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COMMENTARY

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Moving beyond 'claims' about reindeer pastoralism in Finnmark, Norway: a rejoinder

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Abstract

A recent article in *Pastoralism* (Stien et al., Pastoralism 11:1-7, 2021) criticized our earlier analysis of the management models used for reindeer pastoralism in Western Finnmark, Norway (Marin et al., Pastoralism 10:1-8, 2020). According to our critics, we misunderstood the origin of the current emphasis on maximum reindeer numbers and densities. Second, we came to the (wrong) conclusion "that densities are of minor importance for reindeer productivity" because we had made several mistakes in our statistical analyses.

This article discusses the main points we were criticized for, shows where disagreements persist and suggests some possible ways forward. We hope this discussion will help make clearer what we did in our original article and why we still think a focus on density (and implicitly maximum reindeer numbers) is not a good management tool in Western Finnmark. We also show that the influential report from 2001 by Ims and Kosmo was based on controversial interpretations of "quality objectives" for carcass weights as the starting point for their calculations of maximum number of reindeer for each district. In addition, we document some of the reactions from herders to that report and how the choice of districts included in such analyses can lead to different results and conclusions. We re-did our calculations of how much of the variation in the carcass weights of 1.5-year-old bucks (*varit*) can be explained by the number of reindeer in the spring herd (expressed as density of reindeer over the area of the summer district). The combined results of the two research teams show that between 35 and 46% of the variation can be explained by the density of reindeer, depending on the method, which is much less than the 70% that was found in 2001. Specifically, we show that the difference between our results (35% explained by density) and those of our critics (46% explained by density) is mainly because our critics have included 3 districts from Eastern Finnmark (Karasjok districts) in their analysis, but that there is no obvious reason to include these. We emphasize that research of this kind should think carefully about and report precisely the geographical scale at which the analysis is made and the reasons for this choice. Finally, we show that there is a need to report the views of reindeer herders in a more nuanced and precise way, to reflect variations among them, and to better explain their views.

Our conclusion is still that the density of reindeer herds should not be used as the most important indicator for how well the herds are doing or for how sustainable reindeer pastoralism is in Western Finnmark. This is because other complex environmental and social factors also play a very important role, which needs to be better understood. Because of this, we argue for reindeer herders' knowledge to be given more practical influence in the management plans.

(*Fuomáš ahte lea sámegielat čoahkkáigeassu artihkkala loahpas*—geahča Additional file 1 /The article includes a summary in North Sámi language—see Additional file 1).

Keywords Reindeer, Sámi, Finnmark, Density dependence, Governance, Complexity, Sustainability, *Varit*, Jahkodat

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Introduction

In a recent article in *Pastoralism*, colleagues from two Norwegian research institutions (Stien et al. 2021) criticized our earlier analysis of the management models used for reindeer pastoralism (Marin et al. 2020). In the following, we present our response to what we consider the six main points raised against our original article by Stien et al. (2021).

We hope that the present rejoinder will help bring the academic debate out of the realm of "claims" and back into the domain of inter-disciplinary search for better knowledge. Before we turn to the individual points of critique, we find it useful to summarize the arguments and show the areas where, we think, our views in fact coincide with those of our critics.

In our article (Marin et al. 2020), we criticized the policy and practice of the Norwegian government of being too focused on maximum reindeer numbers as well as on a certain herd structure dominated by reproductive female reindeer (does) and with few bucks. Based on official data, we set out to investigate the validity of several guiding principles of the current governance regime, with particular attention to the assumption that there is a strong relationship between reindeer density and carcass weights, with a focus on Western Finnmark—one of the largest reindeer herding areas in Norway.

We found that although the relationship between herd density and carcass weight is present, its explanatory power is often not very strong and considerably weaker than concluded in a previous influential study by Ims and Kosmo (2001). In addition, we argued that as a measure of productivity in reindeer systems (and indeed mobile livestock systems in general), productivity per area unit can be at least as useful as carcass weights.

Our conclusions were based on a historical contextual analysis of reindeer pastoralism using a mixed methods approach that combines statistical analyses of the relationships between carcass weights of reindeer and different explanatory variables, as well as qualitative data from semi-structured interviews with pastoralists, government officials, politicians and researchers. In addition, we also carried out participant observation and informal discussions with reindeer herders in the field, and we benefitted from the life-long practical experience of one of us as a reindeer herder.

Stien and colleagues contend that our analyses suffer from several methodological and conceptual shortcomings that have led us to the wrong conclusions (and "misleading claims") about the governance of reindeer pastoralism in Norway. Specifically, our presentation of the governance regime (historically and at present) is argued to suffer from imprecision and a misunderstanding of the origin of the current emphasis on reindeer maximum numbers and densities. Finally, the critique proposes that due to statistical errors in our analysis of the relationship between densities and carcass weights, we come to the wrong conclusion ("that densities are of minor importance for reindeer productivity"—Stien et al. 2021, p.1) and propose erroneously that productivity is better conceived in terms of output per area unit, rather than kg per reindeer.

While we disagree with most of these points, we are encouraged by the fact that, in reality, we agree with our critics on some important accounts. First, we agree with the important point raised by Stien and colleagues (p.5) that reindeer herds in Finnmark are defined by very complex dynamics deriving from both environmental and social factors. This is also why we support the use of more insightful statistical analyses like the mixed model suggested (albeit in passing) by our critics (on p.4). Finally, we concur that because of such complexities, finding good management regimes is challenging.

The latter point was in fact the gist of our original contribution. Given the complexities that underlie reindeer herding in Finnmark, a management regime that focuses disproportionately on one indicator (density derived via carcass weights) becomes a very blunt tool.

At the very least, we argued, if productivity is to be emphasized, it would be better to look at productivity per area unit instead, and contended that density has received unjustified attention and emphasis in the management regime. On this important point, it seems, we continue to disagree with our critics. Hopefully, the following sections will help uncover why our disagreements persist and whether the two opposing positions can lead to any useful resolution for the governance ahead.

Six points of contention

The governance system

One of the main critiques of our original argument is that we "give a biased description" (Stien et al. 2021, p.2) of the governance of reindeer pastoralism in Finnmark. More specifically, our analysis relies on imprecise and erroneous methods, data and references. In relation to the governance regime, it is "imprecise and erroneous because it does not distinguish between official management regulations, economic incentives, policy goals, advice and the authors' unsubstantiated claims" (ibid.). It is not clear to us if the problem is that we do not distinguish between "management regulations, economic incentives, policy goals and advice", or that we do not distinguish between regulations, etc., and our own misguided interpretations of these. If it is the former point (as implied by Stien et al.'s ensuing list of formal regulations), all we have to say is that our use of the term governance is in line with the standard definition of governance as including an

assemblage of regulations, incentives, goals and advice (e.g. Lemos and Agarwal 2006; Vatn 2015). This is, to our knowledge, unproblematic in all fields of study that deal with management, planning and human organization. Perhaps, the reaction, if indeed directed to this aspect, stems from the disciplinary affiliation of our critics who seem to be uncomfortable with the idea that regulations, incentives, policy goals, etc., can be analysed together as a governance regime.

However, if the critique is directed to the latter point (our deliberate misrepresentation of actual governance by drawing on our own "unsubstantiated claims"), it would require some clarifications. Specifically, Stien et al. "are unaware of any regulations in support of Marin et al.'s claim that economic subsidies *directly* depend on herd structure" (emphasis added). Our transgression here appears to be located in our footnote 1, where we wrote that "herders who slaughter calves and keep to the recommended numbers and herd structure receive significant subsidies." Incentives associated with calf slaughtering and herd size are not in dispute here, it seems. While we did not use the word "directly", we were perhaps guilty of not spelling out the *implicit* association between calf slaughtering and herd structure (i.e. a move away from a traditional herd structure toward one dominated by reproductive females). We will let the readers evaluate the seriousness of this act.

Stien et al. also write that "Neither are we aware of any government representative stating that a deviation from the promoted herd structure will cause 'resource degradation and economic collapse'." This is surely in response to this sentence from our paper: "Routinely, the official advice relies on the assumptions that there are maximum numbers and densities of reindeer as well as optimal herd structures, which, if respected, lead to high productivity and profit and, if ignored, lead to resource degradation and economic collapse" (Marin et al. 2020, p. 2). We stand by our original assessment because in our analysis, virtually all official documents from the Ministry of Food and Agriculture (including the yearly overview of the reindeer herding industry—so-called *Ressursregnskap*) and several important Parliamentary Policy papers (*Stortingsmelding*) of the past 30 years argue for the goal of finding the balance (read equilibrium) between the number of reindeer and the available pasture resources. Several of these central documents also mention how "The reindeer herding sector is today in a difficult resource, economic, and social situation and transformation process. This is the result of a longer process toward increased reindeer numbers, and consequent overutilization of the natural resource base (*naturgrunnlaget*), weak productivity development, and unsatisfactory economic development" (Stortingsmelding 1992, p. 7). The tone of such communications became even more dramatic throughout the 1990s and 2000s and came to include direct references to the sector as being a textbook example of the tragedy of the commons theory (e.g. Reindriftforvaltningen 2002[1]), not least by several Ministers in charge of the reindeer sector (e.g. NRK 2012[2]). Since we have written extensively about these aspects during the past two decades, and since our recent article was not aimed at analysing the governance regime per se, we did not find it useful to revisit this argument again. We see in retrospect that we should have perhaps referenced our previous work to spell out why references to degradation and collapse are very much a part of the governance regime and not our own "unsubstantiated claims". For convenience, we do so here (Marin 2005, 2006, Marin and Bjørklund 2016, Benjaminsen et al. 2015, Johnsen et al. 2015, Benjaminsen et al. 2016).

