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LANDSCAPE ECOLOGICAL INFORMATION THROUGH STATISTICAL ANALYSIS OF THE TERRITORIAL STRUCTURE OF A SHEEP-GRAZING SYSTEM, FAROE ISLANDS.

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0. Abstract

An evaluation of the productivity of landscape units can be derived through standard statistical analysis of the production result from the land-use-units. Where these can be seen as simple additions derived from the productivity of the in-going topological units, the productivity of these can be calculated by means of the least-square method. Where the land-use is adjusted to the chorological structure of the landscape where certain bottlenecks is lowering the overall production, the productivity of the in-going topological units can be estimated by use of linear programming.

In most grazing systems lie historical information on the carrying capacity (grazing potential) of the system through taxations. There where it is possible to chart the territorial structure of the system, one can analyze the landscapeecological conditions of the carrying capacity of the grazing system directly or through statistical analysis.

A regional analysis of the faroese taxation worked out in 1867-73 of approx. 250 outfields, very clearly indicates, that shortage of essential nutrients in the soil has been an important factor behind the relative low carrying capacity of the sheep grazing system.

A local analysis has been made on the 87 pastures in the 13 outfields of eastern part of Sandoy. There a calculation of the average contribution of the single vegetation types to the carrying capacity has been made by means of least-square-method.

By using a linear programming model, a minimum grassland productivity of the vegetation types has been calculated, and the difference between the grass production and the carrying capacity of the single pastures has been charted. It is indicated, that the utilization of the grass production is very strongly influenced by the chorological structure of the landscape.

1. The linkage between landscape units and land-use units

An important purpose of landscape ecological research is to give contribution for an evaluation of landscape potentials for one or a complex of ways of land use. One step in the analysis is to compare the results of a geo-ecological survey with the actual land-use, typically given as a simple statistical survey of land-use within different types of landscape units. This comparancy is by no means limited to topological units (or regional landscape units), but is just as relevant and usable for inductive derived heterogenious units, like nanochores (Mannsfeld, 1983). This is important, because most of the practical land-use in fact refers to such chorological landscape units.

From the point of view of landscape potential this sort of comparison is however mostly a qualitative one, since it only includes the way of land-use, not the intensity or the yield of the land-use. Such figures of yields can be obtained either through measuring on different spots or through statistical information from the land user.

Probably because of the very science-oriented tradition in landscape ecology and related disciplines, we are inclined to prefer if possible the use of direct measurements of yields, which has the advantage that they can be related directly to the landscape units, for instance as a measurement in relation to a complex analysis.

From the point of view of landscape potential the statistical figures from production results might however be just as relevant: they are obtainable for a much wider range of land-use-types (f.ex. forestry and grazing) and often for a longer period as well. Furthermore, they can be historically related to other relevant figures, such as density of crops or grazing animals, and intensity of different inputs.

This source of production oriented information is however seldom used, because it mostly refers to overall measures for land-use-units which does not correspond to the landscape-ecological units. Thus, provided a comprehensive survey this problem can be solved through standard statistical methods so that yields for types of landscape-ecological units can be calculated.

Having yields of " r " areas of land use, each being composited of up to " c " different types of topological units, the following equation system can be set up:

$$a_{11}x_1 + a_{12}x_2 + \cdots\cdots + a_{1c}\,x_c = y_1$$

$$a_{21}x_1 + a_{22}x_2 + \cdots\cdots + a_{2c}x_c = y_2$$

$$\vdots \qquad \vdots \qquad \vdots \qquad \vdots$$

$$a_{r1}x_1 + a_{r2}x_2 + \cdots\cdots + a_{rc}x_c = y_r$$

where

a_{rc} is the area of type "c" in land use areas "r",

x_c is the (unknown) yield pr. areal unit of type"c"

and

y_r is the overall yield of land use unit "r".

This can also be expressed in matrix form:

$$A\bar{x} = \bar{y}$$

This equation system cannot be solved exactly, but through use of the least-square-method one can find such a vector $\bar{x}$, that minimizes $\bar{y} - A\bar{x}$, provided that $r > c$, say that there are more land use-areas than types of topological units.

Often the yield of the overall landuse does not consist of simple addition of yields from the single topological units. In fact it is a basic point in this sort of landscape ecological research that a certain historically developed correspondence exists between the chorological structure of the landscape and the interrelated different types of land use in the area. This is f.ex. the case in many grazing systems, where different parts of a pasture not just give different contributions to the overall production of primary fodder, but also have special necessary functions such as winter- or spring grazing areas, shelter areas for certain wind-directions, areas with seldom occurrance of snowlayer etc. Such necessary functions can work as bottlenecks in the grazing system and lower the yield considerably compared to the situation of simple addition of yields of the single topological mid-values.

