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Reindeer husbandry: A practical decision-tool for adaptation of herds to rangelands*

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Abstract

This decision-tool is focused on the adaptation of reindeer herds to available food resources in a district, i.e. to the availability and quality of winter and summer pastures. Previous studies have found that practical management is complicated by the dynamics involved and by lack of precise information. Hence one is faced with an information problem. The decision-tool captures the essence of optimisation models and should be sufficiently simple to be used in practice. In short, the decision-tool helps organize raw time-series data such that they become directly useful for decision-making. The intention is that the tool shall stimulate to reflection and discussions that may lead to increased mutual understanding, better collection and use of data, and to better strategies. Case studies from the Nordic countries indicate that the tool produces new and interesting insights from existing data. Feel free to ask the authors for a demonstration of the tool.

WINTER PASTURES

In our definition of winter pastures we include autumn and spring pastures where lichen is a dominating food source. The data used is one time-series for herd size and another time-series for the average thickness or density of the lichen mat in the winter pastures. While data on animals are usually quite reliable, the data on average lichen coverage will be of varying quality. The lichen data can range from costly estimates using satellites, aeroplanes and numerous control plots to pure speculation based on unsystematic visual inspections. However, low quality data can also be quite useful. One reason for this is that the thickness of the lichen mat is likely to change slowly. Thus, it is not necessary to have observations from each and every year and one can rely on more easily observable major changes over longer time spans.

The two time-series are used to estimate a relationship between the average thickness of lichen and the growth rate of lichen. When there is no lichen, there can be no growth of lichen. From earlier studies we know that when the lichen mat is very thick, there is no net growth: what grows at the top is compensated by what rots at the bottom. Somewhere in-between, lichen growth on an area basis reaches a maximum. Such a relationship is illustrated by the solid line in Figure 1, a curve we have estimated for the Snøhetta area.

In this graph, lichen growth is measured in yearly reindeer food (lichen) rations. This choice of unit implies that one can compare directly the growth rate in terms of lichen rations to the number of reindeer, each grazing a lichen ration per year. Each plus-sign in the figure denotes the number of reindeer in one particular year. In all years except one, grazing was greater than the growth rate. Consequently lichen thickness was steadily reduced from around 1060 g/m^2 in 1944 to about 220 g/m^2 in 1967. According to the data, the reduced thickness of lichen lead to a reduction in the number of animals from 10,000 in 1964 to 1,400 in 1970.

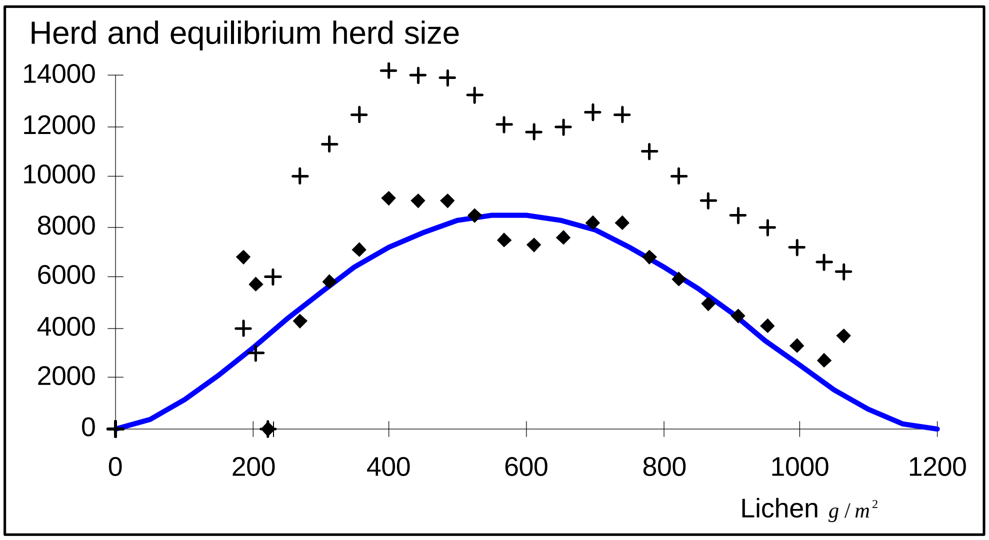

Figure 1: Snøhetta, Norway, time-series data from 1944 to 1967.

