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Record-keeping, management decisions and productivity of extensive reindeer herding on the Seward Peninsula, Alaska

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Abstract: Alaska's reindeer (*Rangifer tarandus*) industry has been faced with the competitive need to increase productivity but cautioned to avoid range degradation as a result of high stocking rates. Consumer demand for lean, healthy, high quality meat has increased throughout the world and has surpassed production. For herders to tap these new domestic and off-shore markets, there will be the need for higher herd numbers and animal productivity, consistent slaughter protocol, and a focused marketing plan. In this paper, we illustrate how record-keeping can benefit reindeer herders in husbandry and management decisions that are necessary to increase animal productivity and, eventually, product quality and profits. These biological parameters were tested in a Lotus® spreadsheet model designed to predict herd growth and economics. Records of three reindeer herds on the Seward Peninsula have shown that calf production for adults has ranged from 35 to 98%. Sensitivity analysis predicted that in some herds, the model was sensitive to small changes in calf survival which could result in insufficient recruitment to maintain long-term harvest. Productivity may be ultimately related to management decisions that cull animals before productivity begins to decline.

Key words: Alaska, modelling, mortality, productivity, record-keeping, recruitment, reindeer herding.

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Introduction

The reindeer (*Rangifer tarandus*) industry in Alaska has grown considerably in recent years as Native entrepreneurs attempt to increase revenues from this extensive agricultural industry (Dieterich, 1991). Perhaps the primary factor influencing the growth and interest in reindeer has been higher world prices for velvet antlers. For the reindeer herder, this implies a quick source of revenue and an incentive to shape the herd structure to favor a large component of males for velvet antler production. To accomplish this goal, concern over survival, recruitment, and productivity have often been abandoned.

Regardless of the temporary direction of the industry the long-term stability of this livestock industry must focus on red meat production (Drew, 1991a, b; Renecker, 1991). However, to maintain a market there must be a product of consistent quality and supply. This requires a productive reindeer population with good survival rates and recruitment into the yearling age class. In a possible attempt to achieve this goal, a herder would be faced with an opposing circumstance. The agencies who manage the ranges have placed limitations on the maximum stocking rates. In addition, this creates a situation where the herder must determine the factors within his management program that will allow him to optimize production and therefore returns. In this study, we compared production data from three reindeer herds on the Seward Peninsula, Alaska in terms of future herd growth and economic returns.

Study area

The ranges of the three sample herds were located near Nome in the south (390,000 ha), Duck Creek in the central region (350,000 ha), and Church Rock in the northeast region (790,000 ha) of the Seward Peninsula, Alaska (Fig. 1). Vegetation communities are diverse throughout the Penisula and consist of 91 ecotypes that vary from riparian habitats to tussock tundra to lichen dominate communities (Swanson *et al.*,

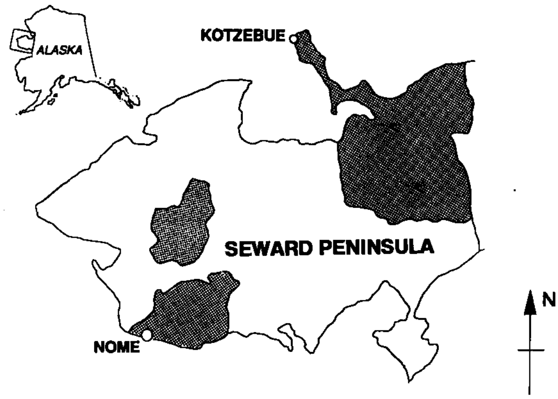

Fig. 1. Location of the Nome (south), Duck Creek (central), and Church Rock (northeast) reindeer ranges on the Seward Peninsula, Alaska.

Table 1. Average biological parameters used in herd growth and economic projections of three reindeer populations on the Seward Peninsula, Alaska.