Multiple landuse systems related to the chorological structure might have the opposite effect: That the overall productivity of the land-use system surpass the productivity which could be obtained from a simple addition of the isolated use of the single topological units.

We might call the simple addition for <u>topological production potential</u> of the chorological unit, which can be compared to the overall production as a step in the search for more complex chorological potentials. This topological potential can be calculated for a single land-use system in the following way:

Having the yields of "r" land-use areas, each composed of up to "c" different types of topological units, we can set up the following unequalities:

$$\begin{array}{l} a_{11}x_1 + a_{12}x_2 + \ldots\ldots + a_{1c}x_c \geqq y_1 \\ a_{21}x_1 + a_{22}x_2 + \ldots\ldots + a_{2c}x_c \geqq y_2 \\ \vdots \\ a_{r1}x_1 + a_{r2}x_2 + \ldots\ldots + a_{rc}x_c \geqq y_r \end{array}$$

In the case of a pasture it means, that the fodder eaten of the grazing animals within the pasture must be equal to or less than the fodder produced on the single types of topological units with the pasture.

Adding these unequalities we get the following unequality:

$$\left(\sum_{n=1}^{r} a_1\right) * x_1 + \left(\sum_{n=1}^{r} a_{n2}\right) * x_2 + \ldots . + \left(\sum_{n=1}^{r} a_{nc}\right) * x_c \geqq \sum_{n=1}^{r} y_n$$

On the left side we have the overall topological potential, which has tobe calculated, on the rightside we have the measured overall production. It is not difficult to find solutions for the system of unequalities; this is just a question of high enough values of $x_1 \ldots\ldots x_r$. The problem is to find a solution which minimizes the difference between the two sides, that is to minimize the linear function

$$H = (\sum_{n=1}^{r} a_{n1})*x_1 + (\sum_{n=1}^{r} a_{n2})*x_2 + \ldots\ldots + (\sum_{n=1}^{r} a_{nc})*x_c$$

under the constraints of the former unequalities concerning the production of the single land-use areas. This is due to the assumption that the structure of the land-use is arranged to produce as close to the topological production potential as possible. With the additional constraint that $x_1 \ldots\ldots x_r = 0$ (which means that the topological productivity cannot be negative) we have a traditional linear programming problem.

Having obtained an optimal solution in form of productivities for the "r" different types of topological units, we can calculate overall topological production potentials for the land-use units and compare them with the actual known production-figures. The study of these deviations can be useful in many different ways.

2. A case: Areal productivity in the traditional Faroese sheepbreeding system

Today the Faroe Islands, located in the Atlantic between Scotland and Iceland, is a rich fishery-nation, where the agriculture contributes under 2% of the national product.But until sea fishing began in the middle of last century, agriculture was the dominant occupation. Here sheepbreeding assumed an outstanding position as it produced an essential product for export and formed a main basis of taxation on the islands, which were in earlier times an entailed estate under the danish crown. Wool and its product thus amounted to approx. 90% of exports during the entire 18th century. From a historical point of view, therefore, strong inducements have formerly risen to increase the exploitation of the acreage available to the faroese communities, expecially by means of sheepbreeding.

Already in 1298 a special law for the Faroe Islands, Seyđabrevit (the sheep letter) was passed, which among other points stated that "the number of sheep to be kept on an area of pasture land shall be the same as it was in previous times, unless men see that it can accomodate more". This figure, in the faroese language called the skipan, expressed the carrying capacity of each individual location, and to this day, it is used as an expression of the optimum carrying capacity, for the various parts of the islands. Additional skipans for cows, horses, dogs, geese etc. were also developed.

The law was changed several times, especially up to the 18th century, where the growing fragmentation of the private property made it still more difficult to maintain the skipan, in disfavour especially for the king's tenants, and other big farmers. Therefore joint management of the sheep, and ownership based on the farmers' share of the total value of the village - the so-called "marketal" was forced through.

