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Research Article

Legal Regulation of Supplementary Cervid Feeding Facing Chronic Wasting Disease

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ABSTRACT The supplementary feeding of cervids is a widespread practice across the northern hemisphere. There are few studies, however, regarding the extent of feeding in space and time. There are adverse effects of supplementary feeding, of which the most severe are increased parasite and disease transmission. With the recent emergence of chronic wasting disease (CWD) among cervids in Norway, a legal regulation was issued that banned all supplementary cervid feeding. We quantified the spatial extent and intentions of feeding cervids across all of Norway using a questionnaire at the municipality scale. We also compared spatial extent of feeding before and after the feeding ban to shed light on the ability of regulations to control supplementary feeding. Supplementary feeding to increase winter survival and targeting roe deer (*Capreolus capreolus*) was more common (48.4% of the municipalities) than the feeding of red deer (*Cervus elaphus*; 20.5%) and moose (*Alces alces*; 7.4%). The main feeding period was January–March, but extensive feeding also occurred from November to December and in April. Reducing traffic accidents was also a motivation, particularly for the feeding of moose (14.5%), and this was the main motivation (86%) for public feeding. Among the 65.7% that responded, 53.3% reported they knew about supplemental feeding of cervids in their municipality. In the region with the first feeding ban, 80.2% of municipalities were feeding in 2015–2016 before the ban, which was reduced to 68.4% in 2016–2017 and remained at 68.4% in 2017–2018. In the remainder of Norway, 81.4% were feeding in 2015–2016, and 72.6% were feeding in 2016–2017, but after the ban, this increased to 78.6% in the harsh winter of 2017–2018. Our study highlights that regulations across broad scales may not be followed and that more spatially targeted regulations and increased enforcement are required for disease transmission to be more effectively combated.

KEY WORDS chronic wasting disease, cervids, disease ecology, disease management, legal regulations, supplemental feeding, wildlife feeding.

The supplemental feeding of wildlife is a widespread practice across Europe and North America (Putman and Staines 2004). Feeding is often intended to increase winter survival of cervids (Schmidt and Hoi 2002, Milner et al. 2014), but feeding is also used as a diversionary measure for reducing browsing damage to forests or attracting cervids away from roads to reduce traffic accidents (Wood and Wolfe 1988). Feeding wildlife changes animal behavior and therefore has many unintended side effects (Milner et al. 2014). Feeding has turned moose (*Alces alces*) into central place foragers (van Beest et al. 2010), and the home range sizes of roe deer (*Capreolus capreolus*) have been reduced (Ossi et al. 2017). Supplemental feeding leads to animal aggregation, causing locally high browsing pressure on natural forage (Brown and Cooper 2006, Mathisen et al. 2014) and changing the plant community structure in turn (Smith 2001). The redistribution of individuals and groups can change the genetic structure of deer populations (Blanchong et al. 2006). However, there are few quantitative studies regarding the spatial extent and intentions of feeding at broader scales. In Spain, 63% of 30 populations of red deer (*Cervus elaphus*) were fed during the rutting season (Pérez-González et al. 2010). In Idaho, Oregon, Utah, Washington, and Wyoming, USA, 31,000 elk (*Cervus canadensis*) were fed (Smith 2001). The feeding of wildlife is controversial and not legal everywhere, but little is known about how effective legal

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measures are at preventing people from feeding (Inslerman et al. 2006, Rudolph et al. 2006).

An effect of feeding is the increased chance of parasite and disease transmission (Milner et al. 2013, Sorensen et al. 2014) due to increasing contact rates between hosts or by promoting pathogen accumulation at feeders or the surrounding environment (Murray et al. 2016). In the United States, there were increased concentrations of the prions that cause chronic wasting disease (CWD) around the artificial mineral licks used for white-tailed deer (*Odocoileus virginianus*; Plummer et al. 2018), and such sites are regarded as hotspots for disease transmission (Mejia-Salazar et al. 2018). It is therefore common in the United States and Canada to ban wildlife feeding and baiting to achieve a lower transmission rate of CWD (Gillin and Mawdsley 2018). There is often considerable uncertainty, however, regarding compliance when new policy or regulations are implemented in wildlife management (Nichols et al. 1995). In Michigan, USA, baiting and feeding of white-tailed deer continued despite a regulatory ban in an area with bovine tuberculosis (Carstensen et al. 2011). In 2016, an outbreak of CWD in a reindeer (*Rangifer tarandus*) population in Norway was discovered (Benestad et al. 2016, Mysterud and Rolandsen 2018). Therefore, the Norwegian Food Safety Authority issued (through the Ministry of Agriculture and Food) a regulation banning all supplemental feeding and the use of saltlicks targeting cervids to limit the chance of spreading CWD (Landbruks- og matdepartementet 2016*a*). Baiting during hunting is not a common practice in Norway, but supplemental feeding has become popular in many areas and is often applied by hunters during winter to enhance deer survival. We therefore do not know how effective management actions, in terms of legal regulation, will be at stopping cervid feeding, and the implementation uncertainty of this management action appears high.