We argue therefore that our portrayal of the current and historical governance regime is accurate. This is important because it shows that, contrary to the argument of our critics, the governance of the reindeer herding sector in Norway does rely overwhelmingly on the idea that the sustainability of the system requires the setting of maximum numbers and densities, which was the premise of our original article.

[1] "Such is the situation today, that large parts of pasture resources in Finnmark are managed in principle as a common resource with open access for a larger number of herders. This brings about a 'game' between common and individual interests, which is conflicting. The common interest is to ensure a maximum sustainable yield (***maksimalt langvarig utbytte***), while individual interests are concerned with how this yield is distributed. This game is governed by the fact that the advantages from appropriating more from the resource affect only the individuals while the disadvantages are equally divided to all. If the 'game' does not come under control, it will sooner or later end up in a resource crisis for everyone. For large areas of the common ranges in Inner Finnmark this resource crisis is now a fact." (Reindriftforvaltningen 2002, p. 34, our translation). Although this formulation changed somewhat in subsequent versions of this yearly report, references to "resource crisis for all", "overexploitation" and "maximum sustainable yield" continued and by 2012 the latter term changed from "maksimalt langvarig utbytte" to "maksimalt varig avkastning" (Reindriftsforvaltningen 2012, p. 20), which is a meaning virtually identical to MSY (maximum sustainable yield) a central concept in ecological equilibrium models, often criticized when applied to pastoralist systems.

[2] In an interview with the Norwegian Broadcasting Corporation (NRK) in 2012, the then Minister of Agriculture T. Slagsvold Vedum stated (referring to the planned forced cullings, a management tool that had been "on the table" for several decades but was yet to be implemented) that "The individual reindeer pastoralist may feel that this has somewhat negative impacts on the individual, but in sum we need to get the reindeer numbers down. If not, the whole industry will lose out. This is an expression of the Tragedy of the Commons, which means that if everyone adds another reindeer, it will be profitable for the individual, but in sum the grazing pressure will be destroyed (sic!). Then all will be losers.".

The importance of the Røros model (and maximum sustainable yield-MSY)

Related to the above point, in our article, we discussed how the current model of reindeer management emerged in the 1970s and 80s in Norway. This is a model that was aimed at a restructuring of herds with a focus on does and optimization of productivity through the production of calves born in the spring and slaughtered in the autumn. We proposed in 2020 that during the last few decades, this model has guided Norwegian policy on reindeer husbandry and has been loosely referred to as the Røros model, since it was developed on the basis of research carried out in the southernmost reindeer herding districts of Norway around the town of Røros.

According to Stien et al. (2021), we assign too much influence to the Røros model in our discussion of today's policy and mis-categorize work by Dag Lenvik who developed this model. This seems like a minor point with little hope of resolution—how to "measure" influence over extended periods of time? We will therefore make just a few simple remarks that may illuminate the issue for the readers. Kosmo and Lenvik (1985) not only combine the effects of culling and a revised herd structure within a typical equilibrium framework (their Figure 2, p. 24) but also emphasize how the lessons learned from "southern pastures" (*sørlige beiteområder*) could and should be applied to Finnmark (p. 24). Stien et al. "find it noteworthy" that neither Ims and Kosmo[3] (2001) nor the Ministry of Agriculture and Food (2009) contain references to the Røros model. But both of these documents are procedurals on how to translate between herd sizes and acceptable carcass weights, and barely contain references to published material; the latter, in fact, refers only to a proposed bill on reindeer management and the authors' own mandate. However, there are examples of official policy documents (e.g. Stortingsmelding 2000) that discuss herd structure as if they were citing from the Røros model, recommending a structure where the "proportion of does can be pushed up toward 80% and the calf proportion down toward 20% in the (winter) and spring herd"[4] (p. 20). This, combined with the examples of government policy documents quoted above that literally refer to the concept of maximum sustainable yield (*maksimalt varig avkastning*), is enough evidence, we propose, that the Røros model rationale has been and still is central to the governance regime (see also Johnsen and Benjaminsen 2017).

With respect to the relationship between number of reindeer and total production that we plot in Figure 3, Stien et al. offer the following assessment:

Inspired by Lenvik (1990, Fig. 2 in Marin et al.), Marin et al. suggest a different measure of productivity for reindeer in West Finnmark, using the relationship between change in herd size from the end of March in 1 year to the same time the following year and the number of animals slaughtered within this period (predominantly in the autumn and early winter). They fitted a non-linear function to these estimates and reindeer numbers and interpreted their results as measuring MSY. This method has no methodological support in previously published work. It is well known that in seasonal environments, the seasonal timing of harvesting in relation to seasonal patterns of mortality has implications for the optimal harvest strategy (Kokko and Lindström 1998; Boyce et al. 1999; Jonzen and Lundberg 1999; Xu et al. 2005), results that are ignored in the attempt by Marin et al. to estimate MSY. If significant mortality occurs between the time of harvest and the census date at the end of March, as is expected for reindeer during winter, their method is unsuitable for estimating MSY. We note that the estimates of meat production used by Lenvik (1990) are also affected by such methodological problems.

The crux of the critique from Stien et al. concerns the possible interaction between harvesting and mortality (as influenced by seasonality and density dependence), and the implications this interaction might have for the identification of MSY. The relevance of that interaction depends on the analytical purpose. If, for example, the goal is to identify a harvesting strategy that maximizes sustainable yield across a universe of possible strategies, or simply to compare the dynamics of natural and managed populations, then this interaction may plausibly matter. It is quite possible that some alternative harvesting strategy, universally adhered to, would produce a higher MSY than the one we computed.

But those objectives were not part of our paper, and this should be obvious from both our text and our data. Our goal was to say something about production under a prevailing management regime, specifically reindeer herding in West Finnmark in the period 1981–2018, in light of an ongoing discussion about that regime's long-term viability and interventions endorsed by the Norwegian state. That management regime surely encompasses a mix of harvesting strategies, and the mix will be reflected in the data, aggregated across Western Finnmark for each year. Because our concern is with the performance of an *existing* regime rather than counterfactuals, the question of

[3] A.J. Kosmo co-authored both the 1985 paper on herd restructuring and productivity and the 2001 procedural on how to determine the highest numbers of reindeer in Western Finnmark. It makes little sense to assume the latter work was not influenced by the Røros model.

[4] Lenvik (1999) proposed the Røros model could be adapted to a so-called Finnmark model (p. 32) which at the time was based on slaughtering 1 ½ year old bucks (*varit* in North Sámi) instead of calves, and insists that a percentage of does of at least 80–85% would be necessary in order to achieve the desired productivity goals (p.34).

whether mortality is additive or compensatory is moot, and the MSY arrived at is a consistent estimate for that regime insofar as the mix of harvesting strategies is reasonably stable through time. While the literature about the nuances of density-dependence (seasonal density-dependence, sequential density-dependencies, etc.) cited by Stien et al. is interesting and perhaps even useful[5] for improving the governance regime, the reality is that the current regime is not concerned with such details: the time step for density is 1 year (1 April-31 March), and the biological processes of interest (reproduction and mortality) are treated as occurring simultaneously within that time step. Moreover, the two measures of productivity that are currently used in the yearly assessments of the reindeer herding industry (slaughter productivity and total productivity[6]) are calculated per 1 year, based on the "change in reindeer numbers converted to kg" (Reindriftsforvaltningen 2022, p. 9). The conversion is done (Ministry of Agriculture and Food—personal communication) by multiplying the change in the number of reindeer with a coefficient calculated as yearly carcass weights averaged over whole regions (e.g. Western Finnmark—ibid, p.9). In our Figure 3, we (given the focus on maximum numbers) plotted total productivity as the change in the number of reindeer, without multiplying it by that regional coefficient.

The timing of the census does pose a potential problem, though. Production, as conceptualized in our analysis, would not be affected over the long run, but population size could be. In a discussion about herd size restrictions, the salient question is whether our population numbers are based on data gathered at the same time as those used to compute associations between population and carcass weights and, subsequently, herd size restrictions. We believe the answer is yes, at least to the extent that data are indeed based on a "census".

