EMERGENCY OR SUPPLEMENTAL WINTER FEEDING AS A TOOL FOR PEARY CARIBOU PRESERVATION

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ABSTRACT. A literature search was made on the use of artificial foods for emergency or supplemental winter feeding of cervids. The search was restricted to Rangifer, including North American caribou and European reindeer; and North American cervids of the genera Cervus, Odocoileus, and Alces. Pertinent points and facts were compiled to aid in evaluating the feasibility and desirability of winter feeding programs for caribou (Rangifer tarandus spp.) on the Canadian Arctic Islands. It appears that emergency winter feeding would not serve well as a conservation tool for caribou on the Arctic Islands of Canada. Prolonged supplemental winter feeding would be feasible, however, from a nutritional standpoint but its desirability still remains in question and it would be extremely costly. Commercial rations containing 11-16% crude protein, 1-3% crude fat, and 7-26% crude fibre would likely provide adequate nutrition for Peary caribou, based on feeding trials with artificial foods for domesticated reindeer in Alaska. A detailed study of food palatability and ingestion rates in terms of daily nutritional requirements and associated behavioural responses by caribou offered a continual supply of artificial food at a feeding station would permit a fuller evaluation of the desirability and feasibility of establishing a workable supplemental winter feeding program as a last option in the in situ preservation of caribou populations on the Canadian Arctic Archipelago. We recommend the Canadian Wildlife Service field base camp on northeastern Bathurst Island, Northwest Territories, as the most practical site for carrying out any initial detailed study of Peary caribou on the Queen Elizabeth Islands.

RÉSUMÉ. Une recherche documentaire a été faite sur l'emploi de nourriture non recherchée naturellement par les animaux en vue du nourrissement d'urgence ou de la fourniture de compléments alimentaires pour l'alimentation hivernale des cervidés. La recherche a été limitée au genre Rangifer, qui comprend le renne d'Eurasie et le caribou, ainsi qu'aux cervidés des genres Cervus, Odocoileus et Alces. Les observations utiles ont été compilées pour aider à établir la pertinence et la faisabilité de programmes d'alimentation hivernale pour les caribous (Rangifer tarandus spp.) de l'archipel Arctique canadien. Il semble que la fourniture d'une alimentation d'urgence ne constituerait pas un bon moyen de conservation des populations de caribous vivant dans l'archipel. On pourrait toujours fournir des compléments alimentaires durant une période prolongée de l'hiver, mais il est permis de demeurer perplexe quant à la pertinence de cette mesure tant du point de vue nutritionnel que des coûts prohibitifs entraînés par cette mesure. Des rations commerciales contenant de 11 à 16 % de protéines brutes, de 1 à 3 % de gras brut et de 7 à 26 % de matières cellulosiques brutes devraient assurer une alimentation adéquate aux caribous de Peary, d'après les expériences faites en Alaska avec des aliments non recherchés naturellement par les animaux sur les troupeaux domestiques de rennes. Une étude détaillée sur la palatabilité et le rythme d'ingestion des aliments, en fonction des besoins nutritifs quotidiens et des réactions comportementales associées des caribous que l'on réunirait en une zone d'alimentation et que l'on nourrirait régulièrement d'aliments non recherchés naturellement par les animaux permettrait une évaluation plus approfondie de la pertinence et de la faisabilité d'un programme réaliste de compléments alimentaires hivernaux comme dernier recours pour la préservation *in situ* des populations de caribous de l'archipel Arctique canadien. Il est recommandé d'utiliser la base du Service canadien de la faune, située dans la partie nord-est de l'île Bathurst, dans les Territoires du Nord-Ouest, qui est le site le plus pratique pour mener à bien toute étude initiale du caribou de Peary dans les îles de la Reine-Élisabeth.

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INTRODUCTION

Peary caribou (Rangifer tarandus pearyi) are unique to the Canadian High Arctic, and are not known from any Old World location. Their numbers on the Queen Elizabeth Islands have declined drastically from an estimated ca. 26 000 in 1961 to only 3300-3600 individuals in the late 1980s (e.g., Tener 1961, Miller et al. 1977, Miller 1990). Therefore, based on a Canadian Wildlife Service, report (Miller 1990) to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Peary caribou were uplisted in 1991 from their 1979 classification of "Threatened" to the more dire level of "Endangered". In addition, the Banks Island population of arctic-island caribou (R. t. groenlandicus x pearyi) was also uplisted by COSEWIC to the "Endangered" classification, while those arctic-island caribou on the remainder of the arctic archipelago (excluding the Baffin and Bylot islands region) remained classified by COSEWIC as "Threatened" (cf. Miller 1990). As a result of these uplistings by COSEWIC a national recovery plan for Peary caribou is being developed for submission to the committee on the Recovery of Nationally Endangered Wildlife (RENEW) in Canada. Part of this recovery plan calls for determination of what could or should be done for the conservation/preservation of Peary caribou.

We made this review to aid us in our evaluation of the desirability and feasibility of using artificial foods for emergency or supplemental winter feeding of Peary caribou (Rangifer tarandus Pearyi) or other "arctic-island" caribou (R. t. groenlandicus x pearyi) on the Canadian Arctic Archipelago. More than 50 articles specific to caribou/reindeer, elk (Cervus spp.), and deer (Odocoileus spp.) were reviewed from which highlights were drawn. Relevant literature for moose (Alces spp.) was also sought with no result. Literature specific to deer and supplemental feeding appears to be the most thoroughly scientifically researched, and articles appear continuously from at least 1939 to the present. There are comparatively few articles written about winter feeding of elk. Most of these are about the program at the National Elk Refuge at Jackson Hole, Wyoming. There are no references detailing any Canadian supplementary feeding programs for caribou. Fennoscandian researchers, however, have applied themselves to the subject. The work of J.R. Luick in Alaska emerges as the premier source of investigative research into many specific aspects of feeding reindeer/caribou. Also, one cannot disregard some of the information which has emerged from the experiences of reindeer herders in the former Soviet Union. The following report is our summary of the highlights drawn from the reviewed literature and our evaluation of the feasibility of emergency and supplemental winter feeding of Peary caribou and other arctic-island caribou on the Canadian Arctic Islands.

METHODS AND MATERIALS

We carried out a standard literature search for information pertinent to the subject of feeding artificial foods as emergency or supplemental winter feeding programs for ungulates of the family Cervidae.

The following references were selected for this report: caribou/reindeer, 26 references; elk 13; deer 15; and 2 general. We then combined what we gleaned from the above literature with our knowledge of the literature and our experiences with caribou on the Canadian Arctic Islands to make our evaluation.

When the term "starvation" is used in this report as the cause of death of an ungulate, it is solely because the author(s) of that source reference used that term in their article. "Starvation" is defined as, "A state of existence without food or with inadequate food." (Van Nostrand's Scientific Encyclopedia 1983). To many readers "inadequate" does not clearly indicate a consideration of nutritional quality as well as the quantity of the food that is accessible to an ungulate. Thus, "starvation" carries only the connotation of a severe lack of food but it does not necessarily specifically connote that the quality (nutritional value) of the food is of primary consideration. Threfore, we suggest that when the term "starvation" is used in connection with free-ranging ungulates, the user(s) provide a working definition to clearly pointout that they are considering only "involuntary starvation"' which is a state of "undernutrition" due to severe reduction in the accessibility of an adequate supply of high-quality forage; and that they are not considering any form of "voluntary starvtion" such as anorexias or partial or total fasting (e.g., Young and Scrimshaw 1971, Mrosovsky and Sherry 1980). We submit that the death of ungulates in the wild (other than for some cases involving newborn calves) essentially always results from extreme "undernutrition" or "malnutrition" rather than from "starvation" (death caused by lack of anything to eat - empty stomach). We therefore suggest that these more exacting terms should be used in place of "starvation", when reporting or discussing the causes of death of ungulates (cf. Mautz 1978:344), with the possible exception of newborn calves in some instances. (1) "Undernutrition" - a condition of substandard bodily health resulting from energy intake that is below the level for the maintenance of good health; may be caused by inadequate food supply or by failure to ingest, assimilate, or utilize necessary food elements. Thus, "extreme" or "extreme prolonged" undernutrition would apply more when the state of "undernutrition" will lead or has led to the death of the individual. (2) "Malnutrition" - any of various disorders of nutrition, caused either by an unbalanced or insufficient diet ("primary malnutrition") or by defective assimilation of foods ("secondary malnutrition").

Short's (1981:126) conclusion regarding the wintertime food supply for deer also apears applicable herein: "The secret to keeping a deer alive during winter is twofold: (1) body energy stores going into the winter must be substantial; and (2) foods yielding adequate digestible energy must be provided throughout the stress period so that a condition of irrevesible undrnourishment is not reached." Although we recognize the importance of adequate summertime nutrition, we deal herein only with the

need for supplying adequate high quality food throughout the winter period.

RESULTS

1. Highlights From Selected References

1.1. Reindeer/caribou

Gul'chak 1954
Reindeer breeding

- low calories of lichen in winter do not ensure sufficient quantities of nitrogen, calcium or phosphorus
- "These components [nitrogen, calcium or phosphorus] can e.g. be compensated by an addition of hay and fish meal,...." (p. 95)
- "A combination of 120 g of fish meal and 15 g of chalk restores fully the positive balance of nitrogen, calcium and phosphorus." (p. 95)
- have experimented with using horse feed (bricketted mixed feed) and found:
  - belly dimensions (ratio of belly to chest circumferences) increased 10%
  - water consumption increased
  - took more time to feed
  - "the loss of time for chewing one lump of food increased by 34% and the number of movements of the jaws per minute was reduced by 42%." (p. 96)
- regarding the use of fishmeal:
  - bulls: 51 g/day for approx. 145 days in winter increased weight by 1.8% while a control group lost 19% of their original weight
  - does: lost 6.3% of live weight while a control group lost 22.9%
- better conception rates, reduction in calf loss, earlier initiation of calving, and better birth weights noted with the addition of fish meal

Djatsenko 1971
The utilization of urea-mineral supplementary feed in the raising of reindeer

- "The researchers at our research institutes have determined that the supplementing of the protein and mineral deficiency of the reindeer with fishbone or meatbone flour or with concentrated feed prevents the protein starvation of the animals during the late winter and early spring." (p. 139)
- conclusions from feeding experiments include:
  (1) "The supplementary feed of urea and mineral fodder gives a high biological effect during the fall and late winter and early spring, when lichen is the principal food of the reindeer." (p. 139)
  (2) "Lichen is a sufficiently good source of nourishment for the micro flora of the rumen to make the use of urea possible for the protein synthesis." (p. 139)

(3) "The supplementary feed of urea-minerals remedies completely the protein-mineral starvation condition of the reindeer during the fall, late winter and early spring." (p. 139)
(4) "The cost of the supplementary feed is repaid five-sevenfold in the form of increased growth and reduced losses of animals. The supplementary feed has also a favourable effect on the usage of lichen and the multiplying of the animals." (p. 139)

- number of cases of urea poisoning "insignificant"
- daily ration of 20 g of urea in the mixture is recommended
- [overall: a very favourable report on the use of urea-minerals but no experimental details provided; such broadbrush conclusions should be viewed cautiously]

