on a feeding unit basis) some sheep with heifers or non-lactating cows. In Scotland it is normally assumed that 10% goats can be added on sheep pastures without affecting sheep pasture productivity (Lars Olav Eik, pers. comm.). Suckling cashmere goats are smaller than sheep (38.5 *vs* 74.5 kg) and can be managed together with the sheep and use the same pastures. Goats are less labour intensive and need little assistance during kidding. The income from the fibre is less than the wool of a sheep in spite of a higher price. The meat price for adult goats is low, but goat kids obtain a better price than lambs and an extra premium if fed a second year before slaughtered. An alternative is thus a reduction in sheep by replacement with goats in a ratio of one breeding goat for each breeding sheep.

Retaining more sheep on the farm could imply fertilizing extra pasture or renting more pasture. This solution may, according to the farmers, work in practise but pasture prices are high in the region and support for outfield grazing (€ 10.4/animal) would be lost. Developing a brand pricing system for lambs from natural pastures (i.e. Sirdal-lambs) would be impossible for such sheep. There is quite a high level of fertilizer use in the area already with associated high run-offs of nutrients. In the most affected waterways the environmental goals for Jæren are not achievable without a dramatic change in agricultural activities (Molversmyr *et al*., 2003). The occurrence of (gastro intestinal) pasture nematodes must also be considered with more animals on the farm, and as the area has a high rainfall this adds to the problems with trampling of pastures. Feeding sheep with bales of silage was not considered to yield a good enough production result by

sheep farmers, although it might sometimes work for cattle. These alternatives have not been examined economically in the study.

2. Sheep farm model

In the account statistics of the Norwegian Agricultural Economics Research Institute (NILF, 2006) there were 31 records in the relevant municipalities for farms with a significant number of sheep. Four records for farms utilizing Setesdal Vesthei and another three records for farms utilizing Hardangervidda have been selected from the 2005 databank. The records were all from specialized sheep farms. Farms combining sheep and cattle have not been considered, but sheep and dairy cow production is quite common in Rogaland and the southern parts of Hordaland and sheep with some young cattle is also common. Many sheep are found in smaller herds on farms with a mixture of animals, but those sheep mainly use farm pastures. The local farms utilizing south-western Hardangervidda commonly combine sheep with orchards. The local farms will have grazing priority in case of a reduction and will not be affected.

The farm records are used in a Linear Programming (LP) model maximizing farm gross margin subject to constraints on farmland area, premiums for landscape preservation, use of manure, hired labour input, and feeding constraints in different periods, based on information from the records. There is a constraint on the number of sheep kept on the farm and remaining sheep has to be sent to the outfield pasture. The recorded fixed costs, including machinery depreciation, interest and ownership charges for the farm capital are subtracted from the gross margins to arrive at farm profit. The model is worked out in the price level of 2006 and described in Asheim (2007), exemplified with data from one of the farms. The model is calibrated regarding meat production per ewe, meadow and pasture yields, labour efficiency, and the amount of family labour available for agriculture. The calibration is conducted in a basic solution reflecting the current situation for each farm.

III – Results

When sheep numbers are lowered by 10% the farm profit per sheep (Table 2) is lowered by € 15 for Farm 4 (lowest) and by € 119 for Farm 2 (highest). A 20% reduction would lower farm profit ranging from €15 to € 122 per sheep. Farm 1 had all the sheep on the farm and is included for comparison. Farm 1 has a high production per ewe and high fixed costs which remains the same when sheep number is lowered. The income effects of reducing sheep number is related to the production of meat per ewe, in particular if Farm 4 could increase meat production from 18.2 to 20 kg per ewe the farmer would produce the same amount of meat with 10% fewer ewes. A production of 20 kg of meat per ewe would still be lower than the production on the other farms examined.

A reduction by 1,000 sheep in the breeding stock to meet the "average level" requirements given in Table 1, would lower the annual incomes for farmers from Jæren using Setesdal Vesthei in a range from € 15,000 to € 119,000. The reduction would be from € 29,000 to € 243,000 in case of 2,000. Farmers pay around € 6-7 per animal for renting the pasture in Setesdal Vesthei. The responsible grazing manager keeps about € 5 for his job and forwards the rest to the land owner (Statskog). The local income reduction will amount to about € 18,000 for 1,000 breeding stock sheep, and double that for 2,000. In addition the transportation of sheep will be reduced by about € 10,000 for 1000 sheep or € 19,000 for 2000 sheep (about € 4 per animal on a tour-return basis). Overall the local economic effects of reducing the number of sheep brought in from other areas seem small. However, there will be associated effects in the processing industries.