The above points, however, serve to disguise rather than clarify the main point in all of this. We are at least as sceptical to the use of MSY as Stien et al., but for entirely different reasons. MSY happens to be one of the parameters that help describe an equilibrium model in what Behnke and Scoones (1993) labelled "the mainstream approach" in range science. With respect to Figure 3 in our paper, we wrote that "Virtually, all of the data points are at or below the herd size corresponding to MSY; there is nothing in the data to suggest the relevance of such a specification." But it is not the exact location of MSY along the population axis that matters here. What matters is this: for any reasonable model specification, production is strictly and monotonously increasing with population across the entire period for which we have data. And for the vast majority of years during that period, the actual population exceeded the official maximum reindeer number. It is, therefore, not possible to reconcile what these data tell us about population size and production with a description of Western Finnmark as chronically overstocked. This is why in our original article we also wrote that "…there is a necessary discussion regarding the application of these principles in practice."

Carcass weights and density

Stien and colleagues point out that there are three significant "discrepancies between what Marin et al. state they do and what they actually do" regarding the relation between reindeer densities and carcass weights. We explore these alleged discrepancies individually, but before we do so it is worth reminding the reader of our rationale for this particular analysis. We said at the time that we "were interested to test if a higher number of observations (more years and more carcass weights in each year) would influence the analysis" (p. 5). In other words, at no point did we claim that we will perform an identical analysis to that of Ims and Kosmo, although we see in retrospect that our text could also be read this way.

The first stated discrepancy is that "Marin et al. use only data from the "Kautokeino" districts (and not the whole of Finnmark as they state in the abstract), while Ims and Kosmo (2001) used districts associated with both Kautokeino and Karasjok" (Stien et al. 2021, p. 3).

To begin with, what we actually said in our[7] abstract is that we set out to investigate the assumption that there is a relationship (between carcass weights and densities)

[5] Under the assumption that herds of semi-domesticated reindeer behave similarly to the wild animal populations discussed therein, which is of course debatable since the former may benefit from supplementary feeding and human-driven information about fodder availability, thus possibly mitigating some of the effects of density.

[6] Our translation of the terms "slakteproduksjon" and "totalproduksjon", central in the management conception of productivity (e.g. Reindriftsforvaltningen 2022, pp. 8–9).

[7] Our critics make in passing the point that we "claim" to have included data for *varit* from 1980 to 2012, while in fact we only include data from 1997 to 2012. For accuracy, what we wrote in 2020 was "We expanded our analysis to the period 1980–2012 and included ca. 57,000 individual carcass weights for *varit* and ca. 230,000 individual carcass weights for calves". Although the period of interest for us was 1980–2012, we did not have data on all variables for all these years, nor did we claim to. The source of our data was a digital compilation we received from the Ministry of Agriculture with values of calf weights for most years, while the values for varit weights lacked for 1980–1996 for most districts. Therefore, while it is true that the varit data did not cover very well our period of interest, our other analyses (of calves' weights, of climate, of productivity per herd—Fig. 3, and of productivity per area unit—Fig. 7) did, justifying our implicit claim that we analyse the period 1980–2012. We therefore reject the insinuation that we have been somehow deliberately misleading the readership by claiming we reported *varit* data we did not have—the contrary is also evident from our publicly available data file.

that is valid over the whole of Finnmark (which is indeed composed of districts associated with the towns of Kautokeino and Karasjok, but also Pasvik and Varanger). We go on to point out (in the abstract as well as in our conclusion) that although the relationship is present, "its explanatory power is not very strong *in a variety of circumstances*" (p.1) and that the "model may be incorrect *in a variety of circumstances* and that it can therefore not be used to frame important governance policies" (p.5) (emphases added). Logically, we argue that if the model is not valid in some circumstances in Finnmark, we demonstrate that the assumption that one can use one model for the whole of Finnmark is invalid.

Having worked with pastoralist systems over three continents for several decades (three authors) and practised reindeer pastoralism for six decades (one author) has taught us to be sceptical of large-scale management models applicable to entire "systems", and reluctant to generalize and extrapolate our findings to larger contexts. This is why, we never assumed to speak for the whole of Finnmark, something evident in our consistent reference to our study area as Western Finnmark (or in Stien et al.'s terminology "Kautokeino districts") throughout the text of the original article.

All this being said, there is a more insightful discussion to be had about the spatial scale used to evaluate the relationship between densities and carcass weights. In fact, the choice to include Eastern Finnmark (or "districts associated with Karasjok" in Stien et al.'s terms) in the original assessment by Ims and Kosmo (2001) is at least puzzling. To begin with, the 2001 report is titled "Highest reindeer numbers for the districts in Western Finnmark".[8] This is a 153-page document that discusses at length individual conditions for each of the districts in Western Finnmark while mentioning Eastern Finnmark twice, both times in relation to the regression curve between density and carcass weights, specifically mentioning that the data used to derive the curve covered "most of the districts, possibly larger siidas, in Karasjok [i.e. Eastern Finnmark] and Western Finnmark" (p.19). At no point in the report (including its annexes) is it spelled out which actual districts (and/or *siidas*) were used in the analysis—although there is a rather detailed appendix explaining the analysis. The only clue the reader has to understanding which districts were used in the original analysis is figure 4.1 (on p.19) presenting data points with names of districts attached to some of them. Each data point represents the carcass weights of all reindeer slaughtered by a particular district averaged for either 1998, 1999 or 2000. The original figure was rather blurry, but it is relatively easy to distinguish the number of data points used to fit the regression curve: 38 data points. Of these, only 30 points were identified with the district numerical code, so it is not entirely clear which districts the remaining 8 points denote. The 30 marked points pertain to the following districts/*siidas*: 13 (3 points), 14 (2 points), 14 A-M (1 point), 16 A-Skn (2 points), 16 C-N (2 points), 20 (1 point), 21 (1 point), 22 (3 points), 23-J (1 point), 26 (2 points), 27 (2 points), 32 (1 point), 33 (3 points), 34 (1 point), 35A (2 points), 40 (2 points) and 41 (2 points). The interesting part regarding these 30 named points is that they include 20 points from Western Finnmark (from 12 districts) and 10 from Eastern Finnmark (from 5 districts/*siidas*). The 8 unnamed points could in theory pertain to 8 different districts/*siidas* from Eastern Finnmark, but this information is not included in the report. However, even if we had these data and insight readily available, we would not have chosen to follow what appears a rather haphazard sample of districts as units of analysis: only 12 of the 15 mainland[9] summer districts in Western Finnmark, and only 5 (or even only parts thereof) of the 14 summer districts[10] in Eastern Finnmark are included. There is no clear argumentation for why these particular 17 districts[11] are selected to depict a phenomenon that is supposedly equally relevant over the whole region of Western and Eastern Finnmark,[12] namely the strong influence of reindeer density over the carcass weights (in turn interpreted to measure objectively the "ecological sustainability" of the reindeer herding system).

[8] In original, in Norwegian *Høyeste reintall for distriktene i Vest-Finnmark*.

[9] Ims and Kosmo identified 13 mainland districts and then added two island districts arguing that the latter had "natural conditions and herding forms that are much more alike mainland districts" (p.24, our translation). During consultation processes, herders disputed this categorization and selection—see below.

[10] Eastern Finnmark districts are officially grouped into two areas: Karasjok and Polmak/Varanger. The former area comprised in 2001 eight summer districts, while the latter six. After removing the islands/peninsulas districts (District 15 in Karasjok, and District 4 in Polmak/Varanger), we are left with seven relevant districts in the former and five in the latter. The five from Polmak/Varanger are not included at all, while of the seven districts in the Karasjok area only two districts (13 and 14) are included completely while only one of three *siida* groups from each of districts 14A, 16 A and 16 C are marked in Ims and Kosmo's figure as being included. Stien and colleagues include data from three whole districts in the Karasjok area but follow Ims and Kosmo in excluding the five districts in Polmak/Varanger.

[11] Or, at maximum 25 if each of the unnamed data points denotes one individual district, observed in only one of the 3 years investigated.

[12] In fact, Ims and Kosmo (2001, p. 24) even argue that "We nevertheless think that the same mechanisms control [carcass] weights in island- and peninsula districts (…) only that the curve 'moves' higher up on the weight axis and the relation between weight and density becomes weaker (59% instead of 70%)." (our translation). Hence, one wonders how legitimate the division into mainland and island/peninsula districts is, given that the mechanisms are the same.

