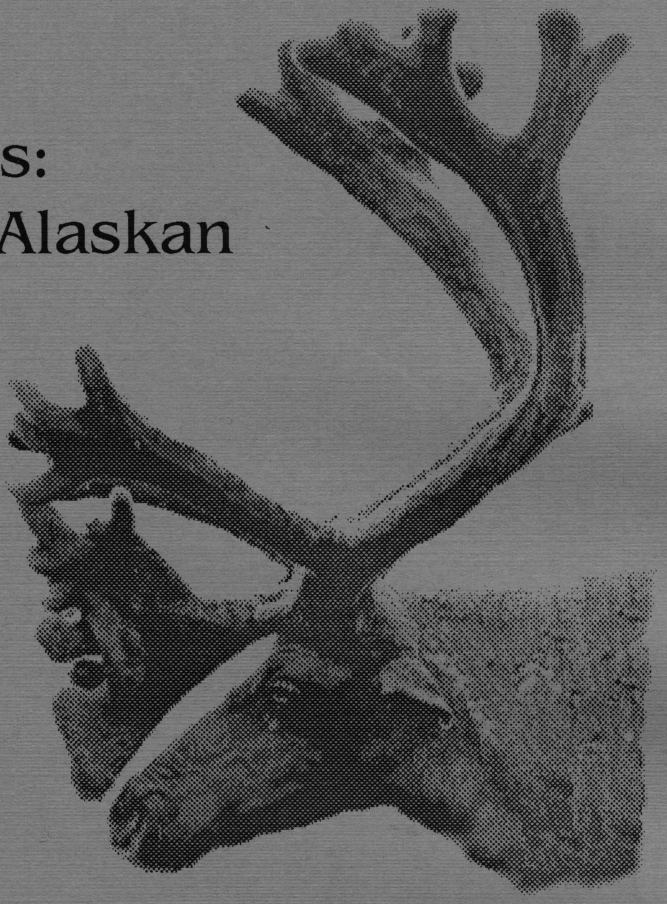
Population Dynamics: An Introduction for Alaskan Reindeer Herders



Andrew John Karter
University of California, Davis

Robert A. Dieterich
Professor of Veterinary Science, Emeritus
Institute of Arctic Biology,
University of Alaska Fairbanks

School of Agriculture and Land Resources Management
University of Alaska Fairbanks,
James V. Drew, Dean and Director

Bulletin 81

May 1989

Population Dynamics: An introduction for Alaskan reindeer herders.

INTRODUCTION

The management of a reindeer herd is an important responsibility, and has implications for the present and future viability of the reindeer industry in Alaska. Management decisions directly affect herd profits and thus these decisions have important implications for both today's herders and future herders. A herder requires much ingenuity and needs diverse skills such as knowing where to find the herd, snowmobile mechanics, survival in the bush, slaughtering techniques and organization of work crews. Another important field of knowledge that will aid in herd management is ***population dynamics*** which explores how and why a herd grows or declines from year to year. These changes are linked to herd composition; that is the number of males versus females (sex ratio) and the number of fawns versus yearlings versus adults (these are called age classes). Knowledge of herd composition allows herders to predict future fawn crops, the potential for annual increase in the herd, meat and antler production, and potential annual income.

There are some aspects of population dynamics that are common sense. Others are less apparent. This bulletin will try to give a general background about several aspects of population dynamics that are of great importance to reindeer herders all over the world: the problems of population explosion, crash and decimation by overharvest. A ***population explosion*** refers to the situation where herd size grows at an increasingly faster rate. This is often followed by a dramatic drop in herd size, called a ***population crash***, which is the ultimate disaster for any herd owner. ***Population decimation*** can result from harvesting too many reindeer, especially too many females. Information presented in this bulletin is based on published reports, data from the University of Alaska Fairbanks Applied Reindeer Research Project's own computer record-keeping system and conversations with herders in Alaska and Scandinavia.