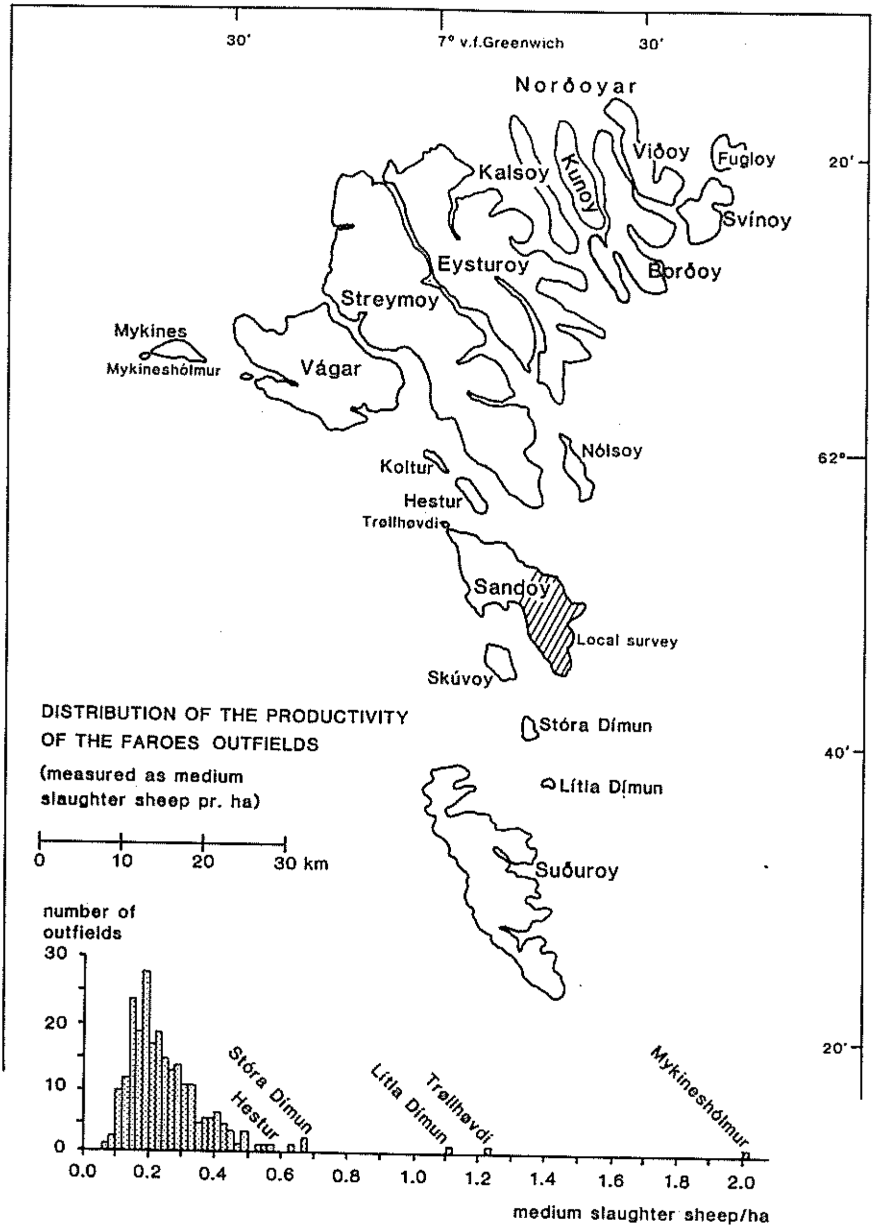

30'
7° v.f.Greenwich
30'
20'
62°
40'
20'
Norðoyar
Viðoy
Fugloy
Kalsoy
Kunoy
Svínoy
Eysturoy
Borðoy
Streymoy
Mykines
Mykineshólmur
Vágar
Nólsoy
Koltur
Hestur
Trøllhøvdi
Sandoy
Local survey
Skúvoy
Stóra Dímun
Lítla Dímun
Suðuroy
DISTRIBUTION OF THE PRODUCTIVITY
OF THE FAROES OUTFIELDS
(measured as medium
slaughter sheep pr. ha)
0 10 20 30 km
number of
outfields
30
20
10
0
Stóra Dímun
Hestur
Lítla Dímun
Trøllhøvdi
Mykineshólmur
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0
medium slaughter sheep/ha

Figure 1.

There were no fences between the outfields before the 1960'es, when an enclosure of the outfields was started, thus dividing the former very flexible grazing system into smaller enclosed grazing units more intensively used by some farmers. The main part of the pasture land, however, is still used in a very extensive way, based on the old sheepgrazing system.