In fact, during the process[13] of deciding the highest permissible reindeer numbers, there was significant criticism levelled at the opaque choice of districts for deriving the relation between density and carcass weights, as documented in a subsequent evaluation of the process (Joks et al. 2006). Several important consultation inputs are cited in this evaluation. In a letter from the Sámi Reindeeer Herders' Association of Norway (NRL) to the Reindeer Herding Administration (from 30 June 2001), the Association mentions that:

In the regression analysis there are used two variables, average carcass weights of varit [1.5 year old bucks] and reindeer density on net area. Ims and Kosmo's method is way too narrow. There are many other variables which are just as important as those used in the method. To illustrate this, one needs only remove the data from the districts that are not in Western Finnmark, or to evaluate these separately, and one can clearly see that there is no relation between grazing area and weight of the varit. Some herding districts in Western Finnmark have several weight records over several years. Some of these [districts] have had heavier varit at higher density over net area. This shows that weight and density can not be used unequivocally as indicator for highest reindeer numbers for individual herding districts (Joks et al. 2006, p. 17, our translation).

In addition, and even more clearly, the Guovdageaidnu (Kautokeino) Sámi Nomadic Reindeer Herders' Association (Kautokeino flyttsamelag) mentions in their input to the hearing, in a letter submitted to the regional reindeer herding Board and the central Reindeer Herding Committee (Reindriftsstyret) that:

Based on the available documents it appears that great emphasis is placed on the curve in figure 4.1, which supposedly shows the relation between reindeer density and carcass weight of varit for the last 3 years. However, the curve shows great differences in density between districts with the same carcass weight, and it is shown no clear connection between reindeer density and carcass weight, on the contrary, there is partly a lack of connection. Furthermore, one could ask if the sample of districts is done randomly, or with the purpose of trying to show a connection between the named variables. Why, for example, are some districts in the Karasjok reindeer region [reinsogn] included, while most of the districts in Kautokeino are left out. Regarding the records of weights, they do not take into account either the jahkodat-variations for example weights from the 1960s are compared with weights in 1998 without considering in the evaluation climatic records and a comparison of these (Joks et al. 2006, p. 18, our translation).

These comments show that the sampling strategy (including the decision to merge Eastern and Western Finnmark in one analysis) is not self-evident and potentially leading to a poor evaluation of the phenomenon investigated. Two decades later, this sampling strategy is still contentious, and we argue that it cannot be treated as the gold standard for investigating the (if any) relation between densities and carcass weights in Finnmark. In retrospect, we see however that it would have been useful to emphasize the differences in samples between us and Ims and Kosmo and the reasons for these differences. For convenience, we summarize these differences in Table 1, where we also include details of Stien et al.'s sample.

However, we think there is a more important point to be discussed here regarding the influence of the sampling strategy on the description of the phenomenon investigated.

The original report by Ims and Kosmo used the by-now famous regression curve to determine a recommended density derived from a desirable "quality goal" (*kvalitetsmål*) of *varit* carcass weight, which the authors have established to be between 25 and 26 kg for the whole region. Once the desired density was known, one could, based on the known net area, recommend the desired number of reindeer for each district. The crux of the method is the regression line, but at the same time the quality goal is very important, if difficult to derive. Ims and Kosmo (2001) used two main sources to arrive at a reliable number: Movinkel and Prestbakmo's (1968) analyses of carcass weights from the 1960s and a report by the Kautokeino Flyttsamelag (PAC 1988).

The first source analysed carcass weights from seven summer districts in Western Finnmark[14] and 10 districts in Troms County recorded over 3 years (1960/1961, 1961/1962 and 1963/1964). One of the remarkable things about this analysis is that it operates with values of the net areas of Western Finnmark districts that are notably lower than what is registered today in official statistics.[15] As a consequence, the densities of reindeer per net area are notably higher than what they would be if current

[13] The report by Ims and Kosmo was a public consultation document (*høringsdokument* in Norwegian), in principle open to public objection and input. The affected herding districts were however hardly involved, the districts characterizing it as a mere token consultation around a mostly finished document, and even the Reindeer Herding Administration admitting that herders were minimally involved, and that "a case with such large consequences for the reindeer herding community ought to have had a different treatment" (Head of Reindeer Herding Administration in Joks et al. 2006, p. 85).

[14] Districts 21, 22, 23 (subsequently divided into 23A, B, C and D), 26, 27, 28 and 29.

[15] The proportions are 66, 55, 80, 77, 36, 45 and 39% respectively. On average therefore, the areas are registered as about 50% of the current official ones, with a variation btw 36 and 80%.

Table 1 Differences between the analyses of the relation between density and carcass weights

	Ims and Kosmo 2001	Marin et al. 2020	Stien et al. 2021
Spatial scale	Western (WF) and Eastern Finnmark (EF)	Western Finnmark	Western and Eastern Finnmark
Number of mainland districts	17 (12 from WF, 5 from EF)[a]	15 districts from WF	16 districts (13 from WF, 3 from EF)
Data removed (quality control)	District 36, observations in years with < 25 *varit* slaughtered	None	District 36, observations in years with < 25 *varit* slaughtered
Temporal scale	1998–2000	1996–2012 for *varit*, 1984–2012 for calves	1998–2019

[a] It is possible the number is as high as 25, but unable to ascertain from the text. See above

area values would be used. The density values observed during the 1960s and applied by Movinkel and Prestbakmo are between 23 and 9 reindeer/km^2 (see their Table 2). They conclude that, based on the estimates of available fodder, "there are way too many reindeer in most districts" (p.21). However, the carcass weights of the animals slaughtered by these districts were between 25 and 32 kg (with an average of 30 kg over 2 years) for *varit*. Now, when Ims and Kosmo (2001) refer to Movinkel and Prestbakmo (1968) as one of the two sources for determining the a priori "quality goal" (kvalitetsmålet) of 25–26-kg carcass weight for *varit*, one is left wondering how the original reference was used. Indeed, the *varit* carcass weights of the 1960s would have qualified all seven Finnmark districts as very good, meeting (and greatly exceeding in most cases) the quality objective of more than 25 kg. And yet, Movinkel and Prestbakmo say there were too many reindeer even then, the problem was presumably compounded in the intervening 35 years until Ims and Kosmo wrote their report. Even if we use the current values for the net area for these seven districts, the densities[16] are higher than the optimal interval (4.5–5.5 reindeer/km^2) recommended by Ims and Kosmo in their figure 4.3., with six out of the seven districts exceeding this value. Importantly though, Movinkel and Prestbankmo are very particular about the fact that carcass weights can be influenced by a complex of factors that, in addition to the available summer pasture, includes winter pastures, migration routes, separation episodes and use of fences (*sperregjerder*). Moreover, they repeatedly underline that the variation in carcass weights should be used only as a supplementary indicator, in addition to the methods of estimating pasture productivity, and that their material is not able to ascertain whether or not there is a "direct proportional relation between the available pasture per land unit ('*beitebelegg per arealenhet*') and carcass weights" (p.21). Finally, Movinkel and Prestbakmo state that if one is to use carcass weights as an indicator of productivity, it would be challenging to find some weight "norm" (*normtall*), but "one can for example use the average of the best half of the districts in a larger area as a norm" (p.21). They fail to specify how big the area can/should be (e.g. including Eastern Finnmark or not), but it is obvious from their numerous caveats that they would rather advise against[17] such a method for determining a "standard" for carcass weights.

Still, this is precisely what Ims and Kosmo use as a starting point in their designing of the famous density curve—the objective of 25–26 kg being set a priori. We are left wondering: was it set by averaging "the best half of the districts" in Finnmark, or how?

The other main source (in addition to Movinkel and Prestbakmo) for the origin of the density curve is a 1988 position paper (*instilling*) by the Pasture and Area Committee (PAC) of the Guovdageaidnu (Kautokeino) Sámi Nomadic Reindeer Herders' Association (Kautokeino flyttsamelag). According to Ims and Kosmo (2001, p.20), the report stipulated that "For adjusting the reindeer number, it ought to be a goal that the average weight of adult animals increased to 30–32 kg" (our translation).

[16] 6.7, 3.3, 5.6, 12, 8.4, 9 and 7 reindeer/km^2 respectively.

[17] The limitations of the method may become clearer with a numerical example. If the "larger area" to be used is Western Finnmark, the average carcass weight of the "best half" of the districts would (based on our carcass weights for 1980–2012) be 29.1 kg. If on the other hand, the larger area is Western and Eastern Finnmark combined, the norm value would be 29.9 kg. If we were to use these values as the "norm", the regression curve used by Ims and Kosmo would fit these carcass weights to densities of ca. 2 and 1.5 reindeer/km^2 respectively. Or 2.5 and 2, if we use the fitted equation ($y = -3.71\ln(x) + 32.41$) in Stien et al.'s recreation of the 2001 model. These densities are, surprisingly, less than half the densities Ims and Kosmo recommended in 2001, ruling out a use of "the best half" of the source of the norm. Furthermore, the difference between including or not Eastern Finnmark (i.e. the difference between a density of 1.5 and 2 reindeer/km^2) would translate into significant differences in total number of reindeer allowed for each district. For instance, for district 21, with a net area of 433 km^2, the difference would be of over 200 reindeer, or ca. 10% of their average herd size of 2400, while the difference for a large districts like district 23, with their 1031 km^2, is over 500 reindeer, but which is ca. 5% difference in their average herd of over 10,000 reindeer. This indicates that the "norm" based method proposed by Movinkel and Prestbakmo may also discriminate between different kinds of districts, having proportionally larger negative impacts on smaller districts. This is perhaps why its authors were cautious about the use of the norm carcass weight.