Rydberg 1971
Supplementary feed for reindeer

- Swedish feed mixture used since 1967 for reindeer, providing 2.51 Mcal/kg and 68 g digestible protein:
  (by weight)
  - 40.2% grain
  - 5.0% wheat bran
  - 50.5% dried beet pulp
  - 4.3% vitamins and minerals
- "feed mixture is eagerly eaten by the reindeer, if they earlier have become accustomed to feed." (p. 175)
- "Familiarizing them with the fodder has...gone very well with an increasing portion of 0.5 kilogram per reindeer and day. In practical conditions, a death rate of 2-3% should be reckoned with on the transition to feed, depending upon the condition of the reindeer at the start of the feeding." (p. 175)
- experiments in winter 1968 increasing the amount of digestible protein from 27 to 44 g/Mcal resulted in no better growth
- have tried distribution on rocks or hard-packed snowdrifts with good result
- observations from testing a pelleted mineral feed for 7 months with a herd of 430 reindeer consuming an average of 15 g/animal/day showed:
  - "During...migration to find food, the mineral feed is pointless. The same thing applies to so-called roaming reindeer." (p. 176)
  - placement feeding cribs should be either to windward or in the middle of the pasture
  - order of familiarization should be old females, calves, young animals, and young males
- protein deficit of flora in winter can be lessened by introducing a source of nitrogen into the mineral feed
- it is not economical to feed reindeer with supplemental feed alone except at the point of an emergency and at the time of calving

Jacobsen and Skenneberg 1975
Some results from feeding experiments with reindeer

- Norwegian State Domestic Reindeer Research Institute
- studies include:
  - development of substitutional foodstuffs
  - effects of different supplements to a lichen diet
- the ideal and practical feed should have:
  (1) good tolerance (normal ruminal digestion)
  (2) slow consumption (especially in transition period palatability should be low)
  (3) high energy content
  (4) simple composition
- findings:
  (1) the ration having the best dietary effect, slow consumption rate and high energy content was: course-ground, pelleted
  - 40% barley
  - 17% oats
  - 15% wheat bran
  - 25% young grass
  - 3% soybean oil

  (2) supplements (proteins, minerals or energy) increased the intake of lichen, reduced digestibility of total ration (compared to lichen alone) and gave a positive growth response
- supplements gave a marked increase in appetite and thus ration intake
- groups given supplementary protein gained weight; protein was the most beneficial additive, and there was better gain with "natural" protein than with urea

Klein 1976
Ecology and management of wild and domestic reindeer in Siberia

- reporting on reindeer herders in Yakutia, USSR
- "Considerable success has been obtained using urea as a nitrogen supplement when animals are on lichen ranges. If offered in late winter animals maintain better body condition with the greatest benefits being in increased size of calves at birth and increased survival and growth of calves. Urea can only be offered when the reindeer are on a high carbohydrate diet otherwise urea poisoning results." (no pagination in article)

Kurkela 1976
Prospects for reindeer husbandry based on grass and silage feeding.

- study reindeer held in 2.5 ha to 8 ha pastures and 2.0 ha forest
- article detailed but not directly applicable
- animals fed on a variety of plant fodder (including root crop feeds) and

silage
- reindeer dug up turnip tops and cabbage from frozen ground, even under 30 cm of snow
- article indicates that reindeer are highly adaptable and will utilize a wide variety of plant foods, both natural and cultivated.

Luick 1977a
Diets for captive reindeer

- article contains feeding guidelines for translocating and maintaining reindeer in captivity
- the transition to a low-protein, high-fibre, pelleted horse ration is more likely to be successful than a change to a high-protein, high-energy dairy cattle concentrate
- article contains:
  - tables on dietary programs for maintaining reindeer in captivity
  - tables on composition and proximate analyses of some successful reindeer rations
  - comments on specific feeds for reindeer

Luick 1977b
Reindeer, horse and yak production in northeast Siberia, USSR

- information obtained during an exchange visit to Yakutia, NE Siberia in Nov/Dec 1977 to the Tomponski State Reindeer Farm
- Yakutian feed supplements consist of urea, salt, minerals, and cereal grains fed for 2 months prior to slaughter
- costs of supplemental feeding:
  - $38/45.4 kg (100 lbs)
  - fed for 30-40 days @ 2 kg (4.4 lb)/reindeer/day = $67 to feed 1 reindeer for 40 days
  - mean weight gain: 20-25 kg (44-55 lb)/reindeer
- "the benefit of supplementing reindeer during winter is due entirely to the energy content of the mixed grains and not to any nutritional effects of the added urea, minerals or salt." (p. 29)
- urea poisoning is a potential problem
- "reindeer are supplemented not only for fattening but also during periods of severe climatic stress, i.e. during deep snow periods or when ranges are covered with ice."

Luick 1977c
Feeding experiments with perennial grasshays being used to revegetate transportation corridors, February/May 1976

- research at Cantwell Reindeer Experiment station using 12 reindeer, 2 treatments, 1 control
- experiment to determine nutritional value of perennial grasshays used to revegetate transportation corridors in Alaska
- experimental feed groups:

- PCS=Purina cattle starter
- NBG=Nugget Kentucky bluegrass (poa pratensis)
- AR/CA=Arctared red fescue (Festuca rubra)/bluejoint reed grass (Calamagrostis canadensis)

- NBG and AR/CA fed in increasing amounts as PCS was decreased
- control group on PCS consumed 4X as much dry matter per day as those on AR/CA
- NBG reindeer consumed 2X as much hay as those on AR/CA
- those reindeer on PCS maintained body weight to at least 85 days vs. those on grasshays lost body weight from 20-40 days after the experiment began (2 reindeer on NBG died at 50-60 days and all reindeer on AR/CA died from 47-57 days)
- "grasshays are not considered a 'natural' foodstuff of freely grazing reindeer and caribou and...speculate that palatability, texture and/or innate food habits may have been important factors in reindeers' failure to consume a sufficient amount of nutrients as grasshay to meet their maintenance requirements." (p. 9)
- article also gives information on blood chemistry work, postmortems, and biokinetic studies of water metabolism

Luick 1977d
Feeding experiments to establish criteria for determining the physiological status of reindeer, February/May 1977

- experiments to determine indices of physiological performance for reindeer feeding on very high and very low planes of nutrition in winter
- also experiments to determine grasshay, lichen, and water preferences
- indices of physiological performance:
  - food intake
  - body weight
  - total body water, turnover and flux rates
  - changes in body composition
  - morphological and biochemical blood profiles
  - kinetics of total body sodium, and estimates of the nutrient recycling via saliva
- 9 reindeer fed QTX for 72 days pretrial, then were divided into in 3 groups
- experimental feed groups:
  - QTX (control) for 64 days
  - ARR (arctared red fescue grasshay - Festuca rubra) for 50 days to minimize death losses
  - LKN (mixed lichen - chiefly Cladonia spp., Cetraria spp., and Stereocaulon spp.) for 64 days
- ARR and LKN were fed in increasing amounts as the basal ration was steadily reduced
- food consumption:
  - reindeer on QTX ate more dry matter per day than those on LKN
  - daily dry matter intake of the reindeer feeding on ARR was only 50% that of the QTX and/or LKN fed reindeer

  - it was obvious that the reindeer feeding on grasshays and mixed lichens were at submaintenance levels of dry matter intake
- article contains information on blood chemistry work
- "tentative conclusion that changes in blood biochemical profiles are of questionable value, at least for monitoring in nutritional status." (p. 36)
- biokinetics of water metabolism:
  - in QTX and LKN fed reindeer, total body water as percentage of body weight increased slightly (approx. 4%), whereas ARR grass fed animals showed a 10% increase in relative amount of body water
  - turnover of the total body water in the LKN fed reindeer and to a considerable greater extent, the ARR fed reindeer was considerably slower than the reindeer fed on QTX
- biokinetics of sodium metabolism:
  - changes in blood sodium concentrations were little affected by the widely different nutritional regimes
  - kinetic parameter (turnover rates) and flux rates responded dramatically for QTX and LKN fed reindeer (reflecting the activity of physiological mechanisms for conserving body sodium)

Luick 1977e
Acceptability of various grass, cereal and legume hays as forages for reindeer/caribou, March/April 1977

- objective: to obtain basic information on the acceptability of grasshays as a foodstuff for reindeer and/or caribou and especially to determine the preferences of Rangifer for various types of mature grasshays now becoming available to these animals as a result of reseeding of transportation corridors and/or through secondary plant succession of disturbed rangelands
- also tested 2 widely used livestock cereal and legume hays as possible feeds for Rangifer during periods of climatic stress
- 4 reindeer used in experiment
- feeds tested:
  - ALF=Alfalfa hay: bright green and leafy
  - OAT=Oat hay: bright yellow consisting mainly of very coarse, long stems and few seed heads
  - NBG=Nugget Kentucky Bluegrass
  - ARR=Arctared red fescue
  - BRO=Manchon brome
  - CAL=Bluejoint reedgrass
- reindeer were confined and offered a choice between 2 of the 6 mature hays (15 paired combinations, 10 selections were recorded for each combination); each reindeer made 150 selections
- individual reindeer were consistent in their selections
- individual reindeer differed considerably in selection patterns
- overall: ARR=BRO>CAL>ARR>OAT>NBG
- no reindeer would consume significant quantities of any hay until fasted for 24 to 36 hours

- grasshays rank far below lichens and pelleted livestock rations as foodstuffs for reindeer

Luick 1977f
Acceptability of atypical feeds by pen-fed reindeer

- objective: to obtain basic information on the acceptability of formulated livestock rations and grasshays as substitutes for lichen in winter feeding programs
- experiment also to establish the physical characteristics and nutritional components of atypical foodstuffs that are important determinants of acceptability to reindeer and caribou

Experiment 1:
- 12 reindeer in 3 groups fed 3 different maintenance rations for 46 days pretrial
- experimental feed groups:
  - PCS=Purina cattle starter
  - NBG=Nugget Kentucky bluegrass hay
  - AR/CA=mixed hay containing bluejoint reedgrass and arctared red fescue
  - LKN=mixed lichens (Cladonia spp., Cetraria spp., and Stereocaulon spp.)
- preference rankings obtained for these 4 feeds (6 possible paired combinations, each reindeer made 10 selections for each combination, yielding 60 selections per reindeer)
- overall preference ranking:
  LKN>PCS>NBG>AR/CA
  85%, 50%, 46%, and 19%

Experiment 2:
- 4 reindeer fed 3 different nutritional regimes pretrial:
  - QTX=Quality Texture
  - LKN (as above)
  - ARR (as above)
- experiment with 8 test feeds (28 paired combinations, each combination tested 10 times per reindeer, each reindeer completing 280 choices, yielding 1120 total choices for the experiment)
- feeds tested (components listed in article):
  - WBY=H & P Skagit Brand Horse Feed
  - GOT=Purina Goat Chow (coarse)
  - PIG=Don's Medicated Pig Starter
  - OMO=Purina Omoline T (horse feed)
  - UBC=University of British Colombia Deer Ration No.36-57
  - QTX=Quality Texture
  - RAB=Don's Alaskan Rabbit Pellets
  - PCS=Purina Cattle Starter No.1
- the reindeer appeared to be decisive in their selections when one of the test feeds was highly preferred (i.e. WBY) or when one was least preferred

(i.e. RAB or PCS)
- individual reindeer differed somewhat in their preference for the various feeds
- WBY always ranked among the first 3 preferred feeds
- overall ranking of feeds:
  WBY>GOT>OMO>PIG>UBC>QTX>RAB>PCS
  75%, 65%, 61%, 59%, 53%, 50%, 24%, and 9%
- "the most highly preferred feed, WBY, contained relatively small amounts of crude protein (but so did PCS) and crude fibre but was higher in fat content a [at] 3.1% than the other seven feeds. In contrast the least preferred feed, PCS, contained the least amount of fat at 1% and by far the highest amount of crude fibre at 26% dry matter." (p. 121)
- "feeds ranking high in acceptability generally contained three or four of the following cereal grains: barley, corn, oats, and wheat mill-run." (p. 121)
- "all eight feeds except RAB contained soybean meal as a source of plant protein, but only WBY contained linseed meal. Other peculiarities of WBY which might account for its high acceptability include the absence of forage products such as alfalfa meal and chopped straw and the use of bone meal instead of calcium carbonate, calcium phosphate, and deflourinated rock phosphate as a source of calcium and phosphorus." (p. 121)
- "The high content of alfalfa meal in RAB seems a likely factor in determining its relatively low acceptability." (p. 122)
- "the very low acceptability of PCS might be attributed to the relatively high content of chopped straw and alfalfa meal,...." (p. 122)
- "It also seems possible that the addition of fish meal to the UBC feed formula might adversely affect its acceptability...." (p. 122)
- "they "conclude that rations containing 11.0-16.0% crude protein, 1.0-3.0% crude fat, and 6.5-26.0% crude fibre will provide adequate nutrition for reindeer and/or caribou -- provided that the palatability of the formulated ration is sufficiently high to assure adequate food intake." (p. 122)