Now, how is the curve for lichen growth estimated using the tool? First note that the tool limits your choice of growth curves to ones that have the logical (or theoretical) properties described above. The user's main involvement is to adjust two parameters, one denoting the maximum growth (measured in yearly lichen rations), the other denoting the lichen thickness (in g/m^2) for which lichen growth reaches its maximum. In other words one suggests the location of the maxi-mum of the growth curve. Once one has suggested one para-

meter set, the program will show the curve and some calculated data points that should be as close to the growth curve as possible (the black dots in the figure). If the dots do not fall close to the curve, then one tries new sets of parameters until a reasonable fit is obtained. The technical report explains the details of this approach. When the curve is close to the black dots, one has a growth curve which is consistent with the historical development of the average lichen thickness and the number of reindeer.

Besides the two key parameters, the user has the option to vary parameters that influence the detailed shape of the growth curve. One can make the curve more or less wide, one can change the lichen thickness for which net growth becomes zero (carrying capacity), one can set a parameter for the maximum growth in lichen measured in g/m^2/year, and one can set a parameter which determines the degree to which lichen is wasted by grazing reindeer. All these parameters should be within relatively tight bounds determined by existing knowledge. Moreover, there is usually a rather limited effect of these variables on the final growth curve that one ends up with. Hence, unless the available time-series are long and quite precise, one will come a long way by considering only the two parameters for the location of this maximum growth rate.

Figure 2 shows the growth curve that resulted when data for a more recent period from 1968 to 1997 were used in the case of Snøhetta. Again there is a good match between the estimated growth curve and the data points (black dots). Lichen thickness grew steadily during this period because the number of reindeer was kept lower than the growth rate measured in yearly lichen rations. Based on the figure it seems that the rebuilding of the area was successful and took about 13 years. A subsequent reduction in the number of reindeer lead to a further growth in lichen thickness to a level well above the one yielding the maximum growth.

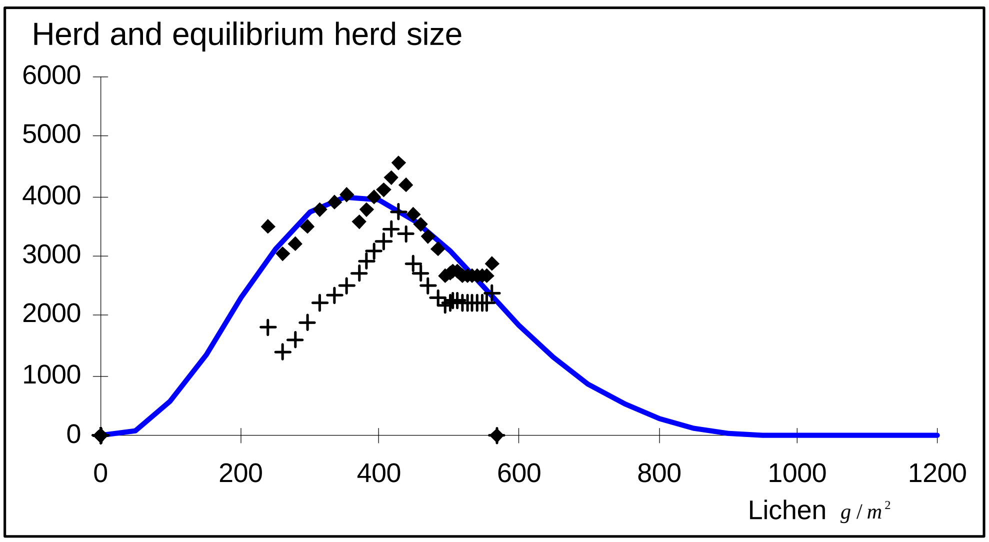

Figure 2: Snøhetta, Norway, time-series data from 1968 to 1997.

Note, however, that the growth curve in Figure 2 differs considerably from the one estimated in Figure 1. The peak is only around 50 percent of what it used to be and it occurs at a lichen thickness about 35 percent lower than earlier. Why? The likely reason is that overgrazing in the early period lead to more or less permanent damage to parts of the area. While regrowth of lichen is rather quick in areas with adequate starting points, it is very slow in eroded areas. Hence the curve for average growth will be reduced for a long time due to erosion. This is a possibility that one should be aware of when using the decision-tool and when managing lichen pastures in general. It implies that one should be extra careful when increasing herd sizes above historical levels.