Presumably because at the time most of the animals slaughtered were *varit* (1.5-year-old bucks), Ims and Kosmo take this to mean that the average weight of *varit* ought to be 28 kg, which they deem "a moderate requirement" ("et moderat krav", p. 20).

However, a close reading of the documentation (Sámi Archive 1991) of the discussions leading to the 1988 report shows that some important details are left out of Ims and Kosmo's rendition. First, the quote reproduced by Ims and Kosmo is incomplete and should end with the sentence "Some districts thought, however, that the number [30–32 kg] was somewhat high." (PAC 1988, p. 31). Second, the committee itself emphasize several times (p. 24, 30, 31) that when they say there are "too many reindeer" they mean too many in particular locations, at particular points in time[18] and in relation to the patterns of using common pastures, that is *not* in relation to the available grazing resources, for which, they say, "it was not possible to draw any conclusion (…)." (p.24). The context of the report is important for understanding this distinction. The 1980s was a period in which the movements of the herds became increasingly unpredictable especially on the so-called common pastures. New patterns of seasonal migrations, new fences and changes in the formal regulations led to what was perceived by the herders as an unpredictable and at times conflictual situation. The committee viewed this proposed "quality goal" of 30–32 kg carcass weights as a solution to both a too unpredictable migration and use pattern and to the pressure emerging in the 1980s to reduce the reindeer numbers because of an assumed "overgrazing". The missing sentence is essential, however, because, as the protocols of the meetings the Pasture and Area Committee with the herders reveal, the quality goal was either contested or outright rejected by many herders. Some proposed the removal of the paragraph altogether, some that it be reworded to simply say "the quality of the slaughtered reindeer should increase" and some argued that one could *not* achieve this quality goal if the highest number of reindeer[19] was set. The last point seems to be reversing the density dependence logic inherent in the use of the quality goal in Ims and Kosmo's density curve. The sum of critical comments indicates to us therefore that the use of the quality goal in order to determine the maximum density allowed was most likely not in line with how many of the members of the Sámi Nomadic Reindeer Herders' Association conceived the connection between reindeer numbers and quality.

This is actually a position that we encounter in our conversations with herders up to these days (most recently in April 2023). Most herders agree that carcass weights can be a useful indicator when one has the necessary contextual background about the environmental and social circumstances in which the herd in question has operated during the relevant period. What they do not agree with is (1) that (decontextualised) carcass weights should be used alone and (2) that carcass weights can be used to conclude that there are too many reindeer/too high densities. The statistical analyses debated here seem to indicate that their misgivings may be well-founded.

The second critique to our original article on this point is that "contrary to Ims and Kosmo (2001), Marin et al. use reindeer densities from the end of the reindeer herding year rather than the onset of the reindeer herding year, as their predictor variable." (p.3). What is meant here is that the influence of densities on carcass weights was originally computed by Ims and Kosmo by connecting the density in herding year X with the carcass weights in herding year $X+1$, whereas we connected density in year $X+1$ with carcass weights in year $X+1$. Herding years are officially counted as starting at 1 April in calendar year X and ending at 31 March of calendar year $X+1$ and are officially referred to as, e.g. herding year 1999/2000 (starting 1 April 1999 and ending 31 March 2000). We have indeed mistakenly connected the density of, e.g. year 1999/2000 with the carcass weights in the year 1999/2000 instead of year 2000/2001, as Ims and Kosmo have done. This was a technical glitch that escaped our attention. Had we computed our data the correct way, the strength of the regression relationship would have been slightly different. Instead of a $R^2=0.24$, the value would have been $R^2=0.31$; in other words, 31% of the variance in the carcass weights could be ascribed to the variance of densities. Nevertheless, we maintain that this is a minor difference, since 31% is still less than half of the variance (70%) originally used by Ims and Kosmo to substantiate the importance of the regression curve applied to the calculation of the maximum numbers of reindeer in 2001.

Third, our critics also propose that the reduced explanatory strength of our regression relationship is because we "do not perform the quality control of data performed by Ims and Kosmo (2001)." More precisely, we did not discard "annual estimates based on small sample sizes (<25) and carcass weight data from varit slaughtered after the autumn rut" (i.e. district 36—D36). The goal of this exercise was to "reduce sample variance and bias" (Stien et al. 2021, p.3). To begin with, we do not agree

[18] This distinction was repeated by herders in their meetings with the PCA, when they mention that there are too many reindeer for instance on the winter pastures "in some, bad winters", or "during difficult cold periods, mid-winter", or in areas that had been trampled by the passing of other herds.

[19] The statement was made in direct reference to a decision by the Reindeer Herding Board (Reindriftsstyret) on 28 August 1987 to limit the highest number of reindeer.

that the "quality control" decisions referred to here are self-evident. If one was to remove all data of varit slaughtered after autumn rut one would have to remove many more districts than just D36, since both in Eastern and Western Finnmark there are many districts that slaughter all their varit after autumn rut[20] (see Reindriftsforvaltningen 2020 p. 46 and 65 for Eastern and Western Finnmark respectively). Moreover, while the 25 slaughtered reindeer threshold may in principle make sense, those observations do not in fact increase the variance[21] of the sample. In other words, there is no obvious statistical reason to remove those observations from the analysis, which means that the argument originally used by Ims and Kosmo and repeated by Stien and colleagues is void: removing these values does not make the relationship more robust statistically.

Nevertheless, we have also re-run our analysis with this "quality control" and found that by removing District 36, the R^2 increased to 0.32, and by also removing the values in years with less than 25 *varit* slaughtered, it increased further to 0.35.[22] This is to say that even with all the (debatable) data quality controls in place, in Western Finnmark, the predictor variable of reindeer density still cannot explain more than 35% of the variation in carcass weights, which is only half of the explanatory power that Ims and Kosmo found in 2001 (70%), and substantially lower than the one found by Stien et al. (47%) for a combined analysis of Western and Eastern Finnmark. However, the strength of our regression (proportion of the variance) with the adjusted data is very similar to that obtained by Stien et al. in their mixed model ($R^2 = 0.37$). This model is a more insightful approach that suits better the reality that one slaughtering is not independent of the next, since they both happen in the same district and the same year, and that different carcass weights in the same year may be more similar to each other than carcass weights from different years—something conceivably similar to the herders' concept of *jahkodat* (approximately translatable as "yearly variation"[23]). However, there still seems to be a surprisingly large difference in the strength of the relationship (35% vs. 47% of the variance explained by us and Stien et al., respectively).

We propose that this difference is in fact due to the difference in our data sets, rather than the method—as illustrated in Table 1.

More specifically, we propose it is due to the inclusion of parts of Eastern Finnmark. As a side note, however, it is worth mentioning that our records of reindeer numbers (which we have received from the Ministry of Agriculture) are not identical to those of our critics (which are based on the database www.reinbase.no, curated by the Norwegian Institute of Nature Research, NINA). Of all the observations of yearly number of reindeer that are common in our and Stien et al. analyses (211 observations) for mainland Western Finnmark, 46% of the observations (97 observations) had different values.[24] We have compared the discrepant 97 values with those in the official statistics published yearly (which we regard as the most reliable) and found that in the majority of the cases (70 cases) where the data were different, the data used by Stien and colleagues were wrong.[25] This suggests that these discrepancies in data may have also contributed to the differences in our findings. However, we have tested this and found out that when using Stien et al.'s numbers of reindeer, but for our sample of districts (only Western Finnmark) and years (1998–2012), the value of R^2 was in fact only 0.26, and when extending the period to 1998–2019 (Stien et al.'s time scale), the value was 0.25. It was only when adding districts 13, 14 and 14A from Eastern Finnmark to the analysis, that the value of R^2 increased to 0.47 (in fact if only district 13 had been added, the value would have still been low—0.36). This, we argue, shows that it is indeed the inclusion of two Eastern Finnmark districts (14 and 14A) that explains the difference in our results. As indicated above, there is little that can justify this inclusion theoretically. Importantly, this also indicates that the method is not robust as it appears to be influenced by sampling bias. More specifically, the lack of robustness seems to be due to the influence of outliers,

[20] They are registered as slaughtering all animals after the autumn rut and they do slaughter *varit*. Hence, their *varit* are slaughtered after rut.