Luick 1977 g
The effect of adding substances of presumed high palatability as incentives for increasing the intake of livestock rations by reindeer

- "Reindeer and presumably caribou do not readily accept livestock rations as substitutes for green vegetation and/or lichens,...." (p. 123)
- "survival [in emergency and/or supplemental feeding situations] will depend upon success in overcoming the reluctance...to consume adequate amounts of atypical rations." (p. 123)

Experiment 1:
- objective: to attempt to improve the acceptability of PCS and QTX livestock rations of low and high acceptability, respectively by adding substances of presumed high palatability

- 7 reindeer used in experiment; animals maintained on either LKN, QTX or ARR pretrial
- experimental feed groups:
    - PCS
    - PCS/MOL=10% (dry weight) dehydrated corn molasses, dissolved + PCS
    - PCS/BP=10% sugar beet pulp, moistened + PCS
    - PCS/OCT=1.0 mg 1-Octen-3-ol added to 10 kg PCS
- "Sugar beet pulp and cane molasses are generally considered highly palatable foodstuffs for dairy cattle and are often used to improve the acceptability of maintenance rations for livestock." (p. 124)
- "Amyl vinyl carbinol* is an important part of the volatile mushroom order [odor]...and...mushrooms are a highly prized foodstuff of freely grazing reindeer and caribou,...." (p. 124: *nonpertinent footnote)
- each substance added in paired combination with PCS (10 selections for each reindeer; there were 50 decisions recorded for the 5 reindeer testing PCS/MOL and PCS/OCT and 40 decisions for the 4 reindeer testing PCS/BP)
- "reindeer showed no more enthusiasm for eating PCS with added flavor than for PCS alone... and ... added substances little affected the acceptability of the basal PCS ration." (p. 124)
- reindeer selected PCS/MOL, PCS/OAT, and PCS/BP on 48%, 40%, and 52%, respectively, of the opportunities to do so

Experiment 2:
- 6 reindeer used in an experiment identical in setup to the one above, except QTX, a more highly acceptable livestock ration was used instead of PCS, and fresh mushrooms were used instead of mushroom odour
- experimental feed groups:
    - QTX
    - QTX/MOL=2.5% dry cane molasses, dissolved + QTX
    - QTX/BP=2.5% dehydrated sugar beet pulp, moistened + QTX
    - QTX/MUS=fresh commercial mushrooms ground and cooked + QTX
- 4 test feeds offered in pairs (6 paired combinations, each reindeer tested 10 times for each combination, each reindeer had 30 opportunities to select each feed yielding a total of 360 selections)
- "added foodstuff did not increase the acceptability of QTX for reindeer and in addition, that the reindeer selected against QTX when it contained added molasses and/or beet pulp." (p. 132)

Luick 1979a
Effect of physical form on the acceptability of alfalfa hay for reindeer

- factors influencing or limiting dry matter intake include:
    - palatability
    - availability
    - nutrient content
    - nutritional status (of experimental animals)
    - climatic factors
    - physical form of the ration

- physical form of the ration is important because it may determine the amount of food and water which can be accommodated in the rumen
- when faced with supplementing reindeer with commercial livestock feed, consider:
    - efficiency of food utilization
    - problems of transporting and feeding the supplement
    - cost of various forms available
    - waste by reindeer
    - availability
    - possible adverse effects on animal health
- 4 day trial on 4 captive reindeer in Nov 1977 at Cantwell, Alaska
- feed types fed ad libitum
    - AHA=long hay
    - ACU=cubed alfalfa hay
    - AML=alfalfa hay meal
    - APT=pelleted alfalfa hay
- 3/4 reindeer preferred APT over ACU or AML
- "is tempting to conclude that the reindeer prefer a high density, relatively small particle size ration...." (p. 73)
- "it appears that...'dustiness' as noted with the finely ground alfalfa meal and large pellet size, typical of the cubed form of the hay, also play important roles in determining daily dry matter intake of a given ratio." (p. 73)
- "The obvious preference...for the pelletized form of alfalfa hay is fortunate as it is a high density feed and thereby facilitates handling and minimizes requirements for storage space." (p. 74)
- reindeer waste relatively smaller amounts of pelleted feed than of cubed feed (i.e. the long form)
- reindeer tend to choke on the cubed form of the hay

Luick 1979b
Preference of reindeer for three cereal grains

- 4 yearling reindeer in a 3 day trial
- experimental feed groups:
    - PCS=Purina cattle starter (a high fibre, low protein complete pelleted livestock ration fed to feedlot cattle)
    - CRN=10% cracked corn + PCS
    - OAT=10% rolled oats + PCS
    - BAR=10% barley + PCS
- "reindeer preferred the pelleted ration to which cracked corn has been added...." (p. 76)
- the acceptability of PCS ration (a single tan-coloured pellet with little odour containing only corn and wheat millrun in the cereal grain fraction) could be improved by the addition of cracked corn and/or rolled barley, especially when these cereal grains are included as separate entities rather than being finely ground and included into a single phase pellet

Luick 1979c
Preferences of reindeer for five concentrate meals

- livestock rations differ in the types of concentrate meals used in the feed formula
- "concentrate meals are included in rations to increase the protein and total digestible nutrients (TDN) as well as to increase the digestibility and palatability,...." (p. 79)
- 4 yearling female reindeer used in a 4 day trial
- experimental feed groups:
    - UBC=UBC deer ration no.36-57
    - CSM=10% cottonseed meal + UBC
    - SBM=10% soybean meal + UBC
    - ALM=10% alfalfa meal + UBC
    - WBR=10% wheat bran + UBC
    - LSM=10% linseed meal + UBC
- there was no consistent pattern on the selection of any of the feeds; however, it appeared that the reindeer were selectively removing the pelleted feed from the mixture (i.e. reindeer preferred UBC without the added finely ground concentrate meal)

Luick 1979d
The effect of added urea on the acceptability of livestock rations for reindeer

- since "During winter reindeer and caribou typically feed mostly on lichens and show [snow], a nutritional regime that is high in energy and very low in nitrogen content. Livestock producers...have found that...the addition of added nitrogen, usually as urea, produces a beneficial effect either through increased growth rate, when environmental conditions are favourable, otherwise through a sparing of body substance during periods of malnutrition or undernutrition." (p. 82)
- "During the past decade urea has been added to mixed grain rations...fed to reindeer in Scandinavia and the USSR during periods of environmental stress." (p. 82)
- 3 day trial of 7 reindeer in Nov 1977
- experimental feed groups:
    - QTX=Quality Texture (complete multi-phase dairy cattle ration)
    - QTX/urea=1% urea + QTX
    - PCS=Purina cattle starter (single-phase beef cattle ration)
    - PCS/urea=1% urea + PCS
- urea added at the 1% level to single- or multi-phase ration has little or no effect on the acceptability of that ration for reindeer
- urea (at 0.89% of PCS) was not responsible for the low palatability ranking of that ration in the 1976/77 palatability experiments

Luick 1979e
The effect of added Alaska seafood meals (shrimp, salmon, herring, and halibut) on the acceptability of a livestock ration for reindeer

- "During the processing of seafoods...large quantities of waste material are available for drying and grinding into seafood meals. These meals might be used as high protein and high calcium additives to rations fed as supplements to reindeer during emergency situations - provided that palatability of the basal ration is not [effected] adversely - at least to the extent where there is a decrease in the daily dry matter food consumption." (p. 85)
- "there is reason to believe that the consumption of seafood wastes by reindeer might have an adverse effect on their health and well being [well-being],...." (p.85)
- 4 yearling female reindeer used in a 5 day trial in Aug 1977
- experimental feed groups:
    - QTX=Quality Texture
    - CRB=10% crab meal + QTX
    - SAL=10% salmon meal + QTX
    - HER=10% herring meal + QTX
    - HAL=10% halibut meal + QTX
    - SHR=10% shrimp meal + QTX
- reindeer showed a strong preference for the basal ration without added seafood meal
- when only basal ration with added seafood meal was available, reindeer seemed to prefer salmon and/or halibut meal over herring, shrimp, and crab meal
- the daily food consumption was little affected by the presence of added seafood meal

Luick 1979f
On the efficacy of urea for reindeer in ameliorating the stress of undernutrition for reindeer during winter

- "urea N can substitute for food protein N or can supplement rations that are low in food protein provided that the daily intake of energy is high." (p. 112) - "These nutritional circumstances can be encountered by reindeer when they graze lichen ranges during winter, lichens being relatively high in digestible energy but extremely low (<3%) in protein." (p.112)
- "for the past 10-20 years, scientists in the Soviet Union and in Scandinavia have recommended that urea be added to rations...to spare body substance during prolonged periods of inadequate food intake, and to decrease death losses during starvation such as occur during the 'icing' over of the lichen ranges." (p. 112)
- feeding experiment using 8 reindeer in a 55 day trial to determine whether the added urea nitrogen produced a beneficial effect over and above that obtained from the energy and nitrogen in the mixed grains
- OCB (OCB=50% rolled oats, 25% rolled barley, 25% cracked corn) + LKN

(mixed lichens) + UREA + MINERALS were added in increasing amounts to one group for 25 days
- results for this group and to the second group fed OCB + LKN showed no visible effects of stresses of winter
- the third group fed LKN + GRAZE (pasture grazing) were obviously stressed
- there was little difference in the dry matter intake between the first two groups
- the addition of urea increased total nitrogen intake by 34%
- the addition of mixed minerals increased total mineral intake by 44%
- these 2 groups weighed 99.3 and 99.4% of their original body weight
- similar figures for water turnover "suggests that the urea and mineral supplemented deer [reindeer] did not...consume the supplements in direct proportion to the total dry matter intake, i.e. that they selectively fed on the mixed grains and the lichens and...refused to eat the supplemental urea and mixed minerals." (p. 115)
- they "found "no evidence that the addition of urea and mixed minerals to a high energy ration...has any beneficial effect to...reindeer over that noted for the reindeer fed only the mixed grains and lichens." (p. 115)"
- "it is the energy content of the mixed grain lichen ration and not the added N (as urea) or the added mixed minerals that accounts for the beneficial effects of supplementing reindeer in winter." (p. 115)

Bøe and Jacobsen 1981
Trials with different feeds to reindeer

- article written in Norwegian, abstract in English
- objective: to see if dried lichens in pellet form can substitute for natural lichen as a fodder for reindeer while changing over from natural pasture to artificial feeding
- 6 calves used: 3 on natural lichen, 3 on pelleted lichen for 5 weeks
- "The calves on pelleted lichen had a higher feed intake and a correspondingly higher weight gain compared with a 38 g weight loss pr. day...in the other group." (p. 39)
- 2 new fodders were composed: RF-80 and RFL (compositions given in article)
- feed intake used as a measure of the digestibility disturbances
- results of second experiment to test the effect on digestibility disturbances when changing over from natural pasture to artificial feeding not clear from the abstract