St. Matthew Island Reindeer Population Dynamics

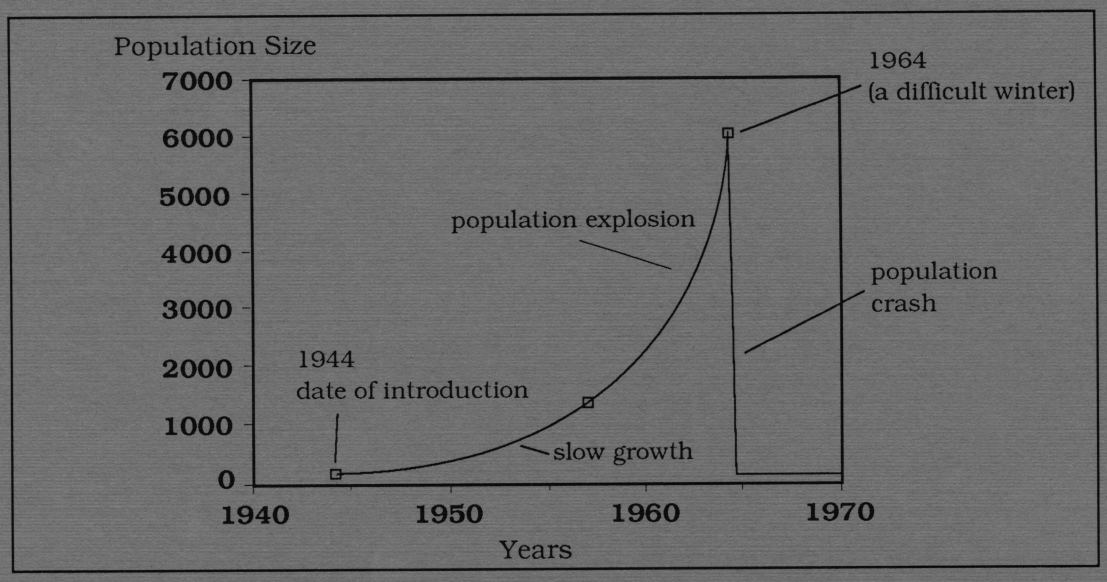


Figure 1. The calculated growth for the St. Matthew Island reindeer herd. The square points are actual counts. (Klein, 1968).

THE EVIDENCE

St. Matthew Island's reindeer herd provides a good example of a population explosion and crash. When 29 reindeer were introduced to St. Matthew in 1944, the island was covered with a thick mat of lichens. With the abundance of high quality forage, the herd increased dramatically, and by the summer of 1963 there were 6000 unmanaged reindeer on the island. There were however, less than 50 reindeer alive that next spring.

St. Matthew's reindeer population increased dramatically because there was little hunting or predation, good fawn production and an abundance of high quality forage. These conditions are currently present for many of the Seward Peninsula's reindeer herds. As the St. Matthew reindeer population grew, increasing amounts of forage were required. Soon most of the lichens (high quality winter forage) were used up, and sedges and grasses (medium quality winter forage) took their place in the ground cover. At the time of the crash, deep snows limited availability of the remaining forage. Crowberry, a low quality food, was the only available forage. As the quantity and quality of forage declined, the condition of reindeer declined as well. The reindeer lacked adequate fat reserves to survive the particularly difficult winter of 1963-64 and 99% of the animals died. In 1982 the last reindeer disappeared from the island. In 1987, 22 years after the period of overgrazing, only 10 percent of the original lichen biomass had grown back, and these were mostly lichens that are not preferred by reindeer. It will take many additional "reindeer-free" years before the island will again be capable of supporting a large population of reindeer.

One might not consider a population explosion and crash as a likely occurrence on the Seward Peninsula since the reindeer herds are managed and harvested, and it is not an island. Nonetheless, there are examples of reindeer population explosions

and crashes in managed herds that do not live on islands. In the 1930s, northern Sweden's reindeer ranges were packed with oversized herds, each of which had a well-defined range boundary as on the Seward Peninsula. Herders watched their deer year-round and kept them within the boundaries of their range, preventing losses to neighboring herds. In a sense, their range was like an island because reindeer rarely left the boundary and other herd's deer rarely entered. The range was overgrazed and all predators (bear, lynx, wolf, wolverine) were so controlled that they presented little problem. In those days, Scandinavian reindeer herders would try to maintain as large a herd as possible because the larger herds brought in a greater income and were considered status symbols (like owning fancy trucks or snowmobiles). Herders would purposely not slaughter animals that should have been removed just to increase herd size. Around 1935, a series of bad winters caused major die-offs resulting in substantial losses for all herders. Subsequently a large proportion of the Sami herders – native to Lapland and Scandinavia – were driven into bankruptcy, leaving only a few herders who had enough reindeer to survive economically. Herders in Scandinavia are now very careful about their herd population dynamics as they are interested in securing their future as well as that of their children's. They believe that a well-regulated herd is insurance against the disaster their fathers experienced.

Alaska has also experienced a reindeer population explosion and crash. There were over 600,000 reindeer in coastal Alaska by the end of the 1930s. Due to a population crash, the number decreased to 250,000 by the beginning of the 1940s and then down to 25,000 by 1950. The reasons for the crash are still disputed. Bad management, overgrazing, disease, predation and caribou are cited as possible causes.

UNDERSTANDING POPULATION DYNAMICS

In general, in the absence of overgrazing, excessive mortality by predation or disease, or heavy harvesting, reindeer herds grow until they crash or disperse to new regions. Initially, herd numbers may grow slowly. However if the herd is allowed to increase in size, it will grow more and more rapidly each year (look at the graph from the St. Matthew Island herd, page 2). With favorable conditions, a herd can increase in size as much as 30 percent per year. In some instances, reindeer herds have increased faster than the herd owner can adjust management capabilities, leading to unintentional overgrazing of lichens. The speed at which this happens and whether it happens at all depend on how many and which animals are slaughtered.