[21] To test this, we have first calculated the variance of the *varit* carcass weights for two "samples" (one sample with, and one without the values in question (D36 values, and values from years with fewer than 25 animals slaughtered)) by using the VAR S function in Excel. The respective values were 9.7 and 9.6, i.e. the two samples had virtually identical variance. Subsequently, we used the F-test function in R to test if the null hypothesis ("the two samples have identical variance") should be rejected. To do so, the *p*-value should be smaller than the significance level 0.05. The *p*-value in our analysis was 0.99 and the ratio of the two variances was 1.007, which shows very strongly that the two samples are virtually identical when it comes to their variance.

[22] We also checked the regression by using Stien et al.'s method of regressing against density over gross (rather than net) area, and without the "problematic data". We found the R^2 increased only to 0.38, which is different from what Stien et al. found: $R^2 = 0.47$. However, we find the use of gross area, surprising methodologically and confusing for the debate. Since neither the original method we critiqued, nor us, use gross area, a comparison becomes unwieldy and the data incommensurable.

[23] More precisely, the term captures the distinctness of a given year as "a particular and unique succession of specific [environmental] conditions, with variable and cumulative effects." (Benjaminsen et al. 2015, p. 226).

[24] For island districts, 42% of the observations were different (56 out of 135 observations).

[25] In 24 cases, our data were wrong, and in 4 cases, both analyses had the wrong values (assuming the official data were right, which we have no reason to dispute).

since the densities (over the gross area) of reindeer in the Eastern Finnmark districts 13, 14 and 14A were less than half (3.5, 2.3 and 3.4 reindeer/km^2 respectively) of the average density in Western Finnmark districts (9.4 reindeer/km^2) in 1998–2019—based on Stien et al.'s data.

Productivity per area unit

In responding to our proposal that productivity per area unit may be at least as relevant as productivity per animal, our critics had the following opinion: "We disagree that high productivity in kilograms per square kilometer is a suitable measure to evaluate "suffering animals" and "economic returns" as implied by Marin et al.'s statement." What we wrote originally was this: "a measure of productivity in kilograms per square kilometer reveals a different picture: rather than being a failed system marred by suffering animals and low economic returns, reindeer herding in Western Finnmark becomes the most productive in Norway." (p.1). The immediate point is that two different measures of productivity are capable of generating very different stories about the success or otherwise of current herding practices in Finnmark, and that the story often favoured by authorities and media (e.g. Riksrevisjonen 2012[26] and NRK 2010[27]), based on productivity-as-carcass-weight, is one of mismanagement and misery. In light of the earlier discussion of complexity in pastoral systems, however, perhaps the more general point that needs emphasis is the folly of allowing a single, crude indicator—whatever that indicator may be—to dictate governance.

Providing empirical material to disprove animal welfare and/or economic problems was beyond the scope of our paper. We hope however that our analyses offered enough evidence to at least question the widespread idea that the Finnmark reindeer pastoralism is a "failed system", in need of strict government oversight. Our critics attempt to provide counter evidence by referring to two indicators: the proportion of marked calves lost on pastures, and net income per enterprise. This, we think, is a too superficial way of treating the thorny issues of animal welfare and economic wellbeing. These important topics deserve detailed discussions and therefore ought to be thoroughly investigated empirically and theoretically. The interested reader may find inspiration in other publications that deal with the complexity of these topics (Jørgensen et al. 2017; Reinert 2014a, 2014b, and 2016).

Ecological literature

Stien et al. claim that we "give the impression that much of the ecological literature on reindeer population dynamics focuses solely on density effects" (p.5). It is hard to understand why our critics raise this point because it is demonstrably wrong. In our article, we argue that the reindeer herding *policy* has had a monolithic view of density as the overarching independent variable, while the *research*, including ecological research, has been concerned with several other factors that influence carcass weights, the most prominent of which being climate variability. In our article, we in fact included 32 references to the ecological research that discusses the complicated relationship between reindeer (and other ungulates), pastures and climate in Fennoscandia. To claim that we do not relate to this research is therefore simply not true—in fact, we cited many of the same references Stien et al. (p.5) use to outline the "current state of knowledge". It would also be against our "interest" to ignore this literature since it generally supports our argument that the reindeer socio-ecological system in Western Finnmark is defined by complex relationships that operate at various scales, a point we emphasized several times in our original article in support of our plea for not basing governance overwhelmingly on simple indicators such as density.

Importantly, some of the aforementioned references (e.g. Sayre 2017) also point out that the issue of sampling is often a political decision, rather than a purely academic one, something referred to as "the politics of scale". We believe the insights from North American range science are also valid for Finnmark. Thus, whereas "[m]ost range *research* took place at the scale of plots or pastures, (…) range *administration* took place at much larger scales, (…) regions or districts that encompassed multiple states. Meanwhile, range *management* typically took place at intermediary scales (…)." (p.26, original emphases). This is a problem when the processes that drive the system operate at multiple spatial scales, something that has been recognized also for the ecology of reindeer for a long time, with Schaefer (1996) decrying that "decisions regarding [spatial] grain and extent in studies of caribou ecology are typically relegated to whim." (p. 259) and proposing that a minimum of three scales is needed in this type of research (*Rangifer* population dynamics): sub-populations, populations and meta-populations. We think that attention is indeed given to scales that can be approximated to these three in the current ecological research in Finnmark, but that perhaps the approximations are not always explicit (e.g. are district herds

[26] "During the last years, the economic situation for reindeer pastoralists in Finnmark has become worse. Low carcass weights, reduced prices, increased costs and more actors in the industry are an indication that the economic development is not sustainable." (Riksrevisjonen 2012, p.10, our translation).

[27] "I think the Norwegian Food Authority should report to the police reindeer herders from districts with the lowest reindeer weights (…) they have a responsibility to look after their animals." (NRK 2010—citing Animal Welfare Alliance).

sub-populations? Is "the herd" in Western Finnmark treated as a population? Is "the herd" of the whole of Finnmark a meta-population?). These are, we propose, potentially important discussions that need more theoretical and practical attention. One cannot simply treat a particular spatial scale (e.g. Western, or Western *and* Eastern Finnmark) as the self-evident locus of a phenomenon (e.g. density dependence) to be investigated, especially not when the choice of scale seems to have important governance implications. This is, incidentally, a phenomenon broadly acknowledged and discussed in cogent disciplines, under terms like "the eco-scalar fix" (Cohen and Bakker 2014). We believe insights from these literatures may help with taking better informed scalar choices and making those choices more transparent and democratic.

Do herders agree with maximum numbers of reindeer?

Finally, Stien et al. argue that reindeer pastoralists in Norway generally agree with the government policy of setting a maximum number of reindeer for different pasture areas. To support this claim, they refer to two sources: a study by Hausner et al. (2011) that interviewed 77 reindeer pastoralists in 2007/2008, and telephone interviews carried out by a journalist in the Norwegian Broadcasting Corporation (NRK) with 27 reindeer district leaders in Western Finnmark in 2019. Stien et al. cite Figure 3 in Hausner et al. (2011) as the evidence that "80% of responding reindeer herders agreed on the overall sustainability goal that reindeer numbers should be adjusted to pasture capacity to increase the condition of animals" (p.1). This is a very surprising interpretation of what is actually reported in the article. The section reporting herders' responses (Appendix 3 rather than Figure 3) does not mention adjusting reindeer numbers to pasture capacity. It does however mention that 70% of the reindeer herders support using "carcass mass as an indicator of pastoral ecosystem conditions" (p.9) and also that "[t]o adapt to adverse winters, more than 90% of interviewees maintained that slaughtering of calves and weak animals would improve herd condition and reduce susceptibility to losses" (ibid.). These seem to be rather uncontroversial findings and well in line with pastoralist experiences the world over (see Behnke and Kerven 1994 on destocking as buffering against risk). What they do not show, however, is that herders believe carcass weights to be the *main* indicator of "pastoral ecosystem conditions", or that light animals are an indicator of too high stocking densities damaging the grazing resources, which are the assumptions of the government policies of setting maximum numbers of reindeer based on carcass weights. In our view, the findings from Hausner et al. (2011) are not enough to support the broad statement of Stien et al. that herders thought "a reduction in reindeer numbers was needed" (p.1). This is also because the Hausner et al. (2011) study sampled their informants (from Western Finnmark alone !) in a very particular fashion: "(…) neighboring districts with high contrasts in abundances and productivity over the last 20 years were selected (20 of the 34 on common winter grazing land in Finnmark)." (Hausner et al. 2011, Appendix 3, p. 1). In other words, the sample of districts can be conceived as representative of a hypothetical population of neighbours with high differences in abundance and productivity, not of the population of all districts in Western Finnmark. The 77 respondents in this particular study represent a rather small proportion (5%) of the total population of registered reindeer herders from Western Finnmark at the time of the investigation.[28] One can therefore hardly use this evidence to support any claim about the opinions of all herders in (Western) Finnmark, let alone the proposition that the necessity of reducing reindeer numbers was a quasi-universally accepted view, as suggested by Stien et al. (2021, p. 1).