The faroese agricultural system, including the "marketal" system and the concept of skipan, can be seen as a historical relic of an agricultural system, which was common all over Europe during the middle ages. Until recently, the geomorphology and the climate of the Faroe Islands have made them marginal for the adoption of new, radical technology in the agricultural field. At the same time, their isolation, their very limited area, and the economic very lucrative fishing industry have meant that only recently has it been of interest to increase the productivity by a reorganization of the work methods. So, because of the important features of the traditional faroese agricultural system in it has survived relatively unchanged to present time, it provides a particularly favourable opportunity to study the faroese system of sheep grazing as a concrete example of the processof optimization of production, which has been constantly refined over the centuries without the social and technological alterations which have occurred elsewhere during the past. Again elsewhere such changes have radically altered the fundamental character of this refined exploitation and of the associated practical methods of management.

3. Regional productivity analysis

Over 95% of the area of the Faroe Islands (app. 1400 km^2) is made up of extensive pastures, traditionally divided into approx. 250 outfields, with the carrying capacity being taxated since the middle ages. A taxation from 1867-73 gives information on the recommended number of ewes (skipan), the relative size or value of the sheep and the number of lambs for slaughter in a normal year. A productivity map has been worked out, based on information from the taxation journal and a detailed surveyance of the outfields. The productivity is measured as "medium slaughtersheep/hectar".

Fig. 1 shows the distribution of the productivity of the outfields together with a map of the Faroes. The productivity map, which is more detailed than can be pictured here, shows a generally low productivity on Vágar, Sandoy, the middle parts of Suđeroy and parts of the islands north-east of Eysturoy (the socalled Norđuroys). As high-productivity areas we have Kalsoy, the eastern parts of Eysturoy, the southern part of Suđuroy, but especially some outstanding deviations from normal performance are immediately apparent on the smaller islands and islets: whereas85% of the outfields have a productivity below 0.35 medium-slaughter sheep/ha, we have the following small inhabited islands: Fugloy (0.47), Nolsoy (0.50), Mykines (0.45), Hestur (0.57), Koltur (0.44). Stóra Dímun, the smallest of the inhabited islands (only populated during the summer since 1970) has a productivity of 0.67. Even more outstanding is the extremely high productivity of some of the smaller uninhabited islets, the socalled feitilendir: Lítla Dímun (1.11), Tröllhövdi (1.23), Mykineshólmur (2.02).

The reasons for this are unknown, but several factors, which are presumably influential, can be pointed out: The primary production, as indicated by the luzuriant character of the vegetation, is no doubt higher in these areas. This can be explained first of all by the high population of bird which manure the islets. Also the greater reflection from the sea around the smaller islands may be of importance. In certain areas a generally favourable microclimate may also be of some influence.

The geographical distribution of productivity of other outfields do show some minor regional differences, but it is not easy to further analyse these differences. In general, the acreage of the outfields prove too big to reveal any close relationship between productivity and the landscape ecological features in this way.

4. Local productivity analysis

A more detailed investigation has been made of a smaller area on the eastern part of Sandoy Island, covering an area of approx. 55 km, that is about 4% of the total area of the Faroe Islands. The productivity of ten outfields, into which the area was divided at the time of the taxation around 1870, is between 0.13 and 0.22 medium slaughter sheep/ha, which is typical of the Faroe Islands.

The analysis is based on data from the grazing areas of individual sheep flocks, arrived at through interviews with old shepherds from eastern Sandoy, carried out in 1974, 76 and 78. The grazing areas for the flocks, although slightly modified, have remained relatively unchanged to the present day. These areas were not fenced but arranged and maintained in such a way, that the sheep stuck to them in normal weather. The grazing areas of the approx, 90 flocks (each consisting of 12 - 90 number of ewes and possibly selected ewthers) are shown on fig. 2.

As is shown, the organization of the grazing areas is characterized by their arrangement in an infield-outfield system, being generally placed in strips from the infield, or the sea, up towards the summit of the hill. The general principle of husbandry has been to keep the sheep as far up the hill as possible during the summer, while the cows were grazing on the lower parts of the outfields. During wintertime, when the cows were stall-feed, as were opened the fences to the enclosed in-fields to give room for grazing sheep. As shown in fig. 2, however, only a percentage of the flocks had rights to wintergrazing on the infield-area. There was no winterfeeding of the sheep.