Replacing 10% of the sheep with cashmere goats would be profitable for Farm 4 and Farm 3 would be largely unaffected. For Farm 2 (and also Farm 1) it would partly improve the situation, but it would not compensate for the reduction in sheep. Generally the farmers with a high production per sheep would lose while farmers with a low production would gain by replacing

sheep with goats. Regarding Hardangervidda the computed impacts were a little higher ranging from € 35 per breeding sheep for Farm 6 to € 211 for Farm 7, possibly due to better pastures. Also in this area the results seem to be associated with the production of meat per ewe, which were 22.5 and 37.1 kg for the two farms. Assuming 20% fewer sheep farm profit was lowered with € 63 - € 213 per ewe. Farm 6 would definitively profit from replacing some of the sheep with cashmere goats, Farm 5 would get a slightly higher and Farm 7 a slightly lower farm profit. It is not possible to compute community effects since the grazing capacity has not yet been determined on Hardangervidda. However, the management regime in each area seems to play a minor role for the costs.

Table 2. Farm area, family labour input, breeding stock and farm profit for sheep farms utilizing two range pastures in a basic situation and when the number of sheep is lowered by 10% or replaced with cashmere goats

Pasture area	Setesdal Vesthei				South-west Hardangervidda		
Farm number	1	2	3	4	5	6	7
Farm area, hectare	14	25	32	14	9	12	28
Family labour input (h/year)	1230	1740	1000	2010	1977	1500	1150
Sheep breeding stock, basic situation	102	147	189	240	84	154	120
Current farm profit 2006 (€)	3878	165	2965	1646	5931	17593	-7162
Profit per hour (€)	3.2	0.1	3	0.8	3	11,7	-6.2
Breeding stock sheep, limited 10%	82	122	172	192	67	126	96
Farm profit 2005-06 (€)	104	-2841	2660	946	3406	15786	-12288
Profit per hour (€)	0.1	-1.6	2.7	0.5	1.7	10.5	-10.7
Breeding stock, goats to replace sheep	10	12	9	24	9	16	12
Farm profit 2005-06 (€)	3724	-373	2915	3302	6058	18765	-7348
Profit per hour (€)	3.0	-0.2	2.9	1.6	3.1	12.5	-6.4
Marginal (-10%) farm profit (€/sheep)	134	119	18	15	101	35	211
Marginal (-20%) farm profit (€/sheep)	185	122	18	15	150	63	213

IV – Discussion

The numbers available for the grazing areas in Setesdal Vesthei show that farmers have decreased the number of sheep by about six percent since 2002. However, in some grazing areas there are still too many sheep relative to the recommendations in Rekdal and Angeloff (2007). Central representatives of the Jæren Smalelag claim there are no realistic alternative to reducing sheep numbers if the aim is to reduce grazing pressure. The economic effects will depend on the farm in question and what alternatives can be worked out in each case. Farmers with a high production per ewe will be most affected in both pasture areas and would have to look at other alternatives such as increased use of lowland cultivated farmland pasture if that can be found. The suggested grazing capacity measures calculates a "grazeable area" and link this to actual sheep numbers by a standard scheme developed more than 50 years ago (cfr. Rekdal and Angeloff, 2007), but little is yet known about how accurate this is. Before management actions are taken, we also recommend a broader discussion of the aims.

The pasture area is mainly situated above the alpine tree line and birch is the most common tree along the border line. The alpine tree line has been creeping upwards in recent years, which is a major management concern. To stop this, higher sheep grazing levels (than recommended in Table 1) or use of alternative livestock animals may be required. From an economic viewpoint, farmers with cattle might replace some sheep with heifers and non-lactating cows. Cattle are more efficient than sheep in keeping down deciduous forests like birch, but fairly high stocking levels are needed (Bjor & Graffer, 1963). Farmers with a low production of meat per ewe might maintain profit by replacing some of the sheep with goats. Goats are mixed feeders, including both graze and browse in their diet, thus using other parts of the vegetation compared to sheep (Mysterud, 2000). Goats are extremely efficient in opening

up the vegetation and enable growth of grass and herbs to be utilized by sheep. Grazing by cattle and goats might be encouraged by lowering their rent relative to sheep. However, farmers were sceptical towards the goat alternative for which they have no experience so it remains to be seen whether goats will become a management alternative in the area.

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