A population explosion and crash is the extreme case of when a herd's annual growth (number of reindeer this year minus reindeer last year) "explodes", increasing rapidly each year until the herd becomes far too large for its range. At this point the herd "crashes," because large numbers of reindeer die within a very short period. The change from a rapidly growing herd to a rapidly declining herd is usually due to overgrazing. A depleted range can not produce enough food to support a herd that is too large and subsequently many deer starve or die due to poor condition. When the number of reindeer dying each year (usually during late winter or spring) exceeds the number being born the herd stops growing and then starts to decline in size. At this point of no growth or declining size, the herd is at or above what is called ***carrying capacity.*** Carrying capacity is the maximum number of deer a region can support

in the absence of harvesting without causing permanent changes in the quantity and quality of available reindeer forage. The population growth stops mainly because there is not enough food for all the animals, resulting in females' failure to produce a good fawn crop and the death of many of the older animals each winter. If conditions worsen, then many more animals die each year than are born and the population declines or crashes.

When the herd size is such that the number born each year is greater than the number dying and harvested, a surplus of animals is created. The size of the surplus depends on winter conditions, the number of animals harvested or killed by predators, the number of males versus females in the herd, and various other factors. This difference between births and deaths causes the herd to grow. If a herd owner slaughters all of this surplus annually and slaughtered deer are chosen wisely (not all females for example), the herd will stay the same size over time. This annual surplus available for slaughter is called ***sustained yield***. If the herd is at or above carrying capacity, there is little surplus created because the number of animals dying usually equals or exceeds the number born and thus the sustained yield is very small. It is then important to reduce the herd size so it will produce the greatest sustained yield each year. The larger the annual sustained yield, the more animals that can be harvested each year without reducing herd size over time.

A characteristic common to reindeer populations is that, unless they are regulated by enough harvesting or predation, they tend to increase past carrying capacity and eventually either move out of the region or starve. At high population levels, there are a variety of warning signs.

WARNING SIGNS

It is important to detect warning signs for a population that is close to or above carrying capacity. Most of these symptoms result from poor nutrition, a consequence of the overgrazed range and can seriously reduce herd profits. The first warning signs in herds approaching carrying capacity are reduced body size and weight. This will decrease the income a herder can make on slaughtered reindeer, as well as lowering the chances weak reindeer will survive a difficult winter. Females have their first fawn at an older age on overgrazed ranges. Thus, an average female on poor range will produce fewer fawns during her life span than a female on good range. A well-fed female can give birth as a yearling, but it is more common for a female to have her first fawn at two years old. In regions where there are too many reindeer (same as saying that the herd size is above carrying capacity), females may not have a fawn until three years of age. Additionally, on overgrazed range mature females may not have a fawn every year. A reindeer with poor nutrition is also more susceptible to disease and parasites, which can further aggravate poor physical condition, increase winter losses, and decrease body and antler weights. A severe winter will cause a major die-off in an undernourished herd. In southern Norway, part of a herd that had overgrazed its range was moved to a new, unoccupied range. Reindeer increased in weight by about 20 percent the first year and fawn survival went from about 50 percent up to 90 percent. Having the right size herd for the range can beneficially affect the size of the fawn crop, the weight of slaughtered deer and also increase the number of animals that survive a difficult winter. These factors translate into increased profit.

Another aspect of a growing herd that can cause great difficulties for a reindeer owner is herd movement. As the herd grows in size it will tend to wander farther looking for better range. On an island herd movement is restricted; however herd boundaries on the Seward Peninsula are only lines on the map. If a herder is not able to keep the herd within the district's boundaries, then reindeer will wander and mix with neighboring herds. If a herd grows too large and is kept within the boundaries of its ranges, the deer may not have enough forage. Herds that approach carrying capacity often spread out over the whole range rather than going in tighter groups. This is because the reindeer forage is more sparsely distributed and there is not enough feed in one area to support a large group. This greatly increases the time and cost of rounding up the herd for handling and the chances of loosing deer to a neighboring reindeer permit area.

The reindeer herd may seem to do well for several years even though it is too large for the range carrying capacity. But during this period, the range is being overgrazed. It is important to catch the problem before the reindeer start showing the warning signs such as reduced weights, lower fawn production, wandering off the range and high mortality. Overgrazing is a serious problem as was learned from St. Matthew Island. Lichen beds may never recover to their original condition if the reindeer continue to graze. Basic range management practices in the form of a range management plan could have prevented the overgrazing and starvation of the St. Matthew Island reindeer herd. Such a management plan is helpful in providing basic information about range conditions and making best use of the range resources.

A way to insure that the herd is at a healthy size for its range is checking the vegetation. The U.S. Soil Conservation Service has developed a system that monitors the range by examining the quality and quantity of available forage in each reindeer district. This system, called ***utilization checks***, will warn herders when the herd size is larger than the range can support. The U.S. Soil Conservation Service can assist herders in learning how to conduct utilization checks on their own, as well as developing a range management plan. Herders in Scandinavia use a similar system and often temporarily keep reindeer out of portions of their range if they see that local overgrazing is taking place.