We used a national questionnaire sent to the person responsible for wildlife management in all 420 municipalities in Norway. Our objective was to answer and quantify 5 questions: 1) What is the spatial extent of the supplemental feeding of cervids? 2) What types of feed are used, and what are the motivations behind feeding? 3) Does feeding vary with the population density of roe deer, red deer, and moose and with broad environmental variables? 4) To what level has the legal ban of feeding reduced the spatial extent of feeding? 5) Has feeding ceased altogether with the stricter legal ban within the CWD management zones (Selbu and Nordfjella)?

STUDY AREA

The study area covered all of Norway (Fig. 1). Norway cover 385,180 km^2 and a wide latitudinal range with contrasting ecosystems (see Mysterud et al. 2016 for a more detailed description). The climate severity, in terms of colder winter temperatures and increasing snow depths, generally increases from coast to inland and from south to north. Moose occur in most of the country, but the numbers are low in western Norway (Fig. 2) and above the tree line. Conversely, red deer occur at high densities in western and central Norway and at lower densities in the south and east (Fig. 2). Roe deer follow the distribution of moose in the southern parts of Norway and are, for the most part, absent from northern Norway (Fig. 2). There is no authorized feeding of wild reindeer in Norway.

Regulations

In the Public Administration Act of Norway, a regulation (forskrift) is a decision concerning rights or obligations to an indefinite number or an indefinite circle of persons (Law paragraph § 2; Justis- og beredskapsdepartementet 2017). The feeding ban regulation was instituted before the winter 2016–2017 and included the counties of Nord-Trøndelag, Sør-Trøndelag, Møre og Romsdal, Sogn og Fjordane, Hedmark, Oppland, and Buskerud (Landbruks- og matdepartementet 2016*b*). These counties were selected because of discovery of a novel type of CWD in 2 moose in the municipality of Selbu (Pirisinu et al. 2018). From 2017–2018, the ban was nationwide. The regulation of CWD zones was implemented in 2017 (Landbruks- og matdepartementet 2017). The CWD zone in Nordfjella included the municipalities of Ulvik, Lærdal, Aurland, Hemsedal, and parts of Eidfjord, Hol, and Ål (north of road RV7), whereas the CWD zone in Selbu included the municipalities of Selbu, Klæbu, Tydal, and Malvik and parts of Stjørdal, Meråker, Melhus, Midtre Gauldal, Holtålen, and Røros (Fig. 1). The regulation allows people or municipalities to apply for short-term exceptions to the ban, but the exceptions are difficult to grant within the CWD zones.

METHODS

Survey

Online surveys can access large and geographically distributed populations (Lefever et al. 2007). We sent a survey as a web-based questionnaire with a link sent by e-mail on 23 May 2018 and a reminder sent on 18 June 2018. We asked 7 main questions: 1) Are you aware of whether there is or has been supplemental feeding of cervids in your municipality? 2) Was fodder made available for the moose, red deer, or roe deer in your municipality (separate answers for 2016, 2017 and 2018)? 3) Has feeding been paid and performed by public or private entities? 4) What was the purpose of the feeding? 5) What was the type of feed used? 6) Approximately how much feed was used per year? 7) During what months did feeding occur? The questions were provided with a set of selected answers, but opening for additional comments in a separate field. The full questionnaire was in Norwegian (available online in Supporting Information).