Blanchard et al. 1983
The effects of feeding whole-grain barley to free-ranging and penned reindeer

- the barley used in the experiment, obtained from the Delta Agricultural Project, Delta Junction, Alaska, "could make supplemental feeding of Alaskan reindeer economically feasible where the high cost of feed shipped from out-of-state sources has historically been prohibitive." (p. 57)

- actual cost of barley 20%, transportation cost 80%
- feeding experiments conducted in 1981 using 8 penned adults, 38 barley supplemented free ranging reindeer, and 39 control
- results:
  (1) long term all-barley diets: there was a 31% increase in initial body weight of the 8 penned reindeer over 257 days
  (2) free-ranging barley supplemented reindeer at 0.45 kg (1 lb) barley/head/day for 37 days: there was an overall 1.7% greater gain for those supplemented over the free-ranging control animals; and barley-supplemented adult males gained more than any other group (9.3% increase in initial body weight)
- conclusions:
  (1) long-term all-barley diets
  · reindeer fed all-grain diets perform comparatively well and can be maintained on barley all year
  · in winter, the animals lost little or no weight
  · feeding regime may cause certain reproductive problems
  (2) free-ranging barley supplemented reindeer
  · supplemental feeding of small amounts of barley to free-ranging reindeer in winter resulted in a substantive positive weight response over a short period of time
  · the barley supplement enables the reindeer to better cope with grazing on marginal rangelands by providing a higher plane of nutrition when natural feed supply is limited

Mathiesen et al. 1984
A test of the usefulness of a commercially available mill "waste product" (AB-84) as feed for starving reindeer

- lichen as a feed supplement is difficult to keep unless frozen because of its high water content
- different concentrates of commercially available feed have been tested to satisfy the frequent demands for starving reindeer
- because most concentrates have a high content of easily soluble protein and carbohydrates, the shock to the ruminal system often leads to enteritis and death
- reindeer should be given a diet high in fibre and low in soluble protein and carbohydrates
- AB-84 is a fine grained and pelleted concentrate (diameter 9 mm) bound together with potato starch made from waste from grain mills: small bits of straw from oats and barley, weeds, seeds of weeds, chaff from oats and barley
- results indicate that "AB-84 is tolerated very well even when offered ad libitum to reindeer suffering from starvation." (p. 31)
- tested on only 2 reindeer which were fed lichen for 40 days pretrial, then were starved for 3 days before being offered AB-84
- daily dry matter intake varied between 2 and 4 kg after 12 days on AB-84 (vs. 1.1 kg on lichen diet)
- rumen dry matter percentage 17 after 5 days (vs. 16 on lichen)

- ruminal pH 6.1 12 hours after feeding (vs. 6.4 on lichen)
- did not detect signs of severe ruminal acidosis and there was a very rapid recovery of both bacteria and ciliate protozoa
- that "AB-84 feed supports the growth of ciliate protozoa instead of destroying them as most concentrates do after abrupt changes in the diet (Dirksen 1970) is in support of the view that the ciliates contribute to the 'buffering' of the rumen during excessive intake of carbohydrates." (p. 32)
- have not investigated the potential mechanical destruction of the intestinal tract from using mill waste products for long periods of time as has been evidenced in cattle

Blanchard and Hauer 1986
Reproductive performance of reindeer fed all-grain and hay-grain rations

- feeding trials conducted between 1983 and 1985 with 24 pregnant Rangifer tarandus cows on three experimental rations:
  - 100% whole-grain barley alone
  - 98.9% whole-grain barley and 1.2% mineral and trace elements
  - 70% whole-grain barley and 30% finely-chopped bluegrass hay
- cereal grain type selected as it is the most available livestock feed in Alaska
- results:
  (1) reindeer fed unsupplemented all whole-grain barley rations failed to produce any live calves
  (2) reindeer consuming supplemented all-barley rations experienced only a slight improvement in reproductive success
  (3) all cows on grain/hay ration produced calves
- article speculates that reproductive failure is most likely a result of a diet induced disfunction in maternal rumen and/or carbohydrate metabolism rather than a micro-nutrient deficiency
- "Replacement of 30% of the grain (by weight) with hay increased neutral detergent fibre by 25% and doubled the acid detergent fibre content of the ration (all barley vs. barley/hay). This increase in fibre may have resulted in significant changes in rumen function, volatile fatty acid production, maternal carbohydrate metabolism and/or partitioning of nutrients between maternal and fetal tissues." (p. 41)

Nieminen et al. 1987
Artificial feeding and nutritional status of semi-domesticated reindeer during winter

- objective: to investigate the utilization of different feeds and changes in body weight and condition of reindeer
- 62 semidomesticated reindeer in 9 groups
- experimental feeds:
  - dry molasses pulp
  - oats

- ground hay
- lichens
- dried water horsetail
- concentrates

- fed in different combinations tested between 1980-1982
- article contains table of compositions and intake
- "body weight, blood and faecal N were lowest in lichen fed groups. Slightly higher values were measured in groups fed with dry or ground hay, dry molasses pulp, oat bran and commercial feeds." (p. 51)

Sletten and Hove 1990
Digestive studies with a feed developed for realimentation of starving reindeer

- feeds with a high energy concentration are usually advocated because of the high expense of transporting feed in bulk
- "An artificial feed ideally should, in the same way as lichen, be palatable and establish normal rumen function quickly when given to starving animals." (p. 35)
- problem with concentrate RF-71 (the only feed commercially available to Norwegian reindeer herders) is that it has a high starch content which "easily produces rumen acidosis when...offered ad lib to starving reindeer" (p. 32)
- "seaweeds contain carbohydrates similar to the carbohydrate fraction of lichens...." (p. 32)
- RF-80 concentrate formula has seaweed meal as part of the carbohydrate fraction and "has been used extensively in preparatory feeding of reindeer before slaughter in 1987-89 in areas where radiocesium contamination from the Chernobyl accident prohibited slaughter directly from pasture (Sletten 1989)." (p. 32)
- experiment comparing rumen fermentation and feed intake of:
  - RF-71
  - RF-80
  - lichens
- there is a difference in concentration of readily digestible carbohydrates between the 2 concentrates (RF-71 is high)
- RF-71: "sodium bicarbonate buffered pelleted reindeer feed with ground barley and ground oats as the major energy source." (p. 32)
- RF-80: some of the barley and the wheat bran replaced by grass meal and seaweed meal
- experiment with 7 male calves after 48 hours starvation
- measurements involved:
  - feed intake
  - rumen concentrations of volatile fatty acids
  - ammonia and pH
- "Feeding RF-80 gave rise to higher feed intakes and more rapid normalisation of rumen VFA and ammonia concentration than the other pelleted freed [RF-71]." (p. 31)

- "RF-80 has now replaced RF-71 as the commercial reindeer feed in Norway." (p.31)

Staaland and Sletten 1991
Feeding reindeer in Fennoscandia: the use of artificial food

- "Artificial feeding of domestic reindeer (Rangifer tarandus) in Fennoscandia is usually* conducted only when adverse grazing conditions persist for long periods of time and losses of animals can be expected." (p.227: * footnote - "Also some feeding under normal conditions, for example, Finland.")
- "Major dietary problems are involved when transferring starving reindeer from natural pasture to artificial feeds....[Feeding] High concentrations of easily digestible carbohydrates [which most supplemental feeds are composed of] increases the risk of acidosis and death." (p. 227)
- Feeding lichens during the transition period to artificial feed is recommended.
- formula RF80 is considered the best concentrate and is fed at a rate of 1 kg/day with adequate amounts of essential nutrients.
- Composition:
    - 40% grass meal
    - 40% ground barley and oats
    - 3% saturated marine fat
    - 15% seaweed meal (used to prevent acidosis)
- hay and silage (which can also be used as a supplement) can cause serious dietary problems
- article contains table of Fennoscandian reasons for artificial feeding (9); benefits (4); and disadvantages (4)
- pros include:
    - survival of animals during adverse grazing conditions
    - better utilization of pasture
    - increased knowledge of reindeer
- cons include:
    - cost
    - possible loss of animals by inappropriate feeding
    - spread of disease
    - manpower requirements
- reasons for artificial feeding include:
    - emergency feeding to save animals from starvation
    - during migration
    - after Chernobyl to decontaminate their tissues of radiocesium (1500 reindeer in Norway)
    - supplementation of required nutrients such as urea or salt
- several concentrates have been developed in Fennoscandia, many attempting to mimic the high carbohydrate content of lichens
- these concentrates are usually fortified with seaweed meal, waste from the fish industry, and soybean products to increase mineral and crude protein content
- these supplements are costly but "easily transported in the field"

- hay is considered to have low palatability for reindeer and must have a fine texture to be acceptable
- article contains tables with types, composition, and digestibility of different foods and minerals used in artificial feeding of reindeer
- "A change in diet is often associated with loss of appetite and disturbance of gastrointestinal functions....problems are exacerbated when feeding is initiated as an emergency measure when animals are in poor condition (Kosmo et al., 1978). Under these conditions, it is important to monitor animals because high quality food can result in enterotoximy and rapid death. As a result, a mixture of lichens and artificial food is recommended in the transition period (Boe and Jacobsen, 1981)." (p. 230)
- there are fewer problems associated with silage because it is eaten slowly (as opposed to concentrates which are eaten quickly)
- 1 feeding per day recommended with mixed sex/age class herds
- "Because of inherent seasonal rhythms in food intake and energy demand (Ryg and Jacobsen, 1982 a, b) it appears that 1 kg DM [dry matter]/day is adequate for reindeer during winter and no benefits result from ad libitum feeding." (p. 237)
- although some positive effects are associated with supplementary feeding, researchers in Scandinavia contend that it is uneconomical to feed reindeer for an improvement in carcass weight or higher milk production
- because supplemental feeding can prevent animal loss due to starvation in winter, the economics can be justified
- article contains table of economics of feeding reindeer on an artificial diet

1.2. Elk

Cooney 1952
Elk Problems in Montana

- elk feeding is not considered desirable in Montana
- when fed, is done so every other day so elk don't lose the urge to 'rustle'
- 1.8 kg (4 lb)/day/elk where moderate browse available

deNahlik 1974
Feeding and Shelter

- re: 1970s Scottish red deer
- reasons for feeding:
  - profit
  - attempt to provide a balanced diet artificially primarily to provide nutrients required for improved antler growth
  - to keep deer from ranging into agricultural/forest areas
- methods:
  (1) provided small cleared plots, sown with selected crops that will attract deer and provide necessary nutrients

(2) provided fodder in winter conditions (may be difficult)
(3) provided food stuffs at feeding stations: wheat, grass, clover, wild rye, potatoes, turnips, corn, fruit
(4) provided nutrient supplements: urea, salt, minerals which may aid in food conversion (break down of cellulose into glucose)

- results: winter supplementary feeding will result in antler enhancement, "better mothering", increased body growth and greater food conversion
- cons:
  - animals may become partly tamed and therefore an easier sporting prey
  - may lose the ability to fend for themselves, especially in bad weather

Mitchell et al. 1977
Ecology of Red Deer: A research review relevant to their management in Scotland

- review of literature in Scotland
- reasons for winter feeding:
  - to improve performance of stags thereby improving trophy value
  - to reduce mortality
  - easier culling
  - prevention of straying into adjacent farmlands and forests
- pros: since herbivores determine the botanical characteristics of an area by selective grazing, they must eat less desirable plants in order to sustain the optimum productivity of desirable ones. Artificial feeding thus gives managers an opportunity to select the stocking rates which produce and maintain the most useful botanical components. Artificial feeding allows a means to modify the dispersion of the deer without the expense of fencing.
- cons: excessive utilization of range may reduce the availability of valuable food plants. The deer may become dependant on the food provided (unwilling to range further afield). Artificial feeding may affect vegetation characteristics and soil conditions near feeding stations. Dominant individuals tend to benefit more from food supplements.
- researchers must be aware of the geographical variations in the motivations for supplemental feeding and not be willing to adapt programs that are based on different motivations and/or habitat types:
  - Scotland: artificial feeding to enhance trophy values
  - N.A.: reduce mortality in winter
  - Europe: reduce habitat damage