HARVESTING FOR PROFIT

The herd size that creates the greatest annual surplus number of animals has been shown to be the herd size that will produce the most meat if the herd owner is able to slaughter the surplus each year. The most profitable population size is difficult to determine exactly, although there are some guidelines that will help a herd owner approach the goal of maximum long-term gross income.

The most important first step is for herd owners to not permit their herd to exceed the maximum size limit set for their range. The second and equally important limit not to be exceeded is the ***manageable size limit***. Let us say that a given herd is increasing at a rapid rate and a large surplus is produced annually. If the herder is not capable of slaughtering the whole annual surplus, then the herd will continue to grow. As it grows, it will produce a larger surplus each year, making it increasingly difficult for an owner to harvest all the deer needed to be slaughtered. This inability to slaughter enough deer can become critical and ultimately result in a population

explosion, overgrazing and permanent range damage, and an eventual crash. If the herd's surplus is larger than a herd owner can manage to slaughter each year, then it is advisable to hire help and slaughter the herd down to a manageable size. Additionally, if the U.S. Soil Conservation Service utilization check detects extensive overgrazing, then herd size should be reduced.

If, however, the herd is decreasing each year and is below the manageable size limit and no large scale predatory or disease-induced mortality or overgrazing is evident, then too many reindeer or the wrong "type" of reindeer (more on this later) are being slaughtered each year. This situation can result in a gradual decimation of a reindeer herd. Annual profitability will decrease as herd size decreases. The situation can eventually reach the point where a herd owner will actually loose rather than make money each year because operating costs exceed net returns. The appropriate herd size may change from year to year as range conditions and the ability to slaughter changes with time. It is important that herd owners keep track of the annual herd growth or decline so that they can make wise decisions come slaughter season.

Monitoring herd changes can be accomplished by using the University of Alaska's Applied Reindeer Research Project's computerized reindeer record-keeping system. Using the traditional summer handling tally may not be sufficient as there is no way of knowing if the individual animals counted one year are the same as the ones counted the next year. Herders could conceivably have twice as many deer as the tally shows if each animal is counted only once every other summer. Thus information about individual animals is needed to make proper decisions about herd size. The record-keeping system uses information on individuals to adjust for the problem of whether missing deer are dead or alive and will give the best estimate of the true herd size.

WHICH REINDEER TO HARVEST?

The choice of which deer to slaughter has a very important effect on herd population dynamics. For the herd size presently found on the Seward Peninsula, if a herder slaughters mostly females, then the fawn crop will be reduced and the herd will decline. This is because by slaughtering a female, the herder also slaughters all the fawns that it would have had during its lifetime. Harvesting mostly bulls and all steers and leaving females should increase fawn production and herd growth. For herd size approaching carrying capacity however, any reduction in herd size by slaughtering will tend to increase the fawn crop. This is because there will be more food for each reindeer after the herd is reduced. When deciding which animals to harvest, there are several things besides sex to evaluate:

1) AGE?
2) CASTRATES OR BULL?
3) IF FEMALE, HAS IT RECENTLY HAD A FAWN?
4) HEALTH/ CONDITION?

Which animals are to be slaughtered depends on whether meat production, velvet antler production, or both is the main goal. In Scandinavia where meat production is most important, reindeer herders use the following priorities when

choosing slaughter deer: First slaughter unhealthy deer. Next slaughter the oldest males and females and all steers. Then slaughter barren females that have not produced an offspring in the last two years. Generally, herders avoid slaughtering the largest, healthiest males as they are saved for breeding stock. Females that have had fawns in the last year are never slaughtered. If the herd needs to be reduced, then they reduce the number of males as they eat much more than females without putting on much weight from year to year. They castrate all of the mature males intended for winter slaughter as they remain fat through most of the winter. Bulls are often slaughtered early in the autumn, prior to the rut.

Information on whether the herd is growing or declining as well as information on individual animals is available through the reindeer accounting system. The program can be utilized by requesting the university staff to identify the type of reindeer the herder wants to slaughter, such as females, that have not had a fawn for two years or males older than six years. The university staff will be able to identify those deer, and the herder can put on a slaughter tag before the animal is released. Much effort has gone into developing the reindeer record-keeping system. It can assist in making sound harvest decisions and thereby increase profits.