Age Class	Survival (%)			Fecundity (%)			Liveweight (kg)	Harvested velvet antler (kg)	Maximum breeding population
	Nome	Duck Creek	Church Rock	Nome	Duck Creek	Church Rock			
Calves	0.57	0.78	0.57				62	0.0[2]	
Yearlings									
Bulls	0.81	0.90	0.75				96	0.80	
Cows	0.85	0.90	0.75	0.08	0.58	0.11	80	0.40	
Subadults									
Bulls	0.79	0.81	0.67				109	1.70	300
Cows	0.85	0.81	0.67	0.43	0.92	0.49	91	0.60	1000
Adults[3]									
Bulls	0.56	0.83[4]	0.45				121	3.20	200
Cows	0.74	0.78	0.45	0.61	0.91	0.61	102	0.90	1500
Old age[5]									
Bulls	0.60	–[4,6]					104	2.40	
Cows	0.65	0.50		0.53	0.66	0.50	100	0.65	

1 Averages calculated from velvet antlers harvested and weighed during June round-ups of the Nome reindeer population.

2 Velvet antlers are present but the harvest is not recommended because of the small antler size and stress on neonate calves.

3 An average of 3–8 year old age class; a specific value of each age class was used in the model.

4 Killed at a maximum of 5.5 years of age.

5 Reindeer that graduate from the adult age class remain in the old age category until the subsequent autumn and then are ciulled for meat.

6 No data available.

1985). Generally, snowmelt begins in late April with green-up during mid-May. However, the spring pulse of growth is delayed by approximately 2 weeks on the northern range.

Methods

Data was collected from these reindeer herds during scheduled June handlings from 1989 to 1991 on a computer database developed specifically for use with the commercial reindeer and game farm industries (Clarke *et al.*, 1990; Blodgett *et al.*, 1992). Although computer records were maintained prior to this date, inconsistencies in tagging and data collection prohibited the use of the information. This information included: individual animal tag numbers, presence or abscence of udder (indicator of fecundity in this model), body weight, weight of velvet antlers harvested, warble fly (*Oedemagena tarandi*) infestation (subjective scale from 0 or none to 3 or high; scale determined from previous counts), vaccinations given, and samples taken. From this data set, average biological parameters were computed (Table 1).

A simple Lotus® spreadsheet model was designed to predict herd growth and economics of these three populations from the computed biological conditions and estimated annual costs and revenues. This framework was utilized to evaluate the sensitive variables that will influence future productivity of a population. The model was based on several assumptions: a) optimal slaughter age in the future will be 18 month old animals (based on the economics of feeding animals for rapid growth versus maintenance of mature animals at a constant weight and the need to provide a consistent, high quality product to a specialty North American marketplace); b) the breeding ratio at enterprise maturity will be approximately 20 breeding females: 1 breeding male; c) breeding males will be culled from the population at 42 months of age (after the rut); d) productivity of females begins to decline after 8 years of age and all females will be culled at 9.5 years of age; e) direct and operational costs will remain similar for all herders except for helicopter costs (the per animal cost has been adjusted for herds where only one animal round-up occurs (Table 2); f) product values are based on average prices for 1991 (Table 2); and g) harvesting and culling animals for meat will occur after the rut at peak autumn weight.

Table 2. Annual costs and revenues required by an extensive reindeer operation.

Item	Cost (US$)
Costs	
Operational (fuels)	200
Veterinary costs/hd	2
Maintenance	1200
Labor ($15/h x 28 days x 8 men)	3360
Harvest cost/hd	198[1]
Cost of cutting velvet antlers	5
Helicopter/h	400[3]
Prices	
Liveweight ($/kg)	5.39
Velvet antlers ($/kg)	110

[1] Based on inspected animals air shipped to abbatoir; including cost of slaughter and breaking carcasses.

[2] The cost for a minimum of 1 h of helicopter flight time/year is a condition that each herder in the simulations must absorb.

In the population projections, the reindeer herds were viewed as a function of the outcome of birth, survival (mortality), commercial harvest, and culling rates. Survival rate for an age category of either sex was calculated as the proportion of tagged animals that survive an annual cycle and are counted in the next June handling. For adults, survival rate was an average of the one year periods within the width of the age category (age 3 to 8 when data was available). Stoching capacity was set as the suggested limit for the range as specified by the respective land agency (approximately 2,500 adult animals/range). The harvest policy enabled recruitment of yearling animals into the mature age classes before culling was initiated. The entire driving mechanism of the model was based on herd growth to enterprise maturity and then maintenance of a stable breeding population with offtake for the meat market. The maximum breeding population was an initial biological parameter that was based on the number of mature animals each range would support over a winter period (the most-limiting time). The 1991 data provided the initial conditions to compute the 1992 predictions. In this model, the populations were assumed to be closed to immigration or emigration with either surrounding herds or the Western Arctic Caribou Herd which often migrates through several reindeer ranges on the Seward Peninsula.