4.1 The topological units: use of a vegetation survey.

No real landscape ecological survey has been made. The charting of topological units is based on a vegetation survey which shall be described in the following:

Evidence has our awareness, that parts of the outfield have been cultivated in the middle ages (Brandt and Guttesen (1978, 1980)). But for at least 300 years, and more likely 500 years, they have been free of cultivation except for the newer enclosed areas cultivated in connection with the population boom which has taken place since the beginning

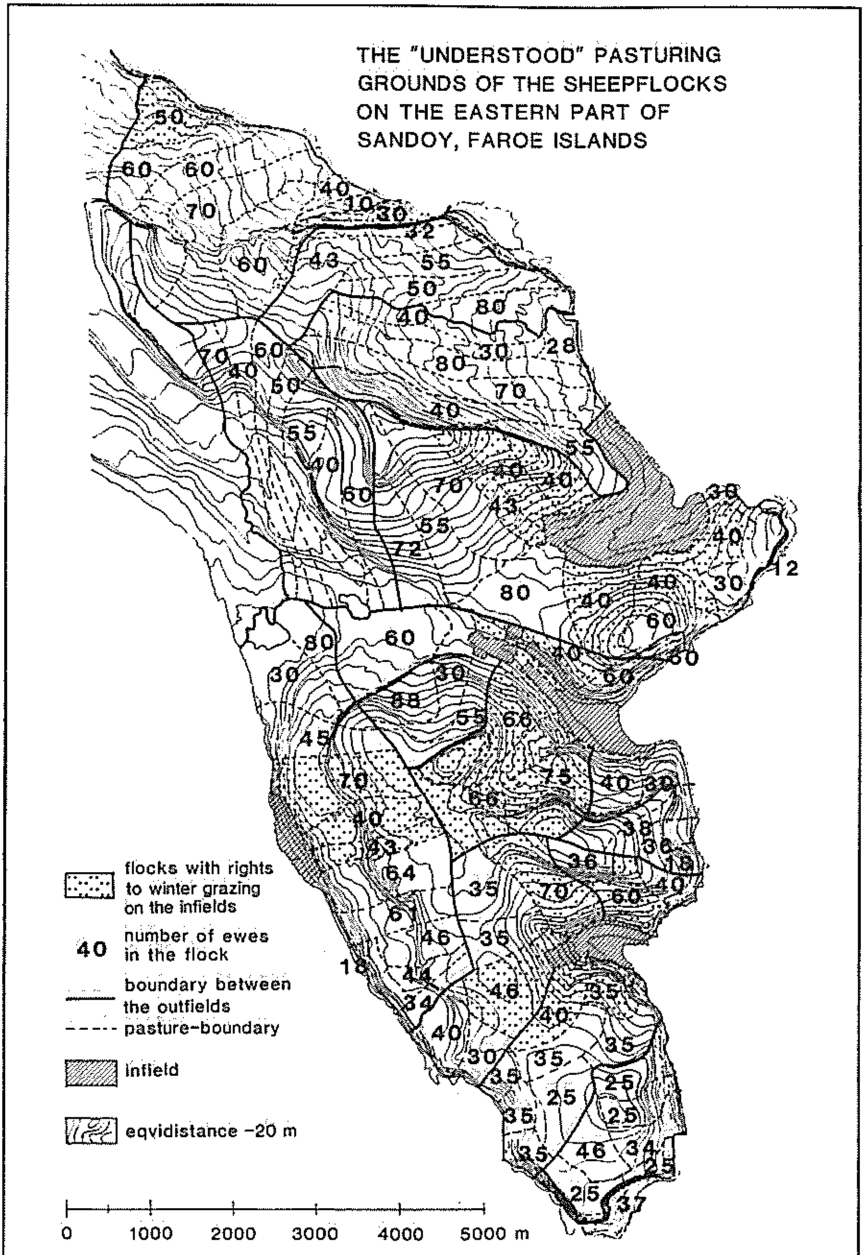

THE "UNDERSTOOD" PASTURING GROUNDS OF THE SHEEPFLOCKS ON THE EASTERN PART OF SANDOY, FAROE ISLANDS
flocks with rights to winter grazing on the infields
40 number of ewes in the flock
boundary between the outfields
pasture-boundary
infield
eqvidistance -20 m
0
1000
2000
3000
4000
5000 m

Figure 2.

of the 19th century, when the fishery industry began. So, as Ostenfeld (1908) points out, traces of human influence are not evident to any noteworth extent outside the enclosed area, except the change brought about by the removal of peat and turf, which produces other conditions in the amount of moisture and thereby effects the original vegetation. One might add that a certain limited draining of the most water-logged parts has been carried through, mostly to avoid certain infections on the sheep.

Certainly the sheep-grazing has undoubtedly had an enormous influence upon the vegetation, since almost everywhere it is closely clipped by the grazing of the sheep, and the taller plants have slight chances of flowering and fruiting. It has also been stated by Ostenfeld (1901) and Warming (1903) that a number of plants in the faroese flora have been immigrated through the aid of man, with the majority of the introduced, naturalized species situated on the lowermost parts (Hansen, 1972).