EXAMPLES OF WHAT CAN HAPPEN

In the examples that follow, a hypothetical herd is managed in four different ways. A different number of animals is slaughtered yearly for each form of management. The herd size projections are based on the following conditions (calculations used for each example are found on pages 11-14):

Assumptions:

- The starting herd is **2000 animals** in 1988
- Maximum herd size for range and management conditions is 5000
- 10% of the adults die due to natural causes each year
- 95% of surviving adult females have a fawn each year
- 15% of those fawns die due to natural causes each year
- 5% of the yearlings die due to natural causes each year
- The average carcass weight is 125 lbs.
- The price of meat is $1.90 per pound and all meat can be marketed

Example 1 (see page 11 for details) : *HERD DECIMATION*

At first, 400 animals are slaughtered each year (100 males, 300 females). Then the annual gross is $95,000 (400 deer x 125 lbs. x $1.90/lb.). Because too many females are slaughtered, the herd declines rapidly and profits decline. Over the 14 years (between 1988 and 2001) the total gross earnings would be $694,213. However, by 1999 there are no reindeer left in the herd.

Example 2 (see page 12 for details): *POPULATION EXPLOSION*

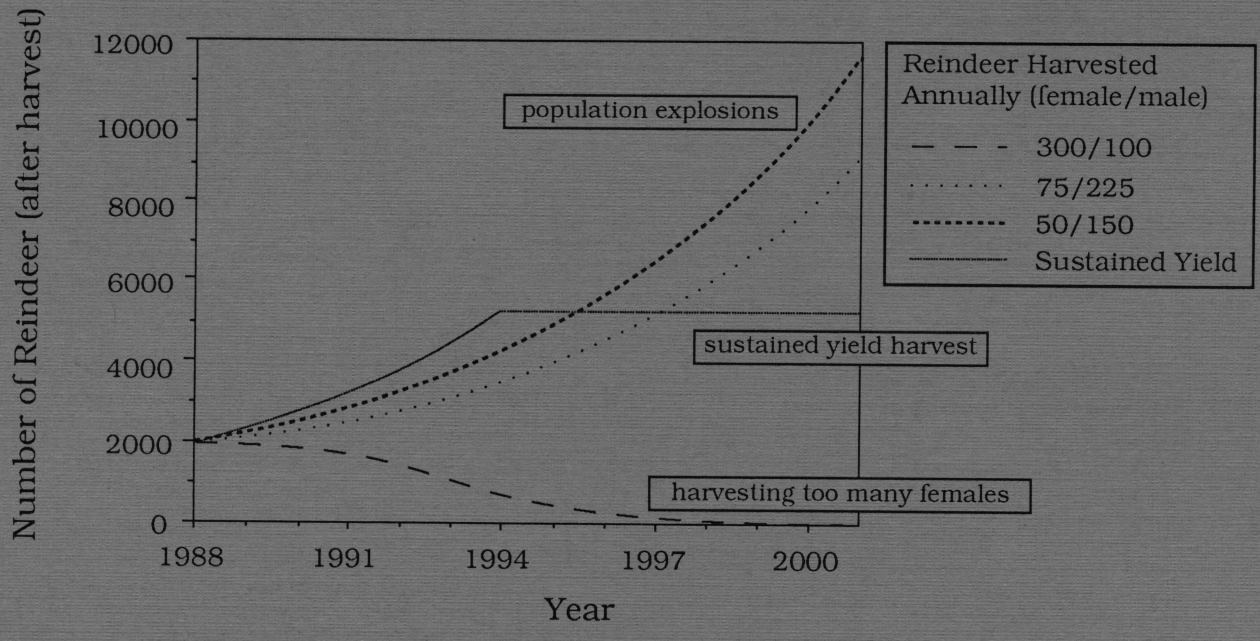
300 animals are slaughtered each year (225 males, 75 females). The annual gross is $71,250 (300 deer x 125 lbs. x $1.90/lb.). Over the 14 years (between 1988 and 2001) the total gross earnings would

be $997,500. However the the herd would increase in size from 2000 to 9140 deer, a population explosion resulting in possible overgrazing and many reindeer would move out of the region.

Example 3 (see page 13 for details): *POPULATION EXPLOSION*
200 animals are slaughtered each year (150 males, 50 females). The annual gross is $47,500 (200 deer x 125 lbs. x $1.90/lb.). Over the 14 years (between 1988 and 2001) the total gross earnings would be $665,000 but the the herd would increase in size from 2000 to 11,562 deer, a population explosion resulting in possible overgrazing and many reindeer would move out of the region.

Example 4 (see page 14 for details): *SUSTAINED YIELD HARVEST:*
100 animals are slaughtered each year until the herd is greater than 5000. (The male/female ratio of animals harvested each year changes depending on how many animals need to be slaughtered and the remaining sex distribution.) Then enough deer are harvested so that about 5000 remain after slaughter each year. The yearly income after the herd reaches 5000 is about $300,000 (1300 deer x 125 lbs. x $1.90/lb.) for meat alone. Over the 14 year period the total projected gross earnings would be $2,430,100. The herd size would remain constant (around 5000) during the 14 years and the range would not be overgrazed.

Projected Herd Changes (1988 to 2001)



CONCLUSIONS

Sustained yield harvest (example 4) would produce by far the greatest gross income for a herd owner in the long run. Costs however would probably increase with the increased harvest. With a sustained yield harvest, herd size would not be allowed to increase to the point where overgrazing would become a problem. The herd would be more easily controlled and it would be less likely to wander off the range. The reindeer would have better chances of surviving a difficult winter.