The economic subroutine calculated the potential revenue obtained from two possible commodities on the basis of macheting assumptions: a) meat; and b) antlers. In this simulation, the marketplace dictated that each operation must produce an inspected product that could be sold commercially on the market shelf anywhere in the USA. To accomplish this mandate, we assumed animals would be shipped via air (as is currently carried out by one herder) to an inspected abbatoir in the state. The costs and prices were computed from actual costs. Production costs were computed on a per handling or a per animal basis.

Sensitivity of the population to changes in survival of calves was examined in terms of rate of herd increase (r), harvest rate of the herd (h), and total production cost of meat sold (US $/kg liveweight) for the three herds.

Results and discussion

Records assembled from our three reindeer populations indicate some profound variations in management and productivity among herders on the Seward Peninsula of Alaska. We have identified thet variation in survivorship and recruitment of reindeer could be a function of a number of variables (Fig. 2). For brucellosis

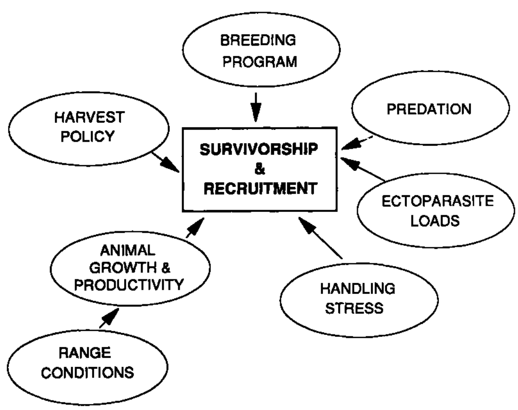

Fig. 2. Variables affecting survivorship and recruitment of reindeer populations on the Seward Peninsula, Alaska.

(*Brucella suis* biovar IV) (Dieterich, 1981) and warble fly (Dieterich & Haas, 1981) problems, management practices have been implemented to reduce their influence (R. A. Dieterich, J. K. Morton, & B. L. Deyoe, personal communication). Ultimately, the ability of any population to survive and remain productive in terms of growth and overall enterprise economics will be characterized by its ability to either expand and achieve the sustainable limit (range capacity) or if culled (as a result of an excessive number of animals) then sustain the recommended population.

Herd growth projections under average conditions until 1991, are presented in Fig. 3. If the

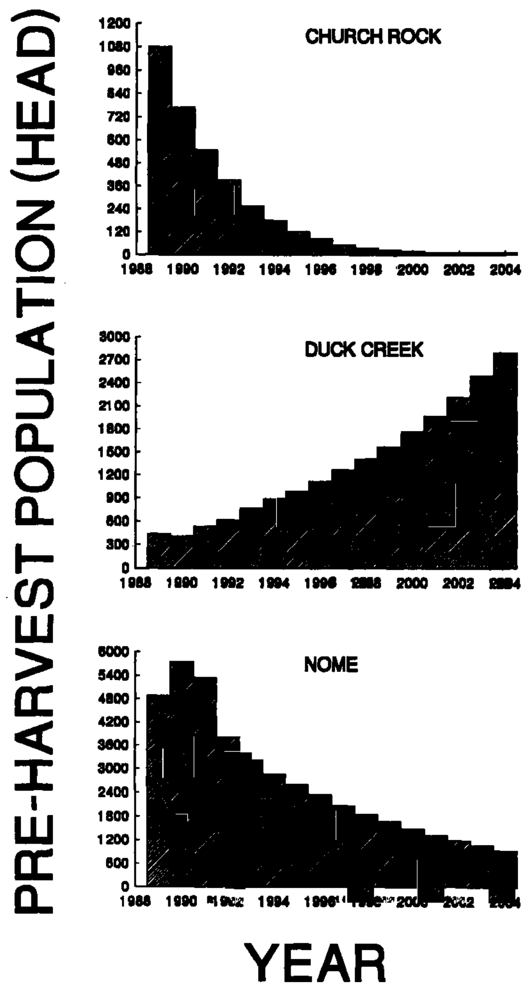

Fig. 3. Herd growth projections for three reindeer populations on the Seward Peninsula, Alaska.