When it comes to the second reference (NRK 2019) used by Stien et al. in support of this argument, we are rather sceptical. The article cited does not say anything of the methodology except that "The NRK has contacted all the 27 leaders of reindeer herding districts[29] in Western Finnmark, where Jovsset Ánte[30] belongs. Of the 20 that have answered, only 9 support Jovsset Ánte. Six think he should slaughter his herd. Two think he ought to have sued his own district (…). The rest will (sic!) not have an opinion." What emerges then is a rather different picture than the simplified reading that all herders agreed to the need to reduce reindeer numbers, as suggested by Stien et al. We return herein to the issue of complexity and suggest that one cannot base governance recommendations on journalist surveys, and surely not on imprecise readings of them. The broader point in all this, however,

[28] There were 1410 persons registered as active herders in Western Finnmark in 2009/2010 (Reindriftsforvaltningen 2012).

[29] There are only 25 (summer) districts in Western Finnmark; perhaps, the journalist included Districts 38 and District Nord Kvaløy in their counting, but the herders using the latter returned to their own district (24A) after 1980, while the former was used at the time of this investigation by district 34, so none of these two districts had in 2019 a leader that could be interviewed.

[30] The NRK article is not, judging by the available information, an enquiry into a general question of whether or not there are too many reindeer in Finnmark. Instead, it was a controversial story titled "With the plateau (vidda) as battleground" that portrayed the story of a young herder (Jovsset Ánte Sara) who was being forced to drastically reduce his herd (down to 75 animals) because he had exceeded the maximum number allowed. He filed a court case against the State which was eventually tried in the Supreme Court and in which he lost. The answers from the district leaders in this article are thus better interpreted in light of the question whether or not they supported this particular herder.

is that there are rather diverse opinions among the reindeer herders themselves and within the Sámi community more broadly, about the emphasis one should place on simple indicators like carcass weights and densities, as we have pointed out in our original article. In part, this diversity of opinions about the nature of the problem and its solutions is due to the complexity of the system. As more recent work on sustainability points out, complex socio-ecological systems (like reindeer herding) are better understood as diverse and dynamic, and their governance will be facing varied notions of what are the appropriate boundaries, spatial and temporal scales and goals and values prioritized for system change (Leach et al. 2010, p.63).

Such statements about problems and solutions cannot, however, be taken at face value, without understanding the socio-cultural context in which they are made. In his seminal work on "everyday resistance", James Scott argues that social groups that feel marginalized by governments or other powerful entities perform differently "offstage" and "onstage" (Scott 1985, 1990). Onstage or "public transcripts" consist of conversations and statements that the actors play out in what they perceive to be official contexts when they are not sure of anonymity or of how the information will be used. In such cases, it is often considered safer to repeat the official narrative. Offstage presentations on the other hand, or "hidden transcripts" as Scott (1990) calls them, are accounts that subordinate actors communicate in the absence of the powerful. Such hidden transcripts reflect conversations among these groups and typically include the subjects' critique of power and its practices.

Sámi reindeer pastoralists in Norway too tend to present some views in public, while often expressing contrasting views in informal conversations among their peers (Johnsen and Benjaminsen 2017). Researchers will therefore need time to build trust before they will be able to access the offstage stories that Sámi pastoralists tell among themselves, especially related to such sensitive issues as reindeer politics and reindeer numbers. Journalists are even less likely to be able to access offstage accounts as the media generally repeat the mainstream Norwegian narrative about overstocking of reindeer, which has led to a deep mistrust among many reindeer pastoralists of journalists as well as of Norwegian researchers and government officials (see Benjaminsen et al. 2016 for contrasting narratives on Sámi reindeer pastoralists and this lack of trust). This means that we need to be sceptical of any simplistic surveys and accounts of "general opinions" among Sámi reindeer pastoralists.

Conclusions

We trust that our commentary helps the reader understand better the logic and nuances of our original arguments. More specifically, our approach to governance in general and to the genealogy of current ideas of governance and sustainability, which in our view can be traced back to the experiments, models and ecological thinking of the 1970s. We argue that the history and details of measuring the relationship between carcass weights and density play an important role in this genealogy of governance ideas, especially given their role in framing productivity as the main proxy for the sustainability of reindeer pastoralism in Norway. Our conclusion, in 2020 and now, is that the (inverse) contribution of animal density to carcass weights is sensitive to scale and location, and therefore to sampling, as well as statistical method. For some districts, in some years, the association is not supported at all. At an aggregate level (in "West Finnmark"), density seems to have an influence (R^2 of 0.31) but this is contrary to the Ims and Kosmo assertion that density overdetermines carcass weights—to the tune of an R^2 of 0.70.

We propose however that the contrasts between the two sets of analyses (those by us and those by our critics) discussed herein converge toward one central point: the relationship between carcass weights and densities of reindeer is not a very robust indicator. This is because it seems to be very sensitive to the sample analysed and in particular to the spatial scale (e.g. including or not Eastern Finnmark).[31] Rather than treating our spatial sampling of Western Finnmark as a mistake (or even as an attempt at misleading), we think a more useful approach for the way forward is to ask why this presumed central relationship is not important at the scale of individual districts, or as important as previously stated at the scale of Western Finnmark, but only emerges when very particular sampling strategies are applied (including parts of Eastern Finnmark, excluding island districts, etc.). We think the answer to this question is that the productivity (however defined) of the pastoralist system in Finnmark is affected by various dynamic mechanisms that are not easily explained or anticipated through stocking densities.

We believe continuing to emphasize density, carcass weights and productivity in the governance toward "sustainable reindeer herding" is the wrong approach. Carcass weight is just one of many potential targets pursued by reindeer herders; maximizing aggregate production

[31] In our original article, we also pointed out that at the scale of individual districts the relationship between carcass weights and density was largely absent.

or outtake, as well as risk-spreading objectives, may have a higher priority—without necessarily having negative implications for sustainability. In this, we follow reindeer herders who generally insist that carcass weights may be a useful indicator only when one has the necessary contextual background about the environmental and social circumstances in which the herd in question has operated during the relevant period. This contextual complexity disappears in the current governance system, with its focus, unwarranted in our view, on density and carcass weights.

Experience from many other pastoral systems shows that regardless of how much scientists may underline the caveats, explicit limitations and theoretical assumptions of our modelling of individual parameters, policy-makers and managers tend to be seduced by linearity, predictability, homogeneity and simplification. This has often resulted (also in Finnmark) in more and more detailed regulations and micro-management, in the hope that they would help deal with uncertainty and stochasticity. To a large degree, this appears to be a false hope. Academic disagreements like the one discussed here are useful for re-emphasizing the complexities in the reindeer pastoralist system and the contrasting views on the interlinkages in the system. Ultimately, though, what pastoralism in Norway and elsewhere needs, we propose, is management regimes that not only recognize dynamic complexities and inherent variability, but also empower those who know best how to interpret and handle such complexities: the pastoralists themselves. In Norway, this would also go some way toward achieving the still elusive political goals of Sámi self-determination and inclusive co-management of natural resources.

Supplementary Information

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Additional file 1.

Additional file 2.

Additional file 3.

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References

Archive, Sámi. 1991. *Guovdageainnu Johttisápmelaččaid Searvi (Guovdageaidnu (Kautokeino) Sámi Nomadic Reindeer Herders' Association), Case Archive 1986–1991, File PA-1093*. Guovdageaidnu: Mimeo.

Behnke, R.H., and I. Scoones. 1993. Rethinking range ecology: Implications for rangeland management in Africa. In *Range Ecology at Disequilibrium: New Models of Natural Variability and Pastoral Adaptation in African Savannas*, ed. R.H. Behnke, I. Scoones, and C. Kerven, 1–30. London: ODI/IIED.

Benjaminsen, T.A., I.M. Gaup Eira, and M.N. Sara. 2016. *Samisk reindrift, norske myter*. Bergen: Fagbokforlaget.

Benjaminsen, T.A., H. Reinert, E. Sjaastad, and M.N. Sara. 2015. Misreading the Arctic landscape: A political ecology of reindeer, carrying capacities and 'overstocking' in Finnmark, Norway. *Norwegian Journal of Geography* 69 (4): 219–229.

Boyce, M., A. Sinclair, and G. White. 1999. Seasonal compensation of predation and harvesting. *Oikos* 87 (3): 419–426. https://doi.org/10.2307/3546808.

Cohen, A., and K. Bakker. 2014. The eco-scalar fix: Rescaling environmental governance and the politics of ecological boundaries in Alberta, Canada. *Environment and Planning d: Society and Space* 32: 128–146.

Hausner, V. H., P. Fauchald, T. Tveraa, E. Pedersen, J. L. Jernsletten, B. Ulvevadet, and K. A. Brathen. 2011. The Ghost of Development Past: the Impact of Economic Security Policies on Saami Pastoral Ecosystems. *Ecology and Society* 16(3).