If, however, consistently too few animals are harvested each year because the herd has grown beyond the manageable size limit, then the herd could begin to grow at a faster rate (example 2 &3). This population explosion would probably end in loss of animals or overgrazing and a crash. In addition to all these problems, the total gross income would be much less than that of a sustained yield harvest plan (example 4). In reality, herds approaching carrying capacity would be far worse off than pictured in the examples. The fawn production would decrease sharply. Winter mortality would increase; disease would become more of a problem. Carcass and antler weights would decrease.

Overharvesting of females (example 1) is a serious problem for some herds in Alaska. The financial gain from harvesting too many females is short term as the herd will yield increasingly less income in the years to come. The long term gross returns from harvesting females is far less than that of the sustained yield. The herd size declines rapidly to the point where there would be no profits after all expenses are paid. If herders are interested in future profits from their herds then care must be taken in selecting slaughter deer.

All the herds on the Seward Peninsula have a great potential to increase profits. The example of sustained yield (example 4) predicted an annual gross income from meat sales alone of more than $300,000. In Scandinavia, there are some well-managed herds that support as many as ten herders with good incomes. One Norwegian herd has 5000 reindeer after winter slaughter and harvests 3000 yearlings annually. The harvest takes five days with mobile slaughter plants and about 30 professional butchers. Seward Peninsula reindeer herds could attain such production with some planning, market development and good management. Additionally, good management will prevent disastrous population crashes like those that plagued former Alaskan and Scandinavian reindeer herders.

In summary, the herd that is the right size for its range produces more meat, decreases the cost of roundups and chances of loosing deer to other herds, and decreases the risk of major losses during difficult winters. By slaughtering the right number of males and females, herders will keep the herd at this right size and keep their profits high. Remember that the range has great value. If it's cared for by not letting the herd get too large, then the range quality will remain high forever, producing meat and antler forever. However once the range is overgrazed, it will probably never again be able to support as large a reindeer herd. The same careful management should be applied to the herd. The female reindeer are the producers, a valuable resource. By slaughtering reproductive females, herders kill future production. The herd will get smaller and smaller until it becomes an expensive hobby rather than a money making proposition.

ACKNOWLEDGEMENTS

We would like to especially thank Jim Dau for his invaluable assistance in the development and editing of this bulletin. We would also like to thank Dr. Terry Boyer, Danny Karmen, Dr. David Klein, Ken Krieg, David Swanson and Dr. Robert White for their careful review of the manuscript and their suggestions. We would also like to sincerely thank the herders that discussed their needs and ideas with us along with the Reindeer Herder's Association for making this all possible. We would like to express our appreciation for economic support to the University of Alaska, Fairbanks and the Jastro-Shields Graduate Research Scholarship fund.

ATTENTION HERD OWNERS:

Assistance in developing a management plan for your herd is available. The University of Alaska Fairbanks' Applied Reindeer Research Project can help you monitor herd health, growth and develop a sustained yield harvest plan. The U.S. Soil Conservation Service can assist you in making utilization checks and in developing a range plan that will best suit your reindeer range.

REFERENCES

Klein, D. 1968. The Introduction, Increase, and Crash of Reindeer on St. Matthew Island. J. Wildl. Mngm. 32(2):350-367.

Klein, D. 1987. Vegetation Recovery Patterns Following Overgrazing by Reindeer on St. Matthew Island. J. Range Mngm. 40(4):336-338.

Krebs, C. J. 1978. Ecology: The Experimental Analysis of Distribution and Abundance. Harper & Row Pub.

Stern, R.O., Arobio, E.L., Naylor, L.L., and W.C. Thomas. 1980. Eskimos, Reindeer and Land. Agricultural Experiment Station, School of Agriculture and Land Resources Management. University of Alaska. Bulletin 59.

Swanson, D. 1988. Personal comment.

Example 1: Herd Decimation
(300 females & 100 males slaughtered annually)

Year	**1988** after winter slaughter	after winter losses	yearlings & fawns mature	95% of females fawn	**1989** after harvest of 300 females &100 males
Adult Females	800	720	910	910	610
Adult Males	400	360	550	550	450
Yearling Females	200	190	170	170	170
Yearling Males	200	190	170	170	170
Fawn Females	200	170		342	342
Fawn Males	200	170		342	342
Total Herd Size	2000				2084
Annual Profits	$95,000				$95,000
Deer Harvested	400				400

Year	**1990**	**1991**	**1992**	**1993**	**1994**
Adult Females	411	346	222	41	0
Adult Males	467	596	647	624	581
Yearling Females	291	222	149	126	81
Yearling Males	291	222	149	126	81
Fawn Females	261	175	148	95	18
Fawn Males	261	175	148	95	18
Total Herd Size	1980	1736	1462	1106	777
Annual Profits	$95,000	$95,000	$95,000	$95,000	$60,800
Deer Harvested	400	400	400	400	256