Beetle 1979
Jackson Hole elk herd: a summary after 25 years of study

- [an article written from a viewpoint quite contrary to most others written regarding the Jackson Hole elk herd]
- "plant communities have been sacrificed to satisfy the public and

private greed of sportsmen and wildlifers." (p. 259)
- "The Mormon settlers did occupy the elk winter range, but rather than starving the elk, they changed the dry sagebrush flats into irrigated pastures, fattened the elk, and giving them the means to increase to a point where they became pests." (p. 260: *footnote at bottom of page)
- "Many people believe yearly reduction to carrying capacity by hunting is feasible. In truth it never has been; in the first place, because the highest kills allowed have been inadequate and in the second place, because the largest kills are always followed by a reactionary underkill." (p. 261)
- there is a large reliance on feeding of hay as a solution rather than herd reduction to range carrying capacity
- hay feeding concentrates the animals and is the surest way to destroy the browse of a range where it is practised
- elk herds managed at maximum population levels necessitates expensive winter feeding operations in some areas to provide the highest possible sustained annual harvests
- "Any good range manager knows the difference between maximum and optimum." (p. 262)

Robbins and Wilbrecht 1979
Supplemental feeding of elk wintering on the National Elk Refuge

- re: National Elk Refuge, Jackson Hole, Wyoming (part of the National Wildlife Refuge System)
- Refuge created in 1912 as a result of Mormon settlers occupying elk winter range
- this encroachment along with severe winters and degradation on privately owned hay stacks initiated feed purchases in the form of loose hay
- supplemental feeding history:
    - 1912-1926: mean length supplemental feeding period 76 days (range: 23-111 days)
    - 1938: switched from loose to baled hay, fencing
    - 1927-1945: mean length supplemental feeding period 73 days (range: 30-110 days)
    - 1946-1977: mean length supplemental feeding period 71 days (range: 16-147 days)
- during winters of 70/71, 71/72, 72/73, alfalfa pellets were tested on penned elk and in 1972 these pellets were also fed to unconfined elk
- alfalfa pellets were found to be acceptable supplemental feed for elk, and were "phased" into the feeding program between April 1973 and April 1975
- feed rate: 3.6 kg (8 lb) pellets/elk/day
- 1 man with a 20T (18 metric ton) truck can feed 7330 elk (7 herds) in 5-6 hours
- attempt feeding on clean snow daily
- pellets should be placed in an "S" pattern to limit trailing behind feed truck

- cost: $72 per 907 kg (ton) for pellets, or 23.4 cents/day/elk (2.9 kg (6.5 lb/elk/day)
- +labour, fuel amounts to $109,616 for 62 day feeding period
- hay is cheaper per ton, but labour, fuel, equipment costs are higher; alfalfa pellets saved $14,620
- pelletized feed purchased in Idaho
- conclusions of 5 year study:
    (1) penned elk on 3.6 kg (8 lb) pellets/elk/day gained more weight than those fed 4.5 kg (10 lb) baled hay/elk/day
    (2) elk readily accepted the alfalfa in pellet form
    (3) calves on pellets gained more than those on baled hay
    (4) pellets are quicker and easier to feed
    (5) 4% waste (dust) from pellets vs. 24% waste with baled hay
- additional (non $-value) advantages:
    · mechanized distribution
    · movement of herd over large area during winter
    · animals kept on clean (and less disease-prone) feeding areas
    · breaks herd into several smaller groups
- the initiation of supplemental feeding is based on:
    · monitoring forage ability
    · utilization
    · elk distribution
    · weather conditions

Dean 1980
Some costs and benefits of elk in Wyoming

- 22 000 elk fed each winter [unclear whether this includes 7500 elk fed in the National Elk Refuge]
- 2 reasons for feeding:
    · damage prevention
    · loss of traditional winter ranges
- feed: baled hay each day (90-180 days/year)
- intake rates of 3.3-5.1 kg (7.2-11.3 lb)/elk/day
- 54% of elk hunters in Wyoming in 1979 hunted feedground elk
- management costs: $41.87 per feedground elk, $22.85 per non-feedground elk
- total cost of elk management in Wyoming (1979)=$1,951,104 while generating $15,000,000 to the economy by hunters
- sale of elk licenses generated $1,700,000
- 10% total cost went to elk feeders
- 21% total cost went to administration
- 69% total cost went to purchase and hauling of the hay

Olterman 1980
Colorado elk management

- Colorado does not advocate winter feeding of big game animals
- however, the winter of 78/79 was very severe, so when presented with a

choice of supplemental feeding or suffering exceptionally high mortality, 726 metric tons (800 tons) of hay (grass and alfalfa) and 9 metric tons (10 tons) of high protein pellets were fed to approx. 4000 elk in February and March via snow vehicles and helicopter (approx. 3.2 kg (7 lb)/day with some natural forage available)

Phelps 1980
Land use planning and habitat management on critical wildlife ranges

- author associated with B.C. Ministry of Environment
- short-term elk feeding program between 08/01/74 and 20/03/78 in which 1 225 metric tons (1 350 tons) of hay were fed on 8 sites for a total cost of $154 000
- during the last year of feeding, costs were $26/elk or $6.85/elk/month for 6000 elk

Robbins and Wilbrecht 1980
Management of the National Elk Refuge Jackson, Wyoming

- [same stats as Robbins and Wilbrecht 1979]
- elk were on the Refuge for 6 months between November and May but are only supplementally fed for 2 months from mid February to mid April
- Refuge size grew from 1117 ha (2760 acres) to 9713 ha (24,000 acres) of elk winter range
- supplemental feeding a product of:
    - excessive elk numbers
    - poor distribution of elk
    - weather conditions limiting free-ranging
    - political considerations

Lyon and Ward 1982
Elk and land management

- winter feeding as a management alternative to over-populated elk range
- controversial
- cons:
    (1) established feeding grounds become "sacrifice areas" suffering from extremes of overuse and trampling
    (2) high animal concentrations may result in increases in diseases and parasites that otherwise might not be significant
    (3) expensive (but may be a practical alternative as noted in cases of Wyoming and Washington)

Nelson and Leege 1982
Nutritional requirements and food habits

- artificial feeding as an alternative for correcting nutritional deficiencies (also habitat manipulation, herd behavioural modification,

harvesting)
- efforts must be based on:
    (1) ecological facts of seasonal habitat within home range, including weather;
    (2) age and sex structure of the herd; and
    (3) unit- or area-specific management objectives

Hernbrode 1985
Colorado's emergency winter feeding operation, 1983-84

- [well-written article]
- "feeding is not a panacea and has potentially dangerous side effects." (p. 67)
- "it must be considered a drastic action to be implemented only under extreme conditions when other actions have failed or were found to be inappropriate." (p. 67)
- "Additionally, it must be supported by strong policy, carried out in accordance with implementation plans, and justified by a thorough evaluation in relation to the population objectives of the species involved." (p. 67)
- "Winter wildlife feeding programs have traditionally had high appeal to the public and low appeal to wildlife professionals in North America." (p. 67)
- "Both prejudices have been based upon incomplete understanding of the winter ecology of big game species." (p. 67)
- "Wildlife professionals have opposed winter food supplementation because they generally believed it was ineffective in reducing big game population losses and because they believed a precedent set by feeding in any situation compelled feeding in every situation." (p. 67)
- emergency winter feeding operations in Colorado have 2 general goals:
    (1) to reduce or prevent game damage
    (2) reduce severe winter-caused mortality
- to have a significant impact on long-term animal population, a minimum of 25% of the population must be fed (and therefore be located so it is feasible to feed)
- evaluation indicates a probable adult female mortality of 30% or more if no feeding occurs
- adult females used as indicators because they are numerous, valuable and less variable in physiological characteristics than other sex and age classes; they represent the reproductive capital of many years of management investment
- mills have built pellets to specifications [article contains specs]
- article contains table of intake, digestibility
- article contains flowchart of decision-making process

Haigh and Hudson 1988
Feeding wapiti on game farms

- article mostly discusses elk nutrition on game farms

- re: work conducted at the Ministik Research Station, Alberta
  - 6.25 kg medium quality alfalfa hay will meet protein and energy requirements but not essential minerals and vitamins for elk hinds
  - recommend adding winter supplement of 1-1.5 kg oats/day
  - simple and cheap
- more complex pelleted rations:
  - are more expensive
  - offer controlled intake of essential minerals and vitamins
  - should be fed at 1 kg/day
- "free choice pelleted feeding is a waste of money and will lead to overfatness." (p. 5)
- problem at Ministik: "animals obtain their nutritional needs rather quickly from the pellets and then proceeded to damage the trees." (p. 5)
- lists ingredients and analysis of 2 pelleted rations from:
  (1) Ministik
  (2) Michigan State University
- "one should supply all feed from troughs or feeders raised off the ground....Contamination of food with feces can lead to heavy parasite build ups. Coccidiosis is of particular concern in this regard." (p. 6)
- [Note: according to a local elk producer, the Ministik pelleted ration currently sells for approximately $300 per metric tonne]

1.3 Deer

Davenport 1939
Results of deer feeding experiments at Cusino, Michigan

- 4 controlled feeding experiments using tame, semi-tame, and wild deer in family group/pen for 90 days in 1938 in Michigan
- objective: to determine the carrying capacity of various types of winter range and to determine the palatability and nutritional value of natural and artificial feed
- animals fed ad libitum
- results:
  (1) natural food diets (browse): satisfactory for maintaining the animals in good health/strength for a period of 90 days (mixed variety of palatable species was necessary)
  (2) single variety/species browse diets: not satisfactory; low palatability and low intake resulted in rapid weight loss
  (3) browse and artificial supplemental food: higher consumption rates; however, adult animals lost a small percentage of weight, while fawns showed a slight increase. Supplements reduced weight loss and prevented death in animals that had already lost 25-30% of their original body weight (30% critical loss in young animals).
  (4) artificial diets (alfalfa hay, clover hay): when supplemented with cracked corn/cottonseed pellets or when fed alone was satisfactory for maintaining deer in good health for a 90 day period
  - timothy hay: unsuitable unless supplemented with more nutritional feed

  - corn/alfalfa hay: while producing weight gain and good condition in animals when fed in summer/fall, it is not satisfactory as a winter supplement
  - alfalfa/cottonseed: produced weight gain

- it is possible to support deer on artificial diets where the natural winter food is insufficient
- maintenance of a large herd by artificial feeding without harvesting/hunting seems impracticable
- feeding deer in overbrowsed yards would cost considerable amounts - more than is realized from hunting licenses
- geographically inaccessible areas prevent efficient feeding programs
- [severely limited data set; use generalizations only]

Carhart 1943
Fallacies in winter feeding of deer

- series of experiments known as the Pittman-Robertson programs in Colorado on deer and elk in 1938 and on mule deer in 1939-40
- reasons for feeding:
  - high populations
  - damaged range
  - high winter losses
  - citizen demand
- feeding program:
  - alfalfa hay 9.4-51.0 kg (20.8-112.5 lb)/deer (2-month-period)
  - Purina concentrate 1.1-6.2 kg (2.4-13.8 lb)/deer (2-month-period)
- results:
  (1) high mortality (winter kill) ranging from 3-43% of total herd
  (2) highest mortality where highest percentage of poundage of feed/deer was consumed
  (3) deer were dying of malnutrition in the long run, although nose bots and lung worms were immediate causes of death
  (4) concentrated alfalfa hay and stock feed could not be assimilated properly; only when natural range browse was available in good supply could this problem be offset. Browse thought necessary to provide roughage or some metabolic element necessary for digestion of supplemental food.
  (5) in nearby herds where browse was dominant in the diet and supplemental food was provided, the mortality was low, although nose bot and lung worm incidence was high indicating that the superior nutrition provided by the combination of browse and feed resulted in the deer being able to withstand the stress of these diseases
- stomach/snow-trailing studies show the natural preference by deer for browse during fall and winter diets was 97% while grasses and weeds/forbs was minor
- because deer like the taste of the commercial feed/hay, they often eat it to exclusion until they die of malnutrition
- the attraction to centralized feeding areas often results in the overbrowsing of adjacent range resulting in increasing dependence on the

feed
- suggestions:
  - winter supplemental feeding should only take place in crisis conditions (when weather conditions such as deep snow prevent the animals from obtaining normal browse and forage)
  - feeding program should only be implemented for short periods of time (2-3 weeks)
- main observations:
  - it is suggested that'we are killing the deer with pseudo-kindness when we attempt to feed them throughout the winter' (p. 337)
  - the majority of feeding programs are unsound, uneconomic and ultimately destructive
  - there is a need for sufficient natural feeds (browse) to carry herd in normal winters
- author relates that the Jackson Hole study on elk shows increased mortality where animals were fed hay (800 bales per day/herd) and that the dryness and coarseness of hay scratches the mouth/throat leading to necrotic stomatitis and impaction of the large intestine.