Ims, A.A. and A.J. Kosmo. 2001. Høyeste reintall for distriktene i Vest-Finnmark - Høringsdokument. Alta: Reindriftsforvaltningen.

Johnsen, K.I., and T.A. Benjaminsen. 2017. The art of governing and everyday resistance: "Rationalization" of Sámi reindeer husbandry in Norway since the 1970s. *Acta Borealia* 34 (1): 1–25.

Johnsen, K.I., T.A. Benjaminsen, and I.M.G. Eira. 2015. Seeing like the state or like pastoralists? Conflicting narratives on the governance of Sámi reindeer husbandry in Finnmark, Norway. *Norwegian Journal of Geography* 69 (4): 230–241.

Joks, S., Magga, O.H., Mathiesen, S.D. & I.M. Henriksen. 2006. Reintallet I Vest-Finnmark, forskningsbasert vurdering av prosessen rundt fastsettelsen av reintallet I Vest-Finnmark. Guovdageaidnu, Sámi University College (Sámi Allaskuvla).

Jonzen, N., and P. Lundberg. 1999. Temporally structured density-dependence and population management. *Annales Zoologici Fennici* 36: 39–44.

Jørgensen, G.H.M., C.M. Mejdell, S.M. Stubsjøen, Ş.Ö. Gülzari, R. Rødbotten,B-J. Bårdsen, and R. Rødven. 2017. *Welfare criteria in the reindeer husbandry*. A review of welfare indicators and potential criteria for reindeer and reindeer meat. https://www.landbruksdirektoratet.no/nb/filarkiv/rapporter/Velferdsindikatorer%20i%20reindriften%20NIBIO%20Sluttrapport.pdf/_/attachment/inline/10906350-2703-48a5-9a93-9cb50ddf46c2:d62803d66c08d9fa4f6f67fcc885051241f751e4/Velferdsindikatorer%20i%20reindriften%20NIBIO%20Sluttrapport.pdf.

Kokko, H., and J. Lindström. 1998. Seasonal density dependence, timing of mortality and sustainable harvesting. *Ecological Modelling* 110 (3): 293–304.
Kosmo, A.J., and D. Lenvik. 1985. Ressurstilpasningen i reindriften. *Landbruksøkonomisk Forum* 2: 23–27.
Leach, M., Stirling, A.C., and I. Scoones. 2010. Dynamic Sustainabilities: Technology, Environment, Social Justice (1st ed.). Routledge. https://doi.org/10.4324/9781849775069.
Lemos, M.C., and A. Agarwal. 2006. Environmental Governance. *Annual Review of Environmental Resources* 31: 297–325.
Lenvik, D. 1990. Flokkstrukturering- tiltak for lønnsom og ressurstilpasset reindrift. *Rangifer* 4: 21–25.
Lenvik, D. 1999. Flokkstrukturering- tiltak for lønnsom og resurstilpasset reindrift (Herd structuring- measures for profitable and resource-adjusted reindeer husbandry). *Rangifer Special Issue* 4: 21–35.
Marin, A. 2005. Pastoral dilemmas in a European context: the case of reindeer rangelands in sub-arctic Norway. *Securing the Commons* (11), IIED, Colchester, UK.
Marin, A. 2006. Confined and sustainable? A critique of recent pastoral policy for reindeer herding in Finnmark, Northern Norway. *Nomadic Peoples* 10: 209–232.
Marin, A., E. Sjaastad, T.A. Benjaminsen, M.N.M. Sara, and E.J.L. Borgenvik. 2020. Productivity beyond density: A critique of management models for reindeer pastoralism in Norway. *Pastoralism* 10 (1): 1–8.
Marin, A., and I. Bjørklund. 2016. Is Finnmarksvidda a commons? (In Norwegian: Er Finnmarksvidda en allmenning?). In *Sámi Reindeer Pastoralism. Norwegian myths (Norwegian: Samisk reindrift. Norske myter)*, ed. T.A. Benjaminsen, I.M. Gaup Eira, and M.N. Sara, 107–127. Bergen: Fagbokforlaget.
Ministry of Agriculture and Food. 2009. *Fastsetting av økologisk bærekraftig reintall*. Regjeringen.no. https://www.regjeringen.no/no/tema/mat-fiske-og-landbruk/reindrift/fastsetting-av-reintall/id546545.
Movinkel, H. and H. Prestbakmo. 1968. Variasjon i slaktevekta hos rein i en del sommerbeitedistrikter i Finnmark og Troms. *Meldinger fra Norges Landbrukshøyskole* 48 (21): 1–26.
NRK 2010. *Fears starvation catastrophe on the plateau (in Norwegian- "Frykter sultkatastrofe på vidda"*. Published 23.11.2010 https://www.nrk.no/sapmi/frykter-sultkatastrofe-pa-vidda-1.7382888
NRK 2012. *The Minister Exhorts to Cooperation (in Norwegian- «Ministeren maner til samarbeid»)*. Published 31.10.2012 http://www.nrk.no/kanal/nrk_sapmi/1.8378991.
NRK. 2019. Med vidda som slagmark. https://www.nrk.no/tromsogfinnmark/xl/med-vidda-som-slagmark-1.14387023.
PAC (Pasture and Area Committee). 1988. Pasture and Area Committee's Recommendation. In *Part of the Case Archive 1986–1991, File PA-1093*. Guovdageaidnu: Mimeo. Sámi Archive.
Reindriftsforvaltningen. 2002. *Ressursregnskap for reindriftsnæringen for reindriftsåret 1. april 2000–31.mars 2001*. Alta: Landbruksdirektoratet.
Reindriftsforvaltningen. 2012. *Ressursregnskap for reindriftsnæringen for reindriftsåret 1. april 2010–31. mars 2011*. Alta: Landbruksdirektoratet (Online: Ressursregnskap for reindriftsnæringen 2010 og 2011.pdf (landbruksdirektoratet.no).
Reindriftsforvaltningen. 2020. Ressursregnskap for reindriftsnæringen for reindriftsåret 1. april 2019-31.mars 2020. Alta. Landbruksdirektoratet.
Reindriftsforvaltningen. 2022. *Ressursregnskap for reindriftsnæringen for reindriftsåret 1. april 2021–31.mars 2022*. Alta: Landbruksdirektoratet.
Reinert, H. 2014a. Entanglements. Intimacy and non-human ethics. *Society & Animals* 22: 42–56.
Reinert, H. 2014b. Weight, density and space in the Norwegian Reindeer crisis-Notes towards a critique. *Valuation Studies* 2 (2): 153–183.
Reinert, E. 2016. Årsaker til at planøkonomien er blitt varig ødeleggende for verdiskapningen i samisk reindrift. In *Sámi Reindeer Pastoralism. Norwegian myths (Norwegian: Samisk reindrift. Norske myter)*, ed. T.A. Benjaminsen, I.M. Gaup Eira, and M.N. Sara, 145–174. Bergen: Fagbokforlaget.
Riksrevisjonen 2012. *Riksrevisjonenes undersøkelse av bærekraftig reindrift I Finnmark (Office of the Auditor General of Norway's examination of sustainable reindeer herding in Finnmark)*. Report 3:14. https://www.stortinget.no/globalassets/pdf/dokumentserien/2011-2012/dokumentbase_3_14_2011_2012.pdf.
Sayre, N.F. 2017. The politics of scale. A history of rangeland science. 288 pp. Chicago, University of Chicago Press.
Schaefer, J.A. 1996. Incorporating spatial scale into ecological studies of Rangifer. *Rangifer Special Issue* 10: 259–260.
Scott, J. C. 1985. Weapons of the Weak: Everyday Forms of Peasant Resistance. New Haven, Yale University Press.
Scott, J. C. 1990. Domination and the Arts of Resistance: Hidden Transcripts. New Haven, Yale University Press.
Stien, A., T. Tveraa, R.A. Ims, J. Stien, and N.G. Yoccoz. 2021. Unfounded claims about productivity beyond density for reindeer pastoralism systems. *Pastoralism* 11 (20): 1–7.
Stortingsmelding. 1992. *St. melding 28 (1991–1992)- En bærekraftig reindrift (A sustainable reindeer herding sector), Parliamentary Whitepaper, Approved 7 February 1992*.
Stortingsmelding. 2000. *St. prp. Nr. 65. Om reindriftsavtalen 2000–2001* Accessed 10 Nov 2022 Stp 65 (regjeringen.no).
Vatn, A. 2015. *Environmental Governance. Institutions, policies and actions*. Cheltenham: Edward Elgar Publishing.
Xu, C., M. Boyce, and D. Daley. 2005. Harvesting in seasonal environments. *Journal of Mathematical Biology* 50 (6): 663–682. https://doi.org/10.1007/s00285-004-0303-5.

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