SUMMER PASTURES

Summer pastures are of great importance for the weight growth of reindeer. Most of the plants consumed by reindeer in the summer differ from lichen in that they do not accumulate from year to year. Grasses and herbs wither and die in the fall, and become available again next year in limited quantities. Hence one should expect a more quick response to increasing herd sizes, crowding and competition about limited food resources. If there is too little high quality food available one year, one gets a rather immediate reaction in terms of animal conditions. For this reason it seems reasonable to manage summer pastures by a trial and error approach: continue to increase the number of reindeer until meat production or economic surpluses stagnate or start to decline. This point defines the meat or profit maximising herd size.

Using a trial and error strategy is however complicated by several factors. If the herd size is adjusted downwards, the extra slaughtering adds to that year's meat production. After the herd size has been adjusted, it takes a year or two before animal conditions start to influence calving ratios and loss fractions. Furthermore, yearly meat production varies with weather conditions, and yearly profits vary with variations in meat prices and costs. All these factors confuse a trial and error approach. Therefore the decision-tool presents a relationship between the number of reindeer and what we call "equilibrium profits".

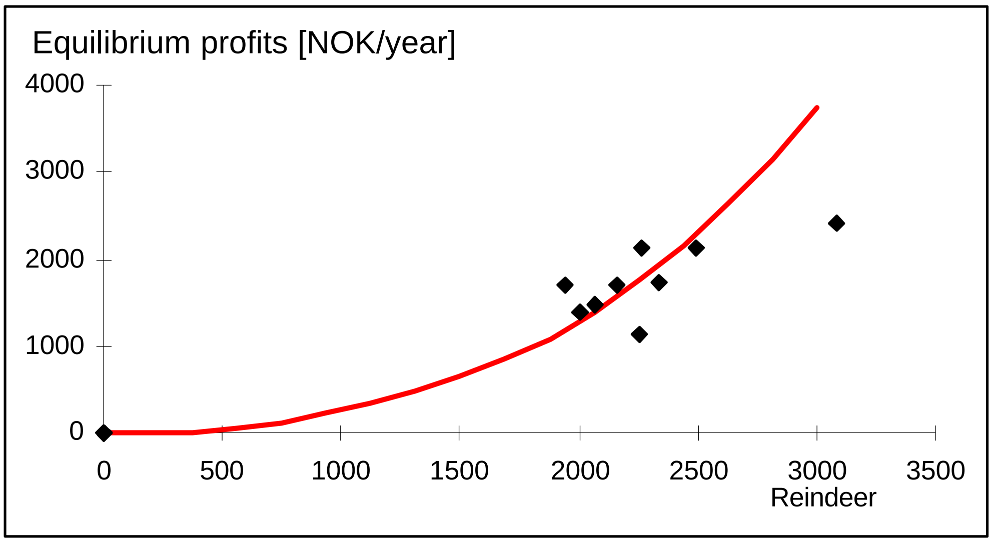

Figure 3: Snæfell, Island, time-series data from 1991 to 2000.

Equilibrium profits is a constructed measure of what the profits eventually will settle towards after a change in the number of reindeer. The tool estimates how the equilibrium profits vary with the herd size. The user can make assumptions about constants like the meat price, the costs per animal, the desired average lifetime of livestock, and the desired fraction of females in the herd. Thus one can easily find out how the profit maximising herd size is altered by changes in these variables. By setting the price equal to 1.0 and costs equal to 0.0, the equilibrium profit curve is turned into an equilibrium meat production curve. The data required is yearly accounts of: the number of reindeer, the ratio of females in the herd, the number of calves surviving to the fall, the slaughter weight of calves and of adults, and the loss of livestock during the year.