reindeer herds were allowed to increase with the assumptions of the model, only the Duck Creek population was predicted to increase and approach the recommended carrying capacity for the range. Although the Nome herd entered the projection with > 5,000 reindeer, after necessary culling, the population did not recover in the 15 year projection. Ultimately, this has a major impact on overall enterprise economics and viability (Fig. 4). In the Church Rock example, negative herd growth rate was exacerbated as a result of low productivity where the simulated population crashed to virtually zero within 9 years. By careful examination of herd recruitment, age, and fecundity records, the herder could have deducted that a decline might occur and made adjustments to management or at least probe to uncover the cause. In a companion project on the Seward Peninsula, causes of neonatal mortality are being explored (C. Chetkiewicz, personal communication) and this coupled with a reliable method of pregnancy testing (to determine conception rates and time of conception) will be more quantitative tools to help producers make future management decisions.

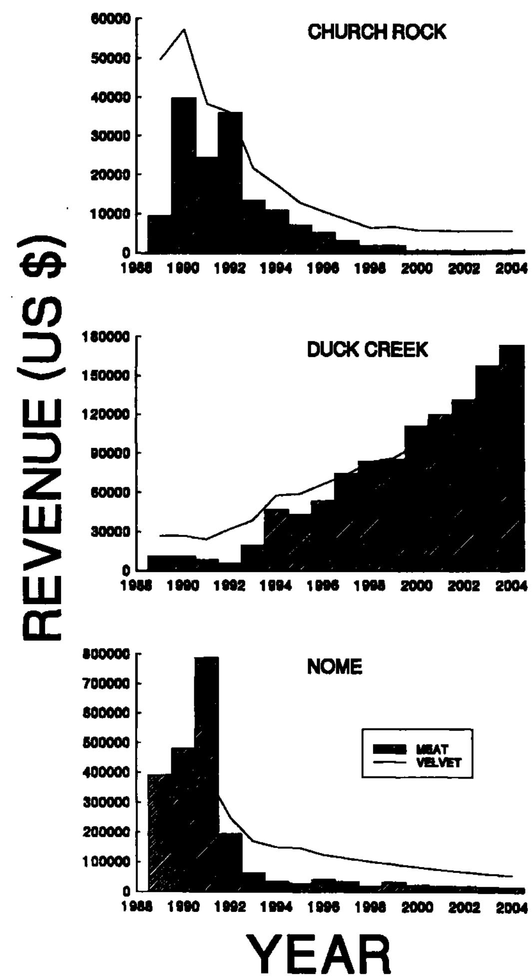

Fig. 4. Economic projections of potential revenue from meat and velvet antler sales from three reindeer populations on the Seward Peninsula, Alaska.

Scandinavian reindeer have been described as a relatively productive species (Staaland & Eikelmann, 1991) when managed extensively in the commercial arena. However, the inability of two of the simulated populations on the Seward Peninsula to respond efficiently to a meat-driven marketplace raises questions about the production and management strategies. Records indicated that fecundity in these populations has varied in the past from 35 to 98 % for animals in the adult age classes. In two of the herds, the average was < 66 %, which would suggest that females capable of breeding were only conceiving and/or carrying a fetus to parturition every 2 of 3 years, a pattern common for free-ranging bison (*Bison bison*) that forfeit the «luxury of reproduction» and do not breed in order to survive and build-up condition for the subsequent year (Fuller, 1966; Reynolds *et al.*, 1982). Reduced conception rates and alternate-year reproduction has been demonstrated in red deer (*Cervus elaphus*) (Mitchell *et al.*, 1976), Rocky Mountain bighorn sheep (*Ovis canadensis*) (Thorne *et al.*, 1984), and wapiti (Freddy, 1987). Expression of reduced animal performance has been suggested to involve a considerable time lag that may be represented by a decline in cow:calf ratios (Saether & Haagenrud, 1983). The Church Rock populatin only showed a small peak in fecundity in one year, probably in response to the low productivity. This may suggest that a limited nutritional base is available during summer for females to replenish sufficient body tissue stores for both autumn reproductive opportunities and winter survival.