Since the vegetation of the faroese outfields can be seen as a semi-natural, rather unmanipulated one, historically adopted to the grazing of animals the vegetation is seen as a partial complex, where the extension of the vegetation types within the single pasture is interpreted as topological - homogenious - units, uniforming a certain primary productivity.

The charting of the vegetation has been based on the plant-sociological works of Ostenfeld (1908). The relevant sub-alpine formations is the moor-formation, the heather-moor-formation (moist Calluna heath) and the grass-slope-formation. Of the alpine formations only the rocky-flat-formation and the grass-slope-formation is relevant due to the relatively low height of Sandoy (max. 479m). The alpine grass-slope-formation does not differ plant-sociologically from the sub-alpine, but it has been separated out because of the obviously lower productivity of the alpine grass-slope.

Despite this plant-sociological tradition no vegetation survey on the Faroe Islands has been made before this study. Already Ostenfeld explains the difficulties:

> "It may be stated as a general rule, that the more insular a climate, and the more irregular the configuration of the surface, then the more difficult it is to form in one's mind a definite picture of the plant-associations, which under these conditions merge gradually into each other, and are liable to frequent change. This holds true in a marked degree for the Faroes. The great humidity of the atmosphere, the frequent and abundant rainfall, and the resulting moistness of the soil nearly everywhere, together ensure almost constant and sufficient supplies of that most important factor, water.
> Consequently most of the plant-associations are closely related, and the distinctions between them depend on small differences in the quantity and the quality of the water. It will easily be understood, that distinctions so slightly defined are difficult to maintain.
>
> The difficulty is further emphasized by the incessant changes, up and down, which characterize the Faroese landscape, and which

within a single square meter may present to the plants widely varying conditions as regards access of water, protection against wind, light and shade, etc. The arrangement of the plant-association which is attempted in the following pages is therefore somewhat more abstract than is the case in most other countries, and it will be necessary again and again to indicate the gradual transition from one association to another."

In this study 5 formation-types and 9 combination- and transitional types have been used as shown in the statistical survey of Table I.

Table I. Areal distribution and average slope of vegetation types of Eastern Sandoy, Faroe Islands.

Vegetation type	Area (ha)	Area %	Aver. slope (deg)
1 Grass-slope formation	695	13.4	18.2
2 Alpine grass-slope formation	194	3.8	7.3
3 Moor formation	1798	35.1	2.1
4 Heather-moor-formation	253	4.9	1.6
5 Rocky-flat-formation	243	4.7	3.9
Combinat. and transit. types:			
1/2	249	4.9	13.0
1/3	283	7.5	5.1
2/3	108	2.1	1.8
2/5	64	1.3	5.0
3/4	442	8.6	1.2
3/5	52	1.0	1.4
2/(4)*	38	0.7	1.6
3/(4)*	516	10.1	0.8
5/(4)*	82	1.6	1.9
Total	5117	99.9	7.9

* sparse occurrence of heather-moor

4.2 The use of the least-square method

If the carrying capacity of the pastures is seen as a simple addition of what is producable from the single vegetation types with the pasture, we can calculate the contribution of the vegetation types by means of the least square method as

$$C_r = a_{r1}x_1 + a_{r2}x_2 + \dots + a_{rc}c_c + \dots a_{r14}\, x_{14}$$

where

a_{rc} = the area of vegetation type "c" on pasture "r"

x_c = the contribution/ha of the "c"th vegetation type

C_r = the carrying capacity measured as the taxated amount of ewes on pasture "r"

r = 1,2, ... , 87 is the 87 pastures

c = 1,2, ... , 14 is the 14 vegetation types and type-combinations

The charted territorial structure is based on the summergrazing situation. As earlier mentioned, a part of the flocks are grazing on the infield during wintertime, and other flocks are taking over their summergrazing areas. In some places the territorial system of the wintergrazing is fundamentally different from that of the summergrazing.

For those reasons an alternative calculation has been made, based on 43 flocks, concerning the probability that the charted territorial structure is showing the exclusive annual grazing area.

The results of the two analysations are given in Table II.

Table II. Contribution to the carrying capacity of vegetation types on 87 (respectively 43 exclusive) pastures, based on a least square analysis.