We sent surveys to the person responsible for wildlife management in each of the 420 municipalities in Norway. Most Norwegian municipalities are small with transparent societies. In rural areas they may have <1,000 but more commonly around 2,000–3,000 inhabitants. Wildlife managers have extensive contact with land owners, hunters, forest managers, and the public as part of deer hunting management (e.g., setting quotas, reporting harvest data, setting management aims in cooperation with land owners) and as part of their obligations of reporting the number and cause of

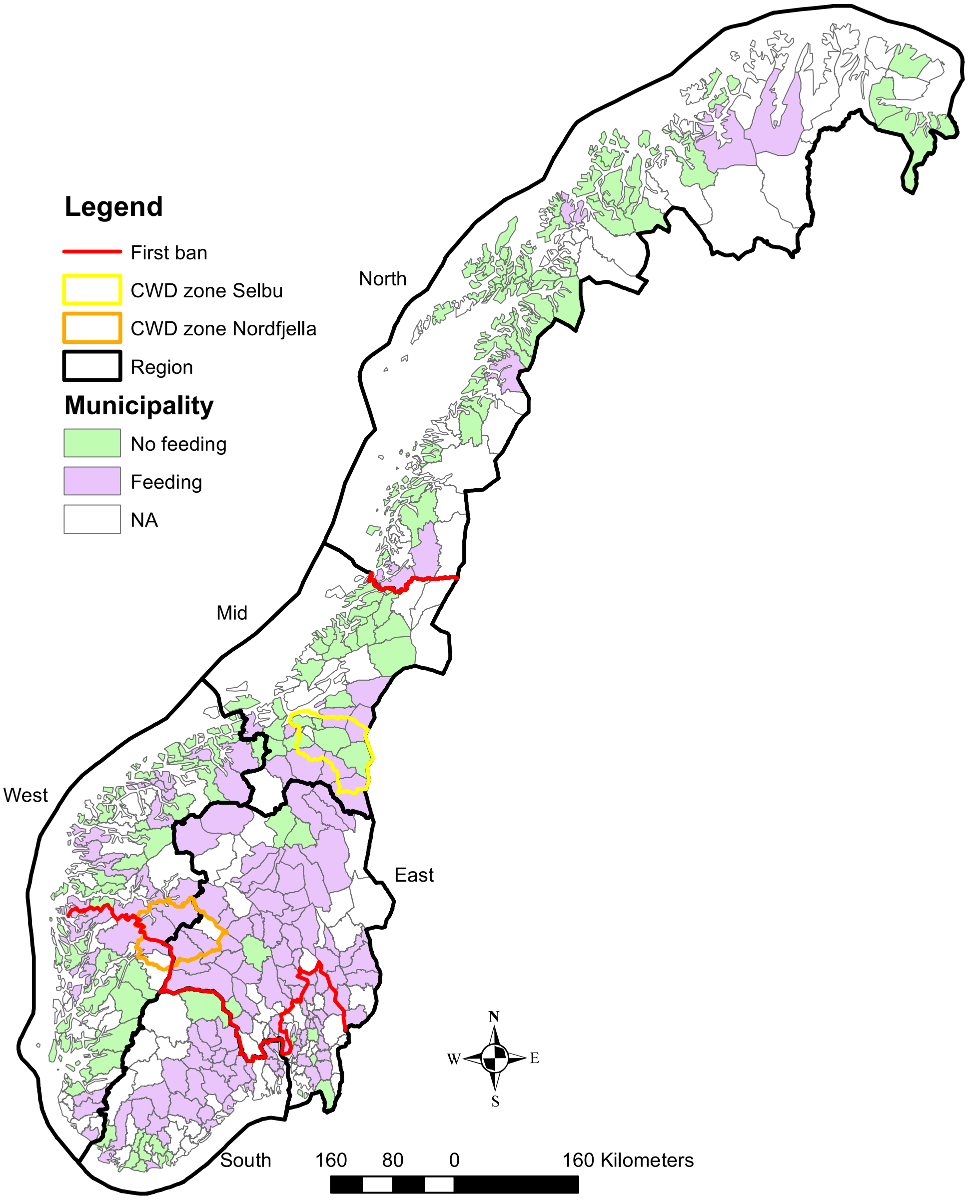

Figure 1. The spatial distribution of supplemental cervid feeding in Norway based on a survey in 2018. A regulation banning all supplemental feeding targeting cervids to limit the chance of spreading chronic wasting disease (CWD) was first introduced before winter in 2016–2017 for the mid region of Norway (first ban). From the winter 2017–2018, the ban was nationwide.

incidental mortalities of deer (e.g., deer-vehicle accidents, animals found dead) in their municipality (Hoffman and Flø 2017). They are usually also the person in the municipality that organizes any public feeding, alone or in cooperation with landowners (those having hunting rights), and the one that on behalf of the municipality or together with the Norwegian Public Roads Administration or the National Rail Administration, finances the feeding. By regular interactions with these wildlife managers, we feel confident that they are reasonably well informed about the level of feeding in their municipality and the best to answer these questions reliably.