Herd structure is important in the overall management strategy for the population. When range is limited it is critical that the herd be extremely productive in order to maximize economic opportunities. To accomplish this, many biologists have implied that a ratio of 1 bull: 10–20 cows is preferred for polygynous ungulates to ensure high rates of fecundity. Baskin (1990) suggested that a bull:cow ratio of 1:18 ensures most domestic female tundra reindeer will be bred because they are maintained in tight groups. For looser management, a male:female ratio of about 1:10 would be expected. When bull:cow ratios of mature animals in tightly managed groups approaches 1:1, actual breeding success could decline as a result of extensive dominance interactions among males.

The velvet antler market will tend to skew herd structure to favor a larger percentage of older males which have higher annual yields of this product. The implications of such a management strategy can have serious repercussions for an extensive reindeer operation. The world velvet antler trade is extremely volatile and has epxerienced price fluctuations from <US$ 25/kg in 1975 (Drew, 1991a) to >US$ 270/kg in 1991 for some velvet antlers from wapiti (L. A. Renecker, personal communication). If we use Nome case as an example, records illustrate that the overall population has a ratio of about 1 male:2 females. If this herder chose to reduce his herd to the required limit in 1991 then the logical decision would be to cull males and aged females to approach the recommended 2,500 adult animals. However, the high proportion of males in the population has pre-empted the presence of a large reproductive female population. This compounded with less than optimal fecundity and survival predict a decline over time. In terms of economics, meat harvests (Table 2) are sub-optimal because continual recruitment is required to accomplish this new herd structure.

The model also predicted that an appreciable increase in productivity could be expected in the Duck Creek population (Table 3). In addition to the higher harvest rates of 18 month old animals, unexpectedly, this enterprise did not experience a reduction in velvet antler reve-

Table 3. Projected harvest of animals from three reindeer populations on the Seward Peninsula, Alaska, from 1991–2004.

Year	Harvest (no. of animals)								
	Nome			Duck Creek			Church Rock		
	Yearlings	Adults	Aged	Yearlings	Adults	Aged	Yearlings	Adults	Aged
1991	218[2]	445	460[3]	–[4]	2	13[5]	–	38[6]	–
1992	41	183	111	–	8	–	–	56	–
1993	57	154	114	–	29	1	–	21	–
1994	–	200	62	–	8	2	–	17	–
1995	–	159	48	–	9	8	–	11	–
1996	–	184	73	2	10	9	–	8	–
1997	–	163	61	37	10	3	–	5	–
1998	–	149	32	46	4	4	–	–	–
1999	–	134	59	64	6	7	–	3	–
2000	–	119	40	100	7	11	–	1	–
2001	–	105	35	117	8	9	–	1	–
2002	–	96	32	149	9	11	–	1	–
2003	–	84	28	190	10	13	–	1	–
2004	–	75	26	222	10	14	–	1	–

[1] Males (age 3–8) were slaughtered in the first year to adjust herd structure. After 1991, only 3-year old males are culled.

[2] Only males were harvested because all females were recruited for breeding in an attempt to maintain a maximum population size. After 1993, all males were required as replacement breeding stock.

[3] Includes 56 males in 1991. All subsequent years consist of only culled females.

[4] Only males were harvested because all females were recruited for breeding in an attemt to maintain a maximum population.

[5] Aged bulls.

[6] Adult bulls.

nue. High velvet antler yields from a productive herd of females closely-tracted the revenue from meat sales over the projected period (if price remains constant). Perhaps, the optimal strategy for commercial management of a cervid, where both sexes produce antlers, is to maximize breeding success, calf production, recruitment, and harvest rates. Only intensive farm operations have the luxury of year-round segregation of males in fenced paddocks for the sole purpose of velvet antler production.