Vegetation type	Carrying capacity (sheep/ha)		% of total area		Frequen- (%)		Avér. area of top. units (ha)	
	I	II	I	II	I	II	I	II
1 Grass-slope	1.5	1.4	14.2	9.9	68	58	12.4	11.0
2 Alpine grass-slope	0.3	0.0	3.8	2.9	20	16	11.5	11.3
3 Moor	o.7	0.7	34.8	34.9	83	81	25.0	27.6
4 Heather-moor	1.3	1.2	4.9	7.7	20	28	14.9	17.6
5 Rocky-flat-formation	÷0.8	0.0	4.7	6.0	37	47	7.6	8.3
Comb.-and trans. types:								
1/2	0.5	0.5	4.9	3.0	33	35	8.8	5.5
1/3	0.8	0.9	4.7	7.3	37	33	12.0	14.4
2/3	0.5	0.2	4.9	3.3	15	21	8.3	10.0
2/5	0.4	-	1.2	-	-	-	9.3	-
3/4	0.9	0.8	8.6	7.5	30	23	17.0	20.6
3/5	0.5	-	1.0	-	-	-	8.7	-
2/(4)	0.5	-	0.7	-	-	-	6.3	-
3/(4)	0.7	0.6	10.0	13.7	33	49	17.8	18.1
5/(4)	0.6	-	1.6	-	-	-	27.3	-

*I: 87 summerpastures
II: 43 annual pastures

With the exception of the rocky-flat formation, their are only minor differences between the two analysies.

It has to be stressed, that these figures do not express the primary production of the vegetation types. So, it is worth noting the negative contribution from the rocky-flat formation in the first analysis, which can be interpreted in the way, that the energy used by the sheep during their stay here is exceeding the contribution from the rocky-flat-vegetation to the carrying-capacity of the pastures.

Theoretical sheep-potentials of the single pastures based on these average contributions have been calculated and their deviations from the actual known skipan has been used methodologically in the further investigations of the grazing system, e.g. checking the boundaries of the pastures, examining the importance of wintergrazing rights to the infield.

4.3 The use of linear programming

The nettoprimary productivity of the different vegetation types has been estimated by use of a linear programming model:

For each pasture we have that

$$C_r \cdot f \lesseqgtr P_r = a_{r1}x_1 + a_{r2}x_2 + \ldots + a_{rc}c_c + \ldots a_{r14}x_{14}$$

where

C_r and a_{rc} are defined as before, and

f = the fodder need pr. ewe (= 0.5 t/year/ewe in that area)

P_r = the nettoprimary production of pasture "r"

x_c = the nettoprimary production of vegetation type "c"

with the criteria that $x_c = 0$ and

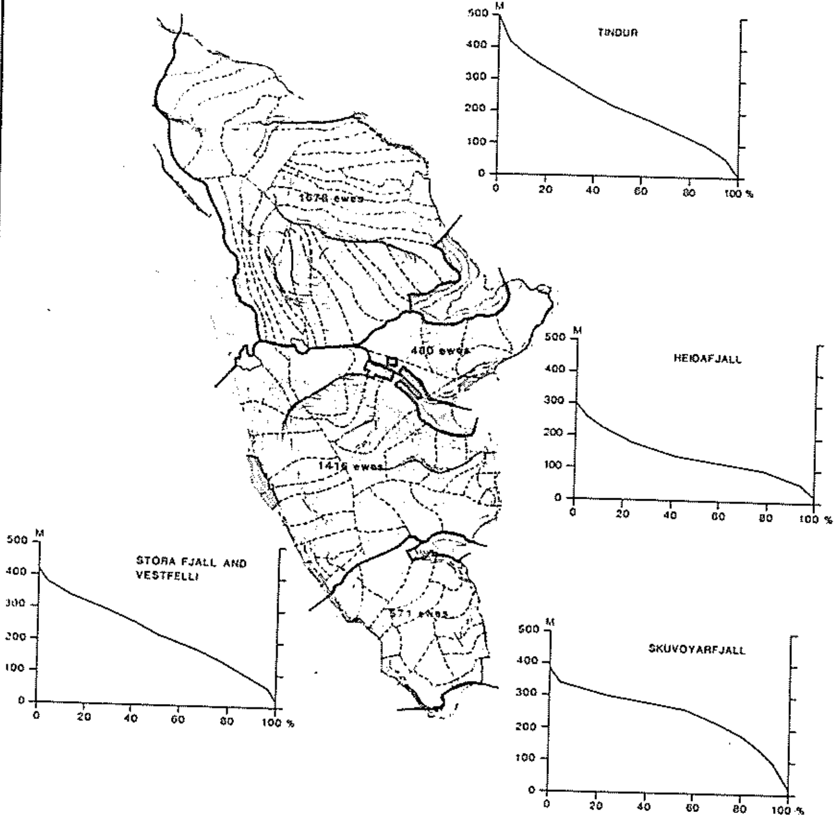
$$a_{s1}x_1 + a_{s2}x_2 + \ldots + a_{sc}x_c + \ldots + a_{s14}x_{14} = \text{minimum}$$

where $a_{sc} = \sum_{r=1}^{87} a_{rc}$. The results are given in Table III.