Year	**1995**	**1996**	**1997**	**1998**	**1999**
Adult Females	0	0	0	0	0
Adult Males	499	364	227	105	0
Yearling Females	15	0	0	0	0
Yearling Males	15	0	0	0	0
Fawn Females	0	0	0	0	0
Fawn Males	0	0	0	0	0
Total Herd Size	529	364	227	105	0
Annual Profits	$23,750	$23,750	$23,750	$23,750	$22,325
Deer Harvested	100	100	100	100	94

Year	**2000**	**2001**
Adult Females	0	0
Adult Males	0	0
Yearling Females	0	0
Yearling Males	0	0
Fawn Females	0	0
Fawn Males	0	0
Total Herd Size	0	0
Annual Profits	$0	$0
Deer Harvested	0	0

Total Profits
1988 to 2001
$748,125

Total Deer Harvested
3150

Example 2: Population Explosion
(75 females & 225 males slaughtered annually)

Year	1988 after winter slaughter	after winter losses	yearlings & fawns mature	95% of females fawn	1989 after harvest of 75 females & 225 males
Adult Females	800	720	910	910	835
Adult Males	400	360	550	550	325
Yearling Females	200	190	170	170	170
Yearling Males	200	190	170	170	170
Fawn Females	200	170		342	342
Fawn Males	200	170		342	342
Total Herd Size	2000				2184
Annual Profits	$71,250				$71,250
Deer Harvested	300				300

Year	1990	1991	1992	1993	1994
Adult Females	838	955	1073	1180	1317
Adult Males	229	257	295	330	401
Yearling Females	291	303	305	347	390
Yearling Males	291	303	305	347	390
Fawn Females	357	358	408	459	504
Fawn Males	357	358	408	459	504
Total Herd Size	2362	2536	2794	3121	3507
Annual Profits	$71,250	$71,250	$71,250	$71,250	$71,250
Deer Harvested	300	300	300	300	300

Year	1995	1996	1997	1998	1999
Adult Females	1481	1665	1878	2126	2413
Adult Males	507	638	804	1010	1259
Yearling Females	429	479	538	605	682
Yearling Males	429	479	538	605	682
Fawn Females	563	633	712	803	909
Fawn Males	563	633	712	803	909
Total Herd Size	3971	4526	5182	5952	6855
Annual Profits	$71,250	$71,250	$71,250	$71,250	$71,250
Deer Harvested	300	300	300	300	300

Year	2000	2001
Adult Females	2745	3130
Adult Males	1556	1909
Yearling Females	773	877
Yearling Males	773	877
Fawn Females	1032	1174
Fawn Males	1032	1174
Total Herd Size	7910	9140
Annual Profits	$71,250	$71,250
Deer Harvested	300	300

Total Profits
1988 to 2001
$997,500

Total Deer Harvested
4200

Example 3: Population Explosion
(50 females & 150 males slaughtered annually)

Year	**1988** after winter slaughter	after winter losses	yearlings & fawns mature	95% of females fawn	**1989** after harvest of 50 females &150 males
Adult Females	800	720	910	910	860
Adult Males	400	360	550	550	400
Yearling Females	200	190	170	170	170
Yearling Males	200	190	170	170	170
Fawn Females	200	170		342	342
Fawn Males	200	170		342	342
Total Herd Size	2000				2284
Annual Profits	$47,500				$47,500
Deer Harvested	200				200

Year	**1990**	**1991**	**1992**	**1993**	**1994**
Adult Females	886	1023	1168	1307	1479
Adult Males	372	461	561	661	798
Yearling Females	291	313	322	372	424
Yearling Males	291	313	322	372	424
Fawn Females	368	379	437	499	559
Fawn Males	368	379	437	499	559
Total Herd Size	2574	2866	3247	3709	4243
Annual Profits	$47,500	$47,500	$47,500	$47,500	$47,500
Deer Harvested	200	200	200	200	200

Year	**1995**	**1996**	**1997**	**1998**	**1999**
Adult Females	1684	1917	2186	2499	2861
Adult Males	971	1175	1418	1708	2049
Yearling Females	475	537	612	697	794
Yearling Males	475	537	612	697	794
Fawn Females	632	720	819	934	1068
Fawn Males	632	720	819	934	1068
Total Herd Size	4870	5607	6467	7469	8634
Annual Profits	$47,500	$47,500	$47,500	$47,500	$47,500
Deer Harvested	200	200	200	200	200

Year	**2000**	**2001**
Adult Females	3279	3764
Adult Males	2448	2916
Yearling Females	908	1039
Yearling Males	908	1039
Fawn Females	1223	1402
Fawn Males	1223	1403
Total Herd Size	9989	11,562
Annual Profits	$47,500	$47,500
Deer Harvested	200	200