Doman and Rasmussen 1944
Supplemental winter feeding of mule deer in northern Utah

- experiments on penned mule deer in Utah during the 1940s
- reasons:
  - population increase in mule deer had exceeded the carrying capacity of the range causing depletion of native forage plants
  - invasion of orchards, cultivated fields, haystacks
- conclusions:
  (1) although winter feeding has been publicized as a solution, no diet/method has proven entirely successful; they have not prevented large losses (20%) on depleted winter range
  (2) heavy winter losses in mule deer are not normal where sufficient native forage is available
  (3) various supplements have been tried (alfalfa, native grass hay, sweet clover, pea silage, barley, purina, deer ration...)
  (4) although none of these appears to replace native forage successfully, alfalfa is satisfactory as an emergency food (< 2 months) when an even less palatable forage species is available (sagebrush, juniper)
  (5) alfalfa supplement will not prevent winter losses if deer are dependent on it solely or if used for more than 2 months
  (6) alfalfa will not support fawns for even a short period of time
  (7) cost is prohibitive in terms of returns from hunting licences
  (8) the more the deer became dependent on supplemental foods and less on native forage, the greater were the winter losses
  (9) deer will continue to browse as long as it is available regardless of the amount of supplement supplied
  (10) animals are concentrated in small areas doing serious and/or irreparable damage to native forage species which in turn reduces

the carrying capacity of the range and makes the deer increasingly more dependent on the supplements
(11) large winter mortalities near the feeding grounds are primarily the result of malnutrition due to the lack of sufficient quantity and/or quality of food
(12) malnutrition weakens the animals and they become susceptible to internal/external parasites and pneumonia (13) abnormal winter losses are not fully attributable to severe winter weather; losses occur where deer are too numerous for the available forage on the ranges they occupy

- management recommendations:
  - regulate deer populations in areas where supplemental feeding is necessary
  - regulate population so that winter feeding as a regular program can be halted
  - feed animals if they are invading/damaging nearby property, orchards, fields
  - use ground fine-stemmed leafy alfalfa as an emergency food supplement (less than 2 months only)
  - use of supplement for time periods >2 months is economically questionable and doesn't prevent winter mortality
- the solution should lie in attempts to adjust the deer population to the carrying capacities of their winter ranges rather than in further search towards methods or diets for supplemental feeding

Swift 1946
A History of Wisconsin Deer

- summary of various state programs and principles
- reasons for feeding: citizen demand; sentiment is the motivating power behind the conservation movement
- methods of supplemental winter feeding:
  - clearcut patches to provide desirable habitat (browse and forage)
  - pruning of trees and shrubs to produce browse
  - feed stations with alfalfa, hay, corn, etc.
  - trucking browse into yards
- problems:
  - artificial feeding during winter has never been proven very successful and at best is seen only as a temporary remedy to prevent starvation; it has never corrected the source of the problem
  - deer become dependent on the feed and less dependent on native forage leading to greater winter losses
  - deer concentrate in small areas year after year thus they can cause serious and irreparable damage to the native vegetation (forage and browse species) thus reducing the areas carrying capacity making the deer further dependent upon the supplemental feed winter feeding requires tons of food, manpower, equipment with a high annual expenditure and effort
  - does not guarantee against winter deaths

· congregation of animals may increase the spread of disease and/or parasites
· feeding would have to be continued at an increasing scale, year after year, as the herd increased and the area became overbrowsed; artificial feeding is the beginning of a never ending and vicious cycle

- exceptions; artificial feeding may be acceptable where:
(1) the winter conditions are abnormally harsh, but only after the herd has been reduced enough so that it can survive on the natural browse during average winters
(2) in/around resort areas

Dahlberg and Guettinger 1956
The White-tailed Deer of Wisconsin

- 80 day study between 1946-1949 on white-tailed deer in Wisconsin to determine the effect of artificial feeding on deer
- artificial diets:
· good quality alfalfa hay in sufficient quantity will support deer through a normal winter period. There is considerable wastage since deer will only eat tips and tender leaves; requires 1.6-2.3 kg/45.4 kg (3.5-5 lb/cwt)to yield 1.1 kg/45.4 kg (2.5 lb/cwt)
· alfalfa meal pellets: an adequate emergency food supplement which is easier to handle than hay and there is less wastage. Requires an average of 0.9 kg/45.4 kg/day (2 lb/cwt/day).
· 75% alfalfa, 25% corn/commercial concentrate yields a satisfactory diet
· Garvers concentrate is satisfactory as long as animals are prohibited from gorging on it (especially during the first week of supplement) as this could cause death. There are initial problems with diarrhea and the concentrate is expensive.
- natural browse: a considerable variety of hardwood and evergreen species are necessary to provide a satisfactory normal winter diet - even low palatability species will sustain deer if those species are available in quantity and variety
- a single, highly palatable species (i.e. cedar) will barely support deer for 60 days; browse species of high palatability do not necessarily have high nutritional value and other species are required
- when deer were fed in unlimited amounts, a large quantity of low-palatables were eaten to provide the same degree of sustenance of lesser quantities of high-palatable species
- considerable differences exist in the amount of food consumed between:
· high/low palatable species
· natural browse and artificial diets: natural browse diets require more intake (pounds)/day (1.6-2.5 kg of browse/45.4 kg deer/day or 3.5 to 5.5 lb of browse/100 wt deer/day) compared to artificial diets (1.1 kg/45.4 kg deer/day or 2.5 lb/cwt deer/day) average quality alfalfa hay

- trapped and penned animals cannot be considered ideal for studying feeding habits

Robinette et al. 1973
Effects of nutritional change on captive mule deer

- Montana captive mule deer herd (92 individuals) in long-term study (1961-1971)
- reasons for feeding: diet supplements were increased to determine if the physical condition of the deer could be improved and fawn losses due to stomatitis reduced
- diet: (diet was altered during the course of the study to a more nutritional one)
    - original (<1968) diet: alfalfa hay, food concentrate (Purina) 0.23 kg/day, oats/barley 0.14-0.23 kg/deer day, wheatgrass and forbs in pen
    - post 1968 diet: alfalfa hay decreased, Purina concentrate 0.7-0.9 kg/deer day, oats/barley 0.91-1.36 kg/deer day, wheatgrass and forbs in pen
- changes in diet were in response to poor condition of the deer, fawn stomatitis, and enterotoxemia due to overeating the concentrate
- alfalfa hay content of diet reduced because of high wastage (75%); deer were selecting out leaves and the finer stems
- general results:
    - improved nutrition and deer weight
    - mule deer did poorly when fed dominantly hay in winter (>2 months)
    - the protein consumption increased by 65% when the alfalfa supplement was decreased (0.12-0.42 kg/deer day)
- associated with the improved nutrition were increases in deer weights, productivity and antler size, earlier dates for breeding and fawning, possibly antler velvet shedding, and a decline in post-partum fawn mortality
- specifics resulting from improved nutrition:
    (1) significantly earlier (5-8 days) dropping of fawns
    (2) productivity increased (1.92 fawns/doe vs. 1.67 fawns/doe), surpassing best results reported from wild mule deer
    (3) antler size increased especially in yearlings
    (4) slightly shorter gestation periods (201.6 vs. 204.3 days)
    (5) increased productivity due to increase in pregnancy rate, increase in number of multiple litters and some breeding by fawns
    (6) decline in fawn mortality (<1 week old) due to increased quality of food and thus physical improvement. This healthier condition may contribute to the decline in diseases (necrotic stomatitis and microbacillosis) that are responsible for most fawn mortality.
    (7) no fawn stomatitis when does consumed forbs along with feed
- while the authors found no effect on early fawn mortality due to improved diet, Verne (1962) noted losses of only 6-7% when deer were given superior diets and 90% of nutritionally poor diets

- Murphy and Coates (1966) reported 42, 27, and 0% fawn mortalities with white tail deer doe diets containing 7, 11, and 13% protein (higher protein = decreased mortality). Increased doe weights may mean increased milk production and consequently better survival rates for fawns.

Ullrey et al. 1975
Consumption of artificial browse supplements by penned white-tailed deer

- experiments on 54 captive adult white-tailed deer
- to study potential uses of manufactured protein-energy supplement blocks used for range cattle: 15.2 kg "Staley Sweetix Hi-Energy 25% Protein Block" in association with natural winter browser; does this supplement influence the chance for winter survival?
- results:
  (1) when fed with evergreen/hardwood browse (cedar, red oak, aspen) the supplement block increased the dry matter intakes from 39-161%. This increase resulted from the increased consumption of browse as well as supplement ingestion.
  (2) the consumption of the protein/energy block supplement (when winter browse was the only other food available) has the potential for reducing winter weight loss and perhaps in reducing death from extreme malnutrition (even when supplement supplied only 10% of total dry matter uptake)
  (3) digestibility of the food was not increased but rumen function appeared more normal with addition of the supplement
  (4) increased nutrient supply to the tissues resulted in decreased tissue catabolism and less weight loss
  (5) average stomach protozoan concentration increased 21 fold
- the nutrient blocks have the advantage of ready portability and the ability to withstand extended exposure to winter weather
- cost-benefit ratio may be favourable in times of emergency

Karns 1980
Winter - the grim reaper

- there has been a northward expansion of deer populations resulting from vegetational changes brought about by logging, fires and settlement (creating suitable habitat)
- along with new habitat came the control of the major deer predators (timber wolf, cougar, man) and a conservation conscience that led to a very protectionist attitude towards deer. As a result, deer populations have erupted
- in severe winters, deer occupied less than 10% of the total range, while in 'deer yards', they exceeded the carrying capacity of the range
- managing overwinter losses has created a battleground between wildlife managers and the populace who support winter feeding programs
- wildlife managers denounce feeding programs arguing that:
  · they don't solve the problem of overpopulation

· they are expensive
· can't feed the entire population (access)
· causes concentration of deer near feeding stations with adverse effect on remaining browse
· promotes the likelihood of spreading parasites and disease
· increases predation
· provides indigestible food