Table III. Primary productivity estimated by a linear programming model (tons pr. ha)

Vegetation type	I	II
1 Grass-slope formation	2.1	2.1
2 Alpine grass-slope formation	0.0	0.0
3 Moor formation	0.5	0.5
4 Heather-moor formation	0.9	0.9
5 Rocky-flat formation	0.0	0.0
Combination- and transitional types:		
1/2	1.7	1.1
1/3	0.0	0.3
2/3	0.0	0.0
2/5	0.0	0.0
3/4	1.1	1.2
3.5	0.0	0.0
2/(4)	0.0	0.8
3/(4)	0.5	0.5
5/(4)	0.3	0.2

DIVISION OF EASTERN SANDOY IN 4 CHOROLOGICAL UNITS



bondary between chorological units

1678 ewes — carrying capacity of the chorological unit

hypsographic curve for the chorological unit

Figure 3.

The model assumes, that the pasture land is used as effectively as possible, and the criteria function expresses, that a vegetation type only is given a productivity in the extent, that is necessary to fulfil the conditions of the main inequalities. This means, that the estimated primary production-figures are minimum values. So, a zero can express two different matters: That the actual primary productivity in fact is near zero (which is reasonable for the rocky-flat vegetation) or that the given vegetation type nowhere can be seen as necessary for the maintenance of the carrying capacity of the pastures (which might be the reason behind the figure for the alpine grass-slope): Thus, the analysis can tell something about the bottlenecks of the system.

Topological production potentials has been calculated, based on these estimates, and the relation between these and the production used under full use of carrying capacity has been linked to the overall chorological structure of the different grazing areas. 4 such chorological units has been separated, primarily due to geomorphological differences, as indicated in fig. 3.

The calculated relations expresses the utilization of the topological production potentials in the different chorological units. These are shown in table IV.

Table IV. Percentual utilization of the topological potential of 4 chorological units, Eastern Sandoy, Faroe Islands.

Chorological unit	I	II
	%	%
1 Tindur	65	67
2 Heidafjall	49	47
3 Stórafjall and Vestfelli	49	50
4 Skúvoyarfjall	50	53

The relative low figures expresses a general problem for the faroese sheepbreeding system, namely the very limited existence of reliable wintergrazing areas due to the geological structure of the islands. They consist entirely of basalt laid down in almost horizontal beds separated by thin strata of tuff and clay (Rasmussen and Noe-Nyegaard, 1969) so that in almost every case the summit of the mountains is flattened and forms a plateau from which the mountain flanks fall away towards the ocean or some valley in a succession of terraces. In connection with the strong coastal erosion it means that only few lowlandareas exists in comparison with the extensive higher situated outfield areas. This means that areas relative rich on grass-slopes very often cannot be used as intensively as their topological potential indicates. Fig. 10 shows the distribution of the main vegetation types on the 4 chorological units.

Table V. Distribution of vegetation types on 4 chorological units and the whole area of eastern Sandoy (in percent).

Veg. type	I	II	III	IV	E.Sandoy
Grass-slope 1,2 and 1/2	12.4	36.9	29.5	29.9	22.9
Moor 3,4, 3/4 and 3/(4)	61.2	61.0	55.6	56.6	58.3
Rocky-flat 5, 2/5, 3/5 and 5/(4)	13.1	-	7.1	1.6	8.5
other types	13.2	2.1	7.9	12.0	10.2

5. Discussion

A basic assumption is a uniform productivity of the topological landscape-types. This should be the case where they have been drawn forth by a thorough-going geo-ecological landscape-analysis. This is not the case for this investigation, where the productivity obviously differs extensively within the single vegetation type. On the other hand, a rough check on the average figures can be obtained by comparing the productivity of the combination- and transitional types with the average productivity of the in-going vegetation-formations. Especially the alternative calculation in tab.II shows very small deviations in such a comparancy.

So at least in the rather simple case of an isolated sheep-grazing system the applied mathematical methods appear to be powerful tools in the landscape-ecological comparancy of landscape-units and land-use-units.

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