Total Profits
1988 to 2001
$665,000

Total Deer Harvested
2800

Example 4: Sustained Yield Management
(after herd size reaches 5000 animals)

Year	1988 after winter slaughter	after winter losses	yearlings & fawns mature	95% of females fawn	1989 after harvest of 0 females &100 males
Adult Females	800	720	910	910	910
Adult Males	400	360	550	550	450
Yearling Females	200	190	170	170	170
Yearling Males	200	190	170	170	170
Fawn Females	200	170		342	342
Fawn Males	200	170		342	342
Total Herd Size	2000				2384
Annual Profits	$23,750				$23,750
Deer Harvested	100				100

Year	1990	1991	1992	1993	1994
Adult Females	981	1159	1357	1560	1804
Adult Males	467	596	751	914	1123
Yearling Females	291	331	356	421	493
Yearling Males	291	331	356	421	493
Fawn Females	389	419	495	580	667
Fawn Males	389	419	495	580	667
Total Herd Size	2807	3255	3811	4476	5246
Annual Profits	$23,750	$23,750	$23,750	$23,750	$23,750
Deer Harvested	100	100	100	100	100

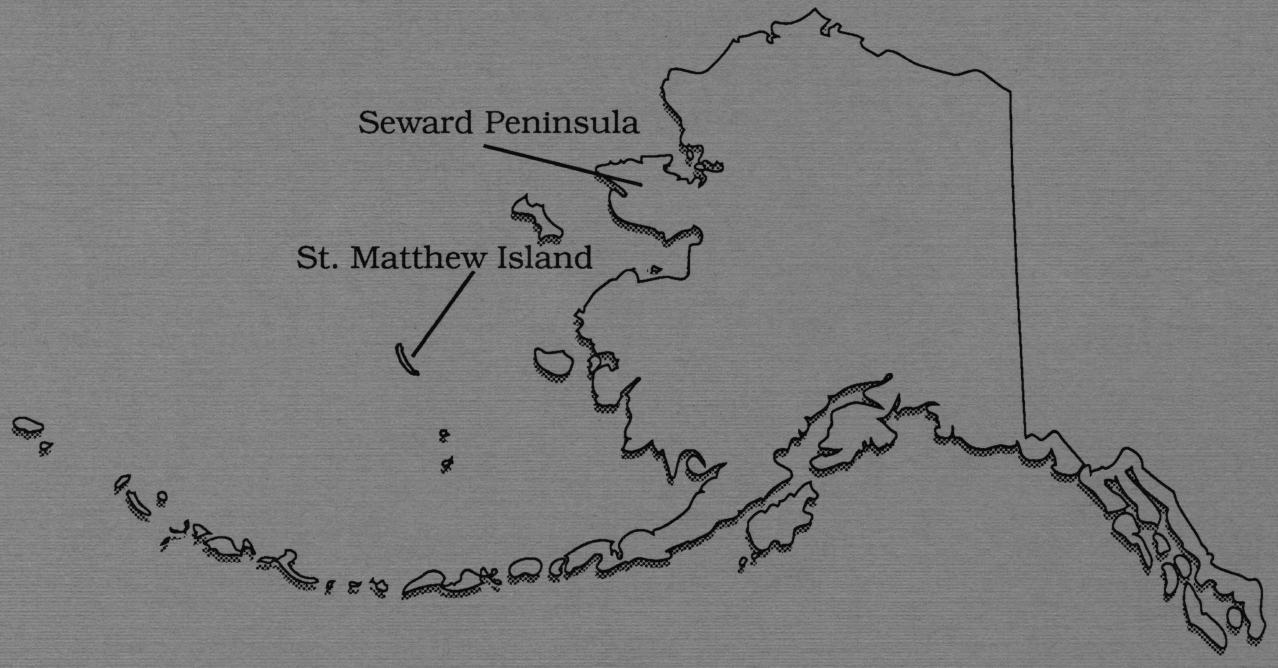
Year	1995	1996	1997	1998	1999
Adult Females	1592	1563	1625	1584	1557
Adult Males	979	1011	1128	1137	1154
Yearling Females	567	655	578	568	590
Yearling Males	567	655	578	568	590
Fawn Females	771	680	668	695	677
Fawn Males	771	680	668	695	677
Total Herd Size	5246	5246	5246	5246	5246
Annual Profits	$343,188	$315,163	$332,738	$327,038	$315,875
Deer Harvested	1445	1327	1401	1377	1330

Year	2000	2001
Adult Females	1563	1552
Adult Males	1201	1226
Yearling Females	576	566
Yearling Males	576	566
Fawn Females	665	668
Fawn Males	665	668
Total Herd Size	5246	5246
Annual Profits	$315,875	$313,975
Deer Harvested	1330	1322

Total Profits
1988 to 2001
$2,430,100

Total Deer Harvested
10232

Map of Alaska



Agricultural and Forestry Experiment Station
School of Agriculture and Land Resources Management
University of Alaska Fairbanks
James V. Drew, Dean and