Covariates Describing the Municipalities

We calculated the distance to the coast and the latitude (Universal Transverse Mercator coordinates) from and at the center point of each municipality, which was based on official Norwegian maps available in a geographical information system (GIS). From Statistics Norway (www.ssb.no, accessed 30 Jan 2019), we retrieved data on the proportion of forested areas, agricultural land, high elevation areas (>200 m above sea level), and the areas used for human settlements in each municipality. Likewise, we retrieved data on cervid harvest statistics for all municipalities from Statistics Norway (www.ssb.no). As a proxy for population density, we used the number of harvested roe deer, red deer, and moose per km^2 of cervid habitat within the municipalities. Cervid habitat mainly includes areas of forest and bogs and is the basis for issuing harvest quotas to land owners (i.e., hunting right holders) by wildlife managers. This density proxy has been tested against independent abundance data and provides an accurate reflection of the spatial variation in cervid densities at the municipal scale (Mysterud et al. 2007, Ueno et al. 2014).

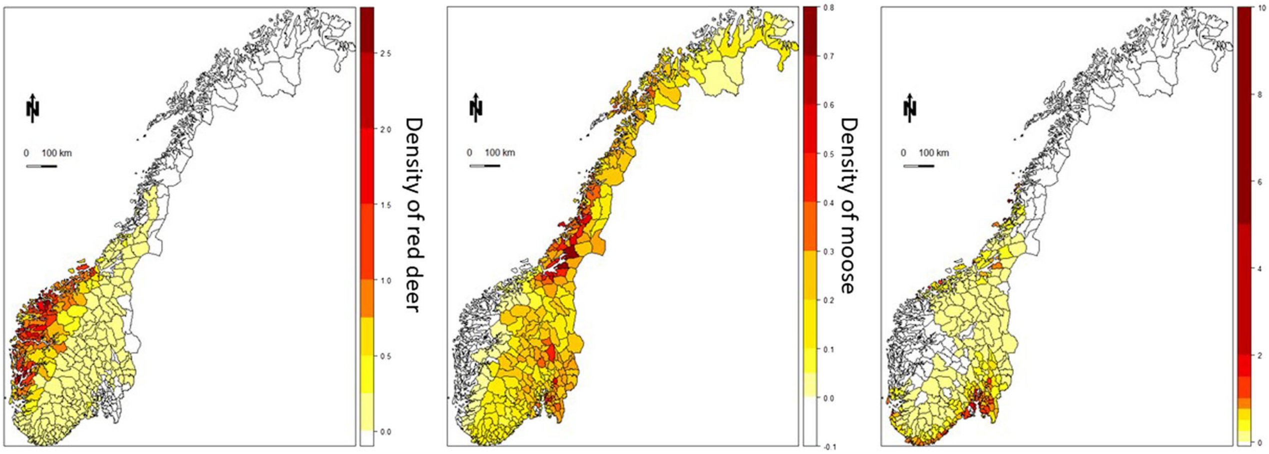

Figure 2. The spatial distribution of cervids in Norway based on harvest statistics from 2016. The density is estimated as the number of animals harvested divided by the forest and bog area/km^2 at the municipality scale.

Statistical Analysis

We used feeding or no feeding at the municipality level as a binary response. We hence used the logistic regression for analyses implemented in R version 3.5.1 (R Development Core Team 2018).

Nonresponse bias.—Missing responses can introduce bias in surveys (Aerny-Perreten et al. 2015). We used 2 approaches to test for bias (Brøgger et al. 2003, Svensson et al. 2012). We ran spatial models analyzing the pattern of missing values with the same covariates as described under analysis of spatial extent in the next paragraph. We also tested whether the results were associated with number of days before answering the survey, or alternatively whether there was an effect of answering before or after a reminder was sent. We added these terms (number of days to response, before or after reminder) to the best spatial extent and temporal models (see below) to see if either term improved model fit.

Spatial extent.—We ran models analyzing the spatial extent of feeding based on the information from all the respondents. We examined to what degree the feeding varied with latitude, distance to coast, the proportion of forest, the proportion of high (>200 m above sea level) elevation areas, and the harvest densities of moose, red deer, and roe deer. We compared models including these variables with a spatial variable of the broad regions (south, east, west, mid, and north; Fig. 1).