The favourable response of the Duck Creek population was probably a reflection of an animal response to high quality abundant nutrition and a designated plan of seasonal utilization. From the 1989–91 data, >50 % of the female calves where bred the first autumn. We can speculate that the availability of high quality food and the seasonal mustering of animals onto critical ranges has allowed calves and adults to grow and attain target set-point weights that are required for high reproductive success. However, we can then further speculate as to whether this early shift to «reproductive luxury» has any effect on the potential lifetime reproductive output of the animal. Although only three years of data have been collected, there appears to be a trend for both rapid and maximum display of reproductive potential in females for approximately 5 years of life and then a continuous decline. This trend in reproductive lifetime of females contrasts with the Nome herd which remains about 58–68 % fecund over a 6 year period.

Consideration of calf harvest

Calves are commonly the primary harvest component in many Scandinavian reindeer herds (Staaland & Eikelmamn, 1991). The harvest of calves has been implemented to reduce grazing pressure on limited winter lichen range (Kojola, 1989). This strategy has indirectly improved population productivity by reserving this limiting food resource for more females (Kojola, 1989; Kojola *et al.*, 1991).

In Alaska, slaughter of autumn calves for meat has not been implemented. Tradition has demanded the larger carcasses of castrated males to meet the demand from local Native markets and for sausage by-products. These carcasses carry a heavy cover of subcutaneous fat. With the new trend to fill the specialty markets in North America, carcass characteristics and optimal slaughter age must be reconsidered. This imposes two critical constraints for successful sales and industry economics: 1) knowledge of the expectations and desires of the market in terms of product, packaging, and promotion; and 2) to deliver the product desired by the consumer at the lowest production cost which must take advantage of the high rate of gain per kg of feed that occurs in growing animals. Although seasonal weight change will occur, growth in Alaska reindeer does not appear to decline until animals are approximately 18 months of age (L. A. Renecker, personal communication). But before optimal slaughter age can be considered, the cause and time window of the low calf survivorship must be quantified and only then can the herder or agency make realistic adjustments to management strategies of either the herbivore or predators.

Sensitivity analysis

Rate of increase of the population and total production cost were most strongly influenced by changes in calf survival (Table 4). Harvest rate was only strongly influenced by a change in calf survivorship when a population displayed a positive increase in growth (a reflection of culling surplus yearling males). The strongest response in these three monitored parameters occurred when calf survivorship was 50–70 %.

Survivorship can also be strongly connected to reproduction and herd structure. For example, recently, congenital effects (Renecker & Blake, 1992) have been expressed in a reindeer herd on the Seward Peninsula, Alaska – they are associated with and/or influence female calving success, herd structure, and genetics. Close examination, knowledge, and partitioning of mortality are paramount exercises for management strategies of productive grazing system.

Conclusion

Productivity and long-term profitability of reindeer populations on the Seward Peninsula are dependent on good herd growth. Potential for increase in herd size is a function of survival and recruitment. Only after productive functions have been thoroughly expolored can herders implement appropriate husbandry practices to manage their reindeer. This can be accomplished through good production and management records, partitioning causes of mortality, and quantification of the relationships between

Table 4. Influence of calf survival rates on intrinsic rate of increase, harvest rate, and total meat production cost in three reindeer populations on the Seward Peninsula, Alaska.

Calf survival (%)	r (%)[1]			h (%)[2]			PCT[3] (US$/kg)		
	Nome	Duck Creek	Church Rock	Nome	Duck Creek	Church Rock	Nome	Duck Creek	Church Rock
50	-13	2	-31	8	4	4	2.91	3.16	45.00
60	- 9	6	-31	8	6	5	2.70	2.75	45.00
65	- 8	7	-31	9	7	5	2.63	2.60	45.00
70	- 6	8	-29	9	8	5	2.57	2.57	45.00
75	- 5	9	-26	9	9	5	2.53	2.50	23.50
80	- 4	10	-25	9	10	5	2.49	2.49	23.50
85	- 2	10	-24	9	10	5	2.54	2.48	16.00
90	- 1	11	-22	10	11	5	2.54	2.44	16.00

[1] Rate of increase of population over projected period.

[2] Harvest rate over projected period.

[3] Total production cost which includes all annual costs (direct and indirect).

animal growth, weight and age. Knowledge of these criteria has become more critical because of the influence of the velvet antler industry and the potential shift in herd structure. Although this model is not highly complex and requires further data acquisition, it does illustrate the importance of survival and reproduction in reindeer grazing system management in Alaska.

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