- management suggestions:
  (1) deer should be harvested before they reach such starvation predicaments
  (2) deer can be fed if provided a complete diet
  (3) feeding may be justified in some conditions (trying to maintain or increase a low population during a severe winter, or to avert crop damage)
  (4) cutting or logging practices that assure a continuum of cover and food
  (5) knowledge of nutrient content of plants consumed year-round may aid in prediction of winter survival (quality and quantity of late summer browse is critical for overwinter survival)
  (6) all factors that may contribute to overwinter kill should be studied in determining the carrying capacity of the range

Carpenter and Wallmo 1981
Habitat Evaluation and Management

- summary section on supplemental feeding
- supplemental feeding can prevent deer starvation in periods of winter stress
- generally negative conclusion on the benefits of supplemental feeding despite innumerable emergency feeding programs that have been conducted; little or no measurable benefits to the deer and in many cases deer continue to die after food is distributed
- cons:
  · food is initially unfamiliar and unpalatable
  · due to poor distribution, food doesn't reach a sufficient number of individuals within the population
  · dominance hierarchy in the herd may prevent the animals with the greatest need (young or weak) from getting any feed
  · supplemental food may be too little or too late; often the programs are undertaken after the deer are already malnourished
  · economic and logistical problems in the feeding programs
  · wild deer, on a progressively deteriorating diet throughout the fall and winter, may be too malnourished or exhausted to find or recognize supplemental feed during crisis periods (especially fawns and bucks following the rut)
  · new diet may require an adjustment in the rumen microflora before optimal use can be achieved
  · may require natural browse for digestion of supplement
  · "mechanical" problems may arise - the coarse, fibrous food must be

regurgitated, rechewed and swallowed again several times for the remnant to be digested
· the high fibre diet may result in the impaction of the intestine; animal will continue to eat until it dies
· it may take several days for deer to adapt to supplemental feed, however, this may be too long if deer are already under severe nutritional stress

- Ullrey et al. (1975) in a study of white-tailed deer found that winter browse and high energy/high protein blocks given in advance of starvation are more effective than when supplements are initiated once deer are in the process of starvation. Of course, it is difficult to accomplish this. Some supplements (corn, barley) reduce the digestibility of natural range forage and do not increase the overall energy intake.
- Nagy et al. (1974) in Colorado calculated costs of $34,000 for feed, manpower, and equipment to feed 2500 deer concentrated rations for 21 days ($0.65/deer day)
- concluding opinion: "wildlife biologists and managers remain unenthusiastic about emergency feeding of deer, but public sentiment and consequent political pressures still force them to undertake such programs." In the end, we "must attempt unnatural kinds [types?] of management intervention to protect deer from the devastating adversities...[and] habitat restrictions imposed by human activities,...." (p. 416)

Goulden 1981
The white-tailed deer in Manitoba

- general overview of the situation in Manitoba
- reason for feeding: citizen protest to avoid winter losses during harsh winters
- methods:
  (1) bulldozing or hand clearing of trees and shrubs to encourage browse growth
  · results are ineffective since browse has insufficient nutrients and is unimportant as a major food source in winter
  (2) supplemental hay and grains
  · problems include variable quality of grain or hay; may be leached of nutrients if stored outdoors-if nutrient quality is too low, deer may develop ammonia toxicity; stomach bacteria used to natural browse and may have difficulty adapting to new foods; deer may become aggressive at feeding stations unless sites are numerous and well distributed; impact on adjacent range due to overuse; dependency on handouts; easy target for predators; spread of disease more likely; competition from livestock industry for hay or grain during harsh winters.
- observations/suggestions:
  · best defense against greater than normal winter kill (10%) is the preservation of good quality habitat and browse
  · in harsh winters, animals which retain 70% of their autumn live

body weight will recover quickly if fed a nutritionally complete commercial supplement
· deer will survive on good quality livestock feed if initiated at the onset of winter and supplemented with natural browse to meet nutritional requirements
· feeding programs are costly and only strategic breeding stocks that are easily accessible should be fed

Kook 1981
The farming of white spotted deer (Cervus nippon taiouanus) in Korea

- [unsuitable article]
- re: feeds used on white spotted deer farms in Korea
- feeds: mixed feed concentrate, barley, bran, shrubby herbage, wild grass hay
- the addition of concentrate increases the total amount of food consumed daily

Ozoga and Verme 1982
Physical and reproductive characteristics of a supplementally-fed white-tailed deer herd

- 5 year project between 1972 and 1977 on white-tailed deer in Michigan
- reasons for feeding:
  (1) inadequate winter range produces serious losses to starvation during bad winter weather
  (2) acute malnutrition of pregnant does resulting in increased neonatal mortality
- objectives: to evaluate the cost-benefit of supplementary feeding of white-tailed deer to achieve higher population levels than the natural habitat could support and to improve the physical traits of the herd through extra ration (supplied ad libitum)
- results due to supplemental feeding:
  · population increased from 23 to 159 animals with an annual increment of 60% (20% greater than pre-experiment)
  · seasonal feed was lowest in spring following snowmelt and during initial renewal of plant growth (15% of diet). This increased to 39% during summer as natural forage matured (decreased palatability and digestibility) and increased due to lactation requirements by does. Highest during autumn and winter (>84%).
  · yearly consumption of feed 375 kg/deer (37-61% of total diet); browse and natural forage comprised 39-63% of total diet
  · annual cost $83/deer
  · winter cost $37/deer (127 days)
  · $220 per metric tonne for food, vehicles, and manpower
  · body growth: 15-30% increase in body weights due to better nutrition
  · enhanced growth rate: chronologically advanced physical maturity

in winter is a sign that a given area contains more deer than can be supported
· supplemental feeding could increase deer populations in habitat where winter food resources were depleted thereby intensifying the problem the following winter
· dietary changes must be slow and gradual enough to allow adaptation by rumen microflora or else rumen disorders or death from malnutrition may result
· concentrations of deer at feeding stations may facilitate disease transmission
· increases susceptibility to predation
- suggestions: winter supplemental feeding should only be attempted during unusually severe or long winters, feed should be introduced gradually, and introduce feed before natural foods are depleted
- "as a general principle, winter feeding is discouraged." (p. 29)

Smits and Haigh 1990
Notes for the fallow farmer: feeding your deer

- deer are quite different from other domestic ruminants in both their nutritional requirements and their responses to nutritional stress
- there is a 40-60% reduction of voluntary feed intake during winter with respect to maximum spring feeding ("winter anorexia")
- emergency feeding of starving deer at the end of winter usually cannot stop deaths because of the total depletion of their energy and protein reserves
- article discusses deer nutrition in game farm setting
- article does have breakdown of Saskatoon Forestry Farm Zoo pellet ration fed at 1% body weight to deer

1.4 General

Mautz 1978
Nutrition and carrying capacity

- "Winter feeding...seems to run through various cycles of public and political controversy." (p. 344)
- "winter feeding could...be made to work from the nutritional standpoint."
-(p. 344)
"arguments against winter feeding do not or should not stem from nutritional considerations, but instead from economic, sociological and perhaps ecological factors." (p. 345)
- "Supplemental winter feeding does not necessarily reduce the pressure on natural food resources....[because deer] continue to utilize natural foods to the extent possible. Therefore, if supplemental feed causes animals to congregate...greater than normal damage may occur to the natural food plants of the area." (p. 345-346)

- supplemental feeding could be used to maintain higher than normal populations for hunters in the face of increased habitat destruction

Moen 1982
Supplemental feeding

- author attempts to address the question of whether or not supplemental feeding is ecologically desirable
- "The feeding of wild ruminants is not ecologically 'natural' in the sense that populations thrived without supplemental feeding for centuries before settlement." (p. 71)
- supplemental feeding is socially acceptable to people who like to see and feed wildlife, but decisions on this basis cannot be reversed the next year when conditions improve; one must separate biological issues from social ones
- supplemental feeding should be provided before nutritional problems appear as the animals need time to adjust to new feed
- feed where cover is available
- spread feed over large area to avoid concentration and provide subdominants access
- once started, feeding must continue
- author prefers to see efforts directed toward controlling herds to levels within carrying capacity of the range
- "Since the timing of the arrival of spring cannot be predicted in early winter when feeding must start, the duration of supplemental feeding is unknown, and the worst case should be expected." (p. 72)
- author presents a list of questions to be asked regarding the cost of supplying feed to wild ruminants and the cost "per animal increase" of feeding wild ruminants

DISCUSSION

Existing evidence indicates that the foremost limitation to population growth and the primary cause of catastrophic winter die-offs of Peary caribou has been widespread wintertime (winter and spring) forage unavailability due to unfavourable snow cover and ice conditions. Thus, the most important cause of death on a range-wide basis has been, and most likely will remain, prolonged extreme undernutrition due to relative unavailability of wintertime forage. What is equally, if not more important, about extreme undernutrition is that various degrees of it can by itself, in addition to being the most serious cause of mortality among 1+ yr-old animals, cause significantly poor growth performance in all areas of population dynamics through (1) delay in the age of first breeding (particularly for females); (2) reduced pregnancy rates; (3) lower initial production of viable neonates; (4) less success in the rearing of calves to the age of independence; (5) lower rates of survival of individuals to breeding age (especially females); (6) environmentally forced emigration or migration, both intra- and inter-island; (7) increased susceptibility of individuals to predation; (8) contributing to

increases in physiological problems; (9) increasing the incidences of pathological disorders; and (10) promoting accidents among individuals in a weakened state.

The most stringent period of nutritional stress is likely to occur during late winter (Apr-May in the High Arctic) and especially in late winter-spring (May-Jun) and the then prevailing snow cover and ice conditions are the two environmental physical factors that would most likely cause either direct mortality of individuals or detrimentally influence essentially all growth performance parameters of a caribou population through prolonged extreme undernutrition. At those times, Peary caribou appear to rely heavily on snow-free patches or small areas of fresh, light powdery snow cover that were previously snow-free rather than cratering in the established snow cover to obtain their daily nutritional requirements (e.g., Miller 1992, 1993a).

The probability that Peary caribou will or will not continue to decline in number can not be predicted. Therefore, it is crucial that we are in a position to take desperate steps to attempt to save at least some of the last of them in situ, if Peary caribou continue to decline to a perilously low number. Thus, there are some preliminary investigations that must be carried out in the near future to allow us to respond in a timely way to any future significant declines.

1. Emergency Winter Feeding Of Peary Caribou As A Conservation Tool

Emergency winter feeding of commercial, high quality food rations to nutritionally debilitated Peary caribou would most likely be an unsatisfactory conservation option. That is, the desired end results of realizing a greater rate of survival than if the animals were unaided, could not be predicted and would very seldom, if ever, be obtained. Most importantly, the end results of such human intervention could be more detrimental than taking no action at all, as the artificial situation created by the feeding operation could lead to a higher mortality than would have been experienced under natural conditions.

Timely detection of severely malnourished Peary caribou caused by extensive relative unavailability of forage due to unfavourable snow and/or ice conditions is not likely on the remote and isolated Canadian Arctic Islands. If such an environmentally stressful event was detected and artificial feeding was attempted, it would likely fail for the following reasons.

(1) Nutritionally debilitated Peary caribou could not make the necessary rumen microflora adjustments quickly enough to obtain proper extraction of nutrients from high quality commercial rations (they would simply die with their rumens impacted with the high quality, but unusable, artificial foods). Even when some nutritional benefits can be drawn from a

commercial ration, low palatability often prevents adequate intake for the survival of a severely weakened animal.