Temporal pattern.—We then ran a model including only the information from the respondents that reported that feeding occurred in their municipality. We were interested in the interaction term between year as a factor (winter 2015–2016, winter 2016–2017, and winter 2017–2018) and the management status. The management status separated the counties in which a feeding ban occurred in 2016–2017 versus those in which the ban was introduced in winter 2017–2018 (Fig. 1). There were too few municipalities to use CWD zone (Nordfjella, Selbu) as a factor in the formal analysis. We also tested whether the temporal feeding pattern differed between the broad regions, combining region into 2 categories (south and east vs. west, mid, and north). For the temporal model, we used a mixed effect logistic regression, including municipality as a random effect (using the lme4 R library).

We controlled for the spatial dependency of the observations by adding a variable for the presence or absence of feeding in the neighboring municipalities. We used the Akaike's Information Criterion corrected for small sample sizes (AIC_c) to compare the models (Burnham and Anderson 1998). We selected the model with the lowest AIC_c value for parameter estimation. If there were models with $\Delta AIC_c \leq 2$, we used the model with the fewest parameters.

RESULTS

Response Rate and Potential for Nonresponse Bias

We obtained a response rate of 65.7% (276 out of 420 municipalities), of which 84 of 276 (30.4%) came after the second request to answer. Thirty-two individuals reported for >1 municipality, but provided independent information for each. For 5 municipalities, we received answers from 2 respondents involved in deer management, but their responses were identical and hence treated as 1 response. The probability of a municipality answering the questionnaire was higher for municipalities with a red deer population, increased with moose density, and was higher if >50% of the neighboring municipalities participated (Table 1). The probability that we obtained an answer also increased with increasing forest cover, but the strength of this effect decreased at intermediate and high forest proportions (i.e., the negative second-order term for the forest proportion was significant). Hence, lack of response was linked to areas with low populations of moose and red deer and with few neighbors answering the survey, and therefore in areas where feeding cervids is not a relevant issue because of low population sizes. Among respondents, we contrasted responses after the first and second request for answers, and also investigated the effect of date of response as a continuous variable. Neither of these variables lowered the AIC_c relative to the best spatial or temporal model of

Table 1. Parameter estimates of the logistic regression models of the spatial pattern of the missing values and the spatial and temporal extent of supplemental feeding of cervids at the municipality scale in Norway, before the ban was introduced and development during 2016–2018. We scaled the continuous variables to a mean of zero and a variance of 1. The 2.5% and 97.5% are the boundaries of the estimated odds ratios (OR) or, for the intercept (reference level), the odds. Spatial dependency1 (1–0 variable) was defined as 1 if the proportion of neighboring municipalities with feeding was >0.5. Spatial dependency2 was defined as feeding (1) or no feeding (0) in neighboring municipalities.

Parameter	Estimate	SE	*Z*	Pr(>|*Z*|)	Odds or OR	2.5%	97.5%
Missing values							
Intercept	0.132	0.268	0.492	0.623	1.14	0.67	1.94
Proportion of forest	0.028	0.123	0.229	0.819	1.03	0.81	1.31
Proportion of forest^2	−0.310	0.115	−2.694	0.007	0.73	0.58	0.92
Red deer density above 0	0.895	0.255	3.506	<0.001	2.45	1.49	4.06
Moose density	0.429	0.153	2.806	0.005	1.54	1.15	2.10
Spatial dependency1	0.738	0.242	3.047	0.002	2.09	1.30	3.36
Spatial extent							
Intercept	−1.464	0.412	−3.550	<0.001	0.23	0.10	0.50
Proportion of area >200 m a.s.l.	0.389	0.176	2.208	0.027	1.48	1.05	2.10
Region north vs. west	−1.134	0.530	−2.139	0.032	0.32	0.11	0.87
Region south vs. west	1.419	0.499	2.842	0.004	4.13	1.61	11.59
Region mid vs. west	−0.480	0.491	−0.977	0.328	0.62	0.23	1.60
Region east vs. west	1.973	0.455	4.338	<0.001	7.20	3.05	18.44
Spatial dependency2	1.594	0.434	3.675	<0.001	4.93	2.16	11.98
Temporal effects							
Intercept	3.172	0.904	3.507	0.001	23.85	5.16	231.79
Year 2017 vs. 2016	−2.529	0.758	−3.336	0.001	0.08	0.02	0.32
Year 2018 vs. 2016	−2.892	0.780	−3.706	<0.001	0.06	0.01	0.23
Region south + east vs. west + mid + north	0.690	0.938	0.735	0.462	1.99	0.34	15.28
Year 2017:region south + east	2.152	0.897	2.398	0.016	8.60	1.59	56.07
Year 2018:region south + east	3.329	0.969	3.436	0.001	27.91	4.67	218.58

feeding when added alone or in interaction with other relevant variables (Table S1, available online in Supporting Information). Thus, our sample is representative for the areas in which population sizes of cervids are high enough to make feeding a relevant management issue from the perspective of local practitioners.