Figure 3 shows an example of an equilibrium profit curve for Snæfell, Island. The data points are quite close to the estimated curve in the range from 2000 to 2500 animals. The data points indicate that higher profits could be obtained for higher herd sizes. Clearly more observations are needed in the range above 2500 animals before one can conclude about the profitability of increasing the herd into this range. Thus, in addition to indicating profit maximising policies, the tool suggests herd sizes which produce interesting data. That Snæfell seems to be "under-utilised" is not surprising because the district is not managed to maximise meat production or profits from meat production. Rather, revenues mainly come from sales of hunting licenses. In this trade old bucks are the most profitable.

A second example comes from Vest-Finnmark, Norway. In Figure 4 the equilibrium profit curve is constructed based on data from the period 1981 to 1990 (the black dots). The curve indicates that the profit maximising herd size is around 50,000 animals. A lack of data for herds below 70,000 indicate that more observations are needed in this range. A similar equilibrium meat production curve (price equals 1.0 and costs equal 0.0) shows a maximum for around 60,000 animals.

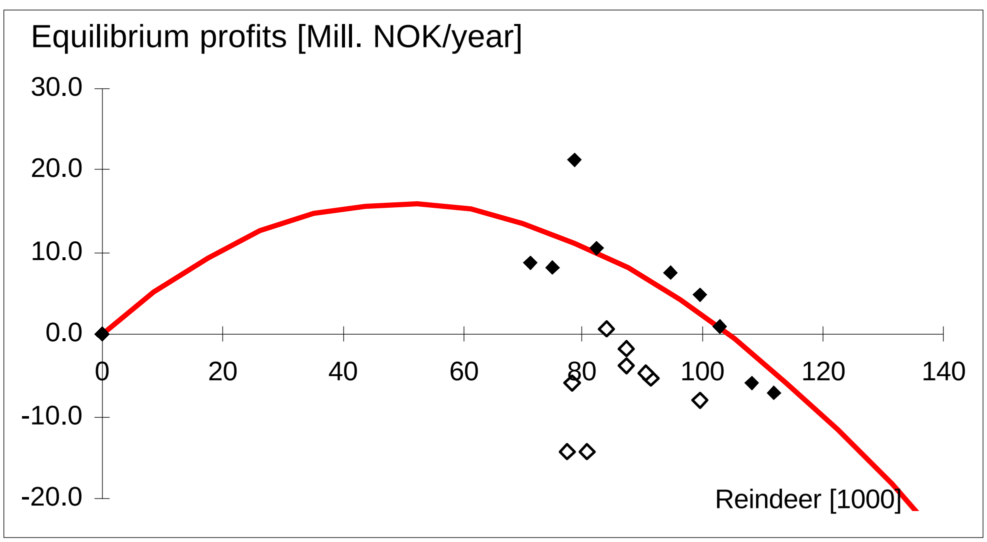

Figure 4: Vest-Finnmark, Norway, time-series data from 1981 to 1999.

The white dots in Figure 4 represent data from the period 1991 to 1999. These data have not been allowed to influence the estimated equilibrium profit curve. If they did, the maximising herd size would still be around 50,000 while the maximum profit would be considerably reduced. All the data points from the last period fall below the estimated curve. Perhaps, this can be explained by unfortunate weather conditions or errors in the data. However, it seems unlikely that all nine observations should fall below the curve for these reasons. Another possible explanation is that there has been lasting negative effects on summer pastures of having more 100,000 animals in the area in the preceding period. Yet another explanation is that the lower data points reflect reduced lichen coverage in winter pastures. In the first period lichen density was in the range from 390 to 190 g/m^2 and in the second period from 190 to 130 g/m^2.

The decision-tool does not correct for any of the above explanations. However, by varying freely the time period one considers, the tool reveals periods with exceptional data. In general, it is always wise to look for tendencies toward permanent changes in new data, so that previous estimates of equilibrium profit curves or lichen growth curves can be corrected. Such permanent alterations could be caused by climate change, vegetational adaptations, changes in herd structure etc.

One version of the decision-tool is also equipped with a simulator. In this version one does not supply data from a reindeer district, rather the data are produced by a simulator. In the simulator one determines the herd size from year to year, and the decision-tool is used to update the estimates of the equilibrium profit curve and the lichen growth curve. Each time the simulator is started from scratch, it represents a new district with unknown characteristics. Hence each new test is a challenge, one cannot just replicate or improve on what one did last time. Using the simulator, one also get experience in dealing with winter and summer pastures at the same time.

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