(2) Logistics would be extremely complex (and costly), and the mechanics of obtaining the necessary funding and or putting the operation into effect most likely would cause precious time to be lost and further promote failure regardless of the subsequent effort. Logistics would include, (a) purchase and shipment of commercial food rations from the south to the archipelago; (b) charter of small aircraft to haul rations from settlement(s) to actual feeding area(s); (c) building of structures to protect large supplies of food rations from the weather; (d) building of feeding stations in a design that will allow animals to take adequate amounts of the rations on a daily basis; (e) hiring of labourers for feeding animals on-site; and (f) providing labourers to live on-site for the entire duration of the feeding operations and providing the necessities of life on an ongoing basis for the labourers living on-site.
(3) Concentration of animals at feeding station(s) would likely markedly increase wolf predation (especially on islands where muskoxen greatly outnumber caribou and associated numbers of wolves were tied to the combined size of the ungulate prey base).

(4) Concentration of animals at feeding station(s) could significantly increase the incidences of disease and parasite burdens.

(5) Behaviour of Peary caribou would make winter feeding extremely difficult: (a) Peary caribou occur as solitary individuals or in small social groups (mean ca. 5) in winter; (b) dominance hierarchy of Peary caribou would cause intraspecific strife at feeding station(s); and (c) the natural foraging of Peary caribou concentrated in the immediate area of the feeding station(s) would quickly impoverish and probably permanently damage available surrounding habitat.

(6) Peary caribou could not survive solely on a high quality commercial ration, as debilitated animals restricted to a high quality artificial diet would be highly susceptible to death by maladies such as acidosis and enteritis.

Emergency artificial feeding of Peary caribou should be considered only as an extreme act of desperation and worthwhile attempting, but not likely to succeed, when and if Peary caribou are reduced to an exceptionally low overall number (e.g., 500 or less on the Queen Elizabeth Islands or 300 or less on either Bathurst Island or Melville Island). Justification for emergency winter feeding could come from "citizen demand" reinforced by "political will", however, even in the face of its biological unsoundness, and, thus, it could be enacted if it is deemed necessary to maintain public support of the Endangered Species Program in Canada.

2. Supplemental Winter Feeding Of Peary Caribou As A Conservation Tool

"Supplemental winter feeding" should not be confused with "emergency winter feeding" described above. Supplemental winter feeding often could "be made to work from a nutritional standpoint" (e.g., Mautz 1978:344), if the supplemental feeding program was highly efficient and long-term, with a biologically sound set of procedures in place throughout the duration of the program.

There are, however, many problems associated with any program of supplemental feeding of artificial food(s) to free-ranging ungulates. Those problems would be heightened with Peary caribou on the remote and isolated Arctic Islands of Canada. Some of those problems could be resolved by supportive socio-political will and decree. Other problems would be largely beyond human control and would involve intra- and inter-specific behaviours of the caribou in relation to the environment.

Above all else, if the socio-political support did not exist to prevent wolves from entering the area of the feeding stations and for controlling those wolves found within that area, the program would almost assuredly be doomed to failure and should not be freely entered into as part of a biologically sound effort to preserve Peary caribou. Control of just those wolves within the localized vicinity of the feeding stations would not be biologically important over time to the regional population of wolves (cf. Miller 1993b). In the long run it would actually serve to better maintain the regional wolf population, if the feeding program subsequently led to the availability of a larger caribou prey base.

The vagaries of winter weather on the archipelago are such that any supplemental winter feeding program would have to be maintained from September through June of each year to maximize the likelihood of success. Supplemental feeding would have to be initiated at the beginning of September in each year, before winter conditions were well established, to ensure ample time for a gradual introduction of new foods to still nutritionally healthy animals and to assure protection against range-wide unavailability of forage due to unfavourable snow or ice conditions, especially in May-June during the time of spring storm revival and the period of ground fast ice accumulation during snowmelt. Existing information based essentially on the literature for domesticated reindeer, (Luick 1977f) suggests that commercial rations containing 11-16% crude protein, 1-3% crude fat, and 6.5-26.0% crude fibre would likely provide adequate nutrition for Peary caribou - provided that the palatability of the formulated ration is sufficiently high to assure adequate food intake. Success of any supplemental feeding will depend largely upon overcoming any natural reluctance of Peary caribou to consume adequate amounts of atypical rations. The danger of any long-term supplemental feeding program is that it might create a dependence on supplemental foods, especially for individuals raised from birth on artificial foods. Supplemental winter feeding programs will be subjected to essentially all

of the problems associated with an "emergency winter feeding program" and thus must be rigidly monitored and improved upon.

It is currently believed that a population of at least 250 properly managed animals of a particular species would be necessary to theoretically preserve 95% of their original genetic diversity after 50 generations (400 years). Therefore, any supplemental feeding program for Peary caribou should involve at least 300 animals (20% safety margin to allow for unforeseen mortalities). Such a program (1) would be very expensive (i.e., probably at least $500,000 to 1 million dollars per annum; (2) feeding would have to be ongoing on a daily basis during the potentially critical period of the year (1 Sep to 30 Jun), because of the uncertainties of winter weather leading to high levels of mortality among 1+ yr-old caribou and partial or total loss of the calf crop; (3) it would have to be long-term, at least 5 years and most likely up to 10 or more years, depending on the then prevailing environmental conditions; (4) the complex logistics would demand a guaranteed level of funding over at least the first 5 years of the program and would require the development of "fail safe" procedures to prevent any disruption of the continual supply of the artificial food(s) once the program is initiated; (5) it would be labour intensive and would require assistants living on-site throughout the critical period (ca. 300 days) to assure proper, uninterrupted supply of the food rations to the animals; and (6) any dead caribou found within the feeding station area (ca. 900 km^2) would have to receive detailed necropsies and the necessary laboratory tests to monitor for possible disease or parasite outbreaks throughout the life of the program.

Wolf control within the feeding station areas would most likely be mandatory to the success of any extended feeding program, or at the least, would markedly improve the number of caribou subsequently produced by the program. Control of wolves within the immediate area of the feeding station(s) (ca. 900 Km^2, 30 x 30 km) could be routinely carried out by on-site Inuit assistants who would normally take any wolf encountered in the area as part of their way of life.

Inuit working at the feeding stations and those Inuit that would potentially hunt those caribou must develop a feeling of community ownership. The hunters must understand the need for total protection of caribou within the range of the feeding stations, as such a feeding operation would not be implemented unless the caribou were at a perilously low number. No harvest of feeding station caribou could be allowed and this restriction could only be satisfactorily enforced through self-restraint and peer pressure from within each settlement.

"Supplemental" or "full ration" winter feeding of artificial foods to free-ranging Peary caribou could be used as a last desperate effort to preserve a remnant population of Peary caribou <u>in situ</u>. The logistics and mechanics of a winter artificial feeding program could be

Sherard Osborn, or the western major satellite islands of Alexander, Marc, Massey, Vanier, and Cameron.

3.1 Research hypothesis

An annual program of winter feeding of artificial foods to free-ranging Peary caribou will sustain them in a state of population growth.

3.2. Test consequences

Free-ranging Peary caribou will ingest sufficient quantities of artificial food to obtain most or all of their necessary daily nutritional requirements.

(Commercial feed of sufficiently high nutritional quality exists or can be formulated upon demand - but the palatability of such artificial feed to free-ranging Peary caribou is unknown. If free-ranging Peary caribou will not ingest sufficient amounts of artificial feed to satisfy any shortfalls in their daily intakes of natural forage, winter feeding of artificial food will not promote the desired end goal of increased population growth.)

3.3 1st working hypothesis

H_0: Peary caribou will not ingest sufficient quantities of artificial food.

H_1: Peary caribou will ingest sufficient quantities of artificial food.

A continual supply of a palatable artificial feed ration will adequately suppress the apparently innate mobile foraging pattern of free-ranging Peary caribou for a meaningful length of time (i.e., 2-8 months, particularly during the May-June pinch period of annual spring migration).

(If the mobility of free-ranging Peary caribou both on a daily and seasonal basis cannot be sufficiently suppressed to keep them in the vicinity of the feeding stations, a winter feeding program could not achieve the desired goal of causing or supporting an increasing population.)

3.4. 2nd working hypothesis

H_0: A continual supply of artificial food will not cause Peary caribou to become sedentary for 2 or more months.

H_1: A continual supply of artificial food will cause Peary caribou to remain sedentary for 2 or more months.

3.5. Plan of action

Carry out late winter to springtime feeding trials of various commercial rations to determine the willingness of free-ranging Peary caribou to accept artificial feed at adequate rates of ingestion to meet daily nutritional requirements. Determine if daily and seasonal movements or migrations can be suppressed by the presence of a continual artificial food supply to the point where the animals become sedentary and attach themselves to the artificial food supply for a meaningful period of time (measured in months).

3.6. Feasibility

Unknown at this time. The logistics and mechanics of a winter feeding program could be worked out, if adequate funding was made available for the duration of the program and public support and political will remained favourable. Commercial feed rations of suitable quality to meet the daily nutritional requirements of Peary caribou are available or could be formulated upon demand. At this time, however, the behavioural response of free-ranging Peary caribou to an artificial food supply is unknown and this basic but all-important response must be determined before the feasibility of mitigating wintertime forage unavailability can be further assessed.

3.7. Criteria of success

Determination that free-ranging Peary caribou will ingest sufficient quantities of artificial feed rations to make up any shortfalls in their daily intake of natural forages, particularly during late winter and spring when nutritional stress should be at its highest level. The desired long-term goal would be the sustainment of a remnant population in a state of population growth that would have otherwise suffered further drastic, and most likely eventually terminal, decline in the absence of a winter feeding program.

3.8. Benefits and advantages

Winter feeding of artificial foods could sustain a remnant population of Peary caribou *in situ* that otherwise would have been further decimated or driven to extinction. Inuit participation in a winter feeding program could foster a stronger sense of ownership and responsibility for the Peary caribou resource. This heightened awareness of ownership and responsibility could in turn lead to a greater degree of future protection of Peary caribou by the Inuit stewards, significantly improving future cooperation with responsible government agencies that are also concerned with the conservation and preservation of Peary caribou.

3.9. Criteria of failure

A supplemental winter feeding program could not be considered a feasible conservation tool to sustain a free-ranging remnant population of Peary caribou *in situ*, if those caribou would not consume adequate amounts of the artificial foods presented to them to a level that would fully compensate for any meaningful shortage of natural forage. Also, even if those caribou did ingest sufficient amounts of artificial food to meet their daily nutritional requirements, the program would still not be feasible if the caribou did not suppress their innate mobility drive to the level necessary to hold them in the feeding area throughout at least the most severe period of nutritional stress due to relative forage unavailability.

3.10. Penalties and disadvantages

A winter feeding program may increase wolf predation on the feeding station animals; increase the incidences of disease or parasite burdens among those animals; destroy local range beyond any usable limits and require several decades for recovery; disrupt movement/migration patterns that provide short- or long-term survival benefits (however, short-term benefits could be nonexistent to individuals in some years of extreme environmental stress, therefore, becoming sedentary in such years could be a benefit rather than a detriment to those individuals); and fed caribou could die from maladies caused by the artificial food.

3.11. Duration of studies

(1) The first fiscal year would be devoted to logistics, detailed project design and statistical procedures, construction of observation posts and feeding stations, and renovation of the Canadian Wildlife Service camp to provide adequate and safe accommodation for occupation from April through June of the following 2 years.

(2) The second fiscal year would be the first operational year. Field studies would be conducted from April through June; then, the field season would be evaluated; and a project annual progress report produced; and logistics for the field season of the second operational year would be carried out.

(3) The third fiscal year would be the second and final operational year. The field season would again be April through June; all data would be analyzed; and a project completion report would be produced.

3.12. Person-years and funding

(1) A minimum of 1.5 person-years per annum would be required but 2.0 person-years annually would allow the obtainment of a significantly larger database.

(2) The level of funding should be at least $60,000 per annum.

(3) Funding would be sought from the Canadian Wildlife Service, Government of the Northwest Territories, and other government agencies and nongovernment organizations.

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