Spatial Extent of Feeding

Among the respondents, 53.3% said they knew about the supplemental feeding of cervids in their municipality. The remaining 46.7% were not aware of any ongoing feeding of cervids in their municipality, indicating feeding was absent or at least rare in their area. Before the onset of the feeding ban, there was less feeding in the north and in mid-Norway, and more feeding in the south and east than in the west (Table 1). The models including the broad regional categories or longitudes and latitudes outcompeted the models that included the covariates of the roe deer, moose, or red deer population densities ($\Delta AIC_c > 2$). However, cervid population densities correlated with the regions (Fig. 2). Red deer are mainly found on the west coast, with lower feeding levels, whereas roe deer and moose have denser populations in the eastern and southern parts of Norway, with more feeding. In the mid and northern parts of Norway with the lowest feeding levels, the moose density was lower and roe deer were only present in a few areas. Among the environmental variables, only the proportion of high elevation areas entered the best model, indicating more feeding in municipalities with a large proportion of total area >200 m above sea level. This elevation variable correlated with the distance to the coast, but the model with elevation rather than distance to coast gave a slightly better fit to the data ($\Delta AIC_c = -1.4$).

Temporal Pattern of Feeding Before and After Regulation

Among those reporting the occurrence of supplemental feeding, 80.8% of the municipalities fed in 2015–2016, of which 70.5% continued to feed in 2016–2017 and 73.3% in 2017–2018. In the region with the first ban, 80.2% of the municipalities were feeding in 2015–2016. This share was reduced to 68.4% in 2016–2017 and remained at 68.4% in 2017–2018. In the remainder of Norway, 81.4% were feeding in 2015–2016 and 72.6% in 2016–2017, but this increased to 78.6% instead of decreasing after the ban in 2017–2018. The best spatial representation of the pattern was south and east Norway combined, with a higher feeding level than the west, mid, and north of Norway combined. The best model based on AIC_c score included year as a categorical variable and the interaction term year × region. The interaction indicated a decline in the proportion of municipalities feeding in winter 2016–2017 compared to winter 2015–2016 and in winter 2017–2018 compared to winter 2015–2016 for the west, mid, and north of Norway (Table 1). We did not observe a decline in winter 2016–2017 or winter 2017–2018 for the south and east regions. Adding management status ($\Delta AIC_c = 1.9$) or the management status × year interaction increased the AIC_c score ($\Delta AIC_c = 14.9$ if management status × year is used instead of the region × year interaction); hence, the timing of the ban had little predictive power for explaining the feeding pattern. Some municipalities also reported feeding occurrence in the Nordfjella and Selbu CWD zones.

Duration, Intention, and Feeding Type

Most of the feeding occurred in winter, with 92.5% of the municipalities feeding in January (of those reporting that supplemental feeding occurred), 97.3% in February, 87.7%

in March, 39.7% in April, 0.7% in May, 0% in June, 0.7% in July, 2.7% in August, 3.4% in September, 6.2% in October, 37.0% in November, and 63.7% in December ($n = 146$). Increasing survival during winter was the most commonly reported motivation for supplementary feeding, with 48.4% (90 of 186) aimed at roe deer, 20.5% (47 of 229) aimed at red deer, and 7.4% (19 of 256) aimed at moose. The reduction of traffic accidents was the second main motivation, of which 7.8% (20 of 256) were aimed at roe deer, 3.8% (10 of 266) aimed at red deer, 14.5% (35 of 241) aimed at moose, and 3.8% (10 of 266) aimed at all cervids. Only 3.8% (10 of 266) noted that the motivation for feeding was to reduce forest damage. In 2016 ($n = 135$), the feeding was organized by private individuals in 79.3% of the municipalities and by the public community in 3.7% of the municipalities, whereas in 17.0% of the municipalities, the feeding was organized by both private and public communities. Among the 20.7% in 2016 reporting the feeding was organized by the public (or public and private), the feeding intention was to reduce car-vehicle collisions in 86% (24 of 28) of the cases. Only 114 respondents reported when the cervid feeding was initiated; hence, the reports were likely biased towards those with a recent onset. Only 9.6% reported that the feeding started from 1980–1989, 14.9% from 1990–1999, and 42.1% from 2000–2009, whereas the remaining 33.3% started after 2010.

Hay bales were offered as feed in 76.0% of the municipalities ($n = 146$), but they were typically combined with oats or grain pellets (25.3%), vegetables (52.1%, of which carrots were identified for 35.5%), fruits (20.5%, of which apples were identified for 45.5%), bread (6.2%) and silage (8.9%). Several noted that the hay bales for livestock were unintentionally used by cervids when they were stored in agricultural fields. The mean number of hay bales provided per municipality per winter was 188 (10–1,700), but the sample of respondents indicating the number was low ($n = 28$). The number of feeding areas in each municipality was on average 13 and as high as 60 ($n = 72$). Many noted that the number of private feeding places of roe deer was unknown but likely to be extensive, so these figures should be viewed with caution.

DISCUSSION

Cervid management in Europe has mainly been for hunting but also for regulating populations to avoid adverse effects on agriculture and forestry and reducing deer-vehicle collisions (Apollonio et al. 2010). With the emergence of CWD, this situation has changed in Norway; limiting the transmission and spread of disease are becoming an integral component of cervid management (Mysterud and Rolandsen 2018). This is likely to become an issue in any country in Europe with CWD detection (Mysterud and Edmunds 2019). One important measure in Norway is the ban on the widespread practice of winter feeding because this concentrates cervids and may promote disease transmission. Feeding bans are a commonly implemented management practice in the United States to limit CWD (Williams et al. 2002, Inslerman et al. 2006) and other diseases, such as bovine tuberculosis (Rudolph et al. 2006). Feeding and disease transmission is also of relevance for the spread of African swine fever in Europe (European Food Safety Authority Panel on Animal Health and Welfare et al. 2018) and it may become illegal to feed wild boar (*Sus scrofa*). Understanding the implementation uncertainty of regulations with regard to feeding is therefore of general interest. Our study documents the limited ability of legal regulations to limit such feeding in the face of a severe wildlife epidemic.

Feeding cervids and wildlife in general clearly affects the behavior and performance of individuals, especially under adverse conditions (Schmidt and Hoi 2002). As expected at these northern latitudes, most of the feeding occurs in winter. The feeding of roe deer accounted for almost half of the intentional feeding and typically consisted of vegetables and fruits in addition to hay bales. Starvation and high mortality are typical of roe deer populations during severe winters (Cederlund and Lindström 1983). The winter of 2016–2017 was milder than the snow-rich winter of 2017–2018, at least in the south of Norway, where roe deer dominate. Therefore, when the feeding ban became nationwide, the proportion of municipalities that were feeding slightly increased instead of decreasing, most likely as a result of the harsher winter. Feeding was more common in municipalities with a higher proportion of high elevation areas, which are municipalities with a higher proportion of migratory cervids and a larger seasonal range contraction (Mysterud et al. 2001). A limitation of our study was that few respondents reported the feeding level, but some of the municipalities reported using >1,000 hay bales. Estimating the number of feeding sites across Norway was beyond the scope and economy of our project. Our aim was to assess the spatial extent of feeding and the level of compliance to a new regulation across broad scales. Our study has limitations in design regarding detecting more fine-scale variation in feeding because there may be an effect of less feeding beyond the proportion of municipalities with feeding or no feeding. However, our results are consistent with observations from Michigan, USA, where the baiting and feeding of white-tailed deer continued after a regulatory ban was implemented in an area with bovine tuberculosis (Carstensen et al. 2011), with consequences for further disease transmission (Cosgrove et al. 2018).

Implementation uncertainty around new policy is often considerable in wildlife management (Nichols et al. 1995). Changing the behavior of hunters and people in general through regulations can be difficult to achieve, even for more ordinary hunting management goals (Cornicelli et al. 2011, Cornicelli and Grund 2011, Schroeder et al. 2017, Watkins et al. 2018). In Wisconsin, USA, the implementation of new harvesting regimes in the form of deer antler tine restrictions were met with skepticism because of established beliefs (Cornicelli and Grund 2011), and introducing antlerless moose hunting in Alaska, USA, led to agency mistrust (Brinkman 2018). The management actions for limiting disease transmission are often more pronounced (Uehlinger et al. 2016), and hunter reactions can be difficult to predict and counter to expectations (Heberlein 2004, Holsman et al. 2010). In the United States, hunters' attitudes are sometimes negative towards regulations that limit CWD (Haus et al. 2017). It was therefore not surprising that many people continued feeding the cervids even after the ban was introduced in Norway, although the level documented here was high. For feedings organized by the public, the main intention in 86% of the cases was to reduce traffic accidents, and there was resistance to end these feedings. Though a review reported that diversionary feeding appears to be a promising tool for accident prevention (Milner et al. 2014), there is scarce scientific evidence regarding the efficacy of feeding to reduce deer-vehicle collisions. The most commonly cited study reported the expected effect in only 2 of 6 cases and the reverse effect in 1 of 6 cases (Wood and Wolfe 1988), and another study had a sample size that was too low to draw conclusions (Peterson and Messmer 2011). Current evidence suggests a weak effect at best, and reducing the density of cervids is likely more efficient than feeding to reduce deer-vehicle collisions (Mysterud 2004, Rolandsen et al. 2011).

A lack of knowledge about the ban may be an issue. We searched the Retriever database (https://web.retriever-info.com/services/archive.html, accessed 14 Jan 2019) containing all paper and online news channels in Norway for the terms "ban AND feeding" and "roe deer OR red deer OR moose OR cervids" during the last 3 years and obtained 183 hits, of which 26.8% were in 2016, 15.8% were in 2017, and 57.4% were in 2018. This can be compared to 6,210 hits on CWD during the same time frame. In a survey performed by Norstat on behalf of the Norwegian Institute for Nature Research for the general public in Norway, 33.2% had not heard about the feeding ban, and only 55% understood the necessity of a ban (C. M. Rolandsen, Norwegian Institute for Nature Research, unpublished data). The survey was also distributed by e-mail and social media to members of the Norwegian Association of Hunters and Anglers and hunters in general. Among the responding hunters, 98% had heard about the feeding ban, but as for the general public, only roughly half of them (56%) sympathized with the ban (C. M. Rolandsen, unpublished data). Part of the reason for this result may be the common conception that the regulation is too strong given the current disease situation. How stakeholders perceive disease risk is important (Hanisch-Kirkbride et al. 2013, Triezenberg et al. 2014*a*). The implementation of a national ban on feeding cervids in Norway is a rather extreme implementation of the precautionary principle. All of the cases of the classic contagious type of CWD are currently restricted to a single population of wild alpine reindeer (Benestad et al. 2016, Viljugrein et al. 2019) within the CWD zone in Nordfjella (Fig. 1), yet the ban was applied to all of Norway. The new type of CWD discovered in moose is assumed to have low or no transmissibility (Pirisinu et al. 2018). It is therefore a risk that the national ban on feeding can lead to the erosion of trust for more necessary actions that are taking place to fight classic CWD.

There is little doubt that the feeding ban should be implemented in areas with CWD, but then compliance and regulation enforcement are important issues to consider (Rudolph and Riley 2017). Information campaigns may have some effect on changing hunter behavior in efforts to control disease (Muter et al. 2013), but the media may overemphasize scientific uncertainty (Heberlein and Stedman 2009), and the effects of campaigns to change behavior are not always strong (Triezenberg et al. 2014*b*, 2016). New antler restrictions were enforceable and adhered to by hunters despite the low social acceptance of a regulation change (Wallingford et al. 2017). The social consideration regarding the implementation scale of a baiting ban was important for the efficacy of fighting tuberculosis among white-tailed deer in Michigan, USA (Rudolph et al. 2006). Supplementary feeding may, in some cases, promote the spread of pathogens (Becker et al. 2018), but it is likely to mainly affect the transmission of CWD in a given area. The distribution of supplemental feed may also affect contact rates and the assumed disease transmission (Creech et al. 2012), and a more dispersed local feeding distribution may be a publicly more acceptable alternative to a full feeding ban in areas without CWD detection.

MANAGEMENT IMPLICATIONS

A wide cervid feeding ban with little or no regulation enforcement is occurring in Norway. It may be advisable to ban cervid feeding only in or near areas where CWD is detected, and that the enforcement of the ban in such areas should be much stronger than it is today. In areas without CWD detection, a more dispersed local feeding distribution should be considered as an alternative to a full ban. With such a change in strategy, the management to limit CWD and potentially the transmission of other diseases may become more effective because of a higher level of adherence, yet this remains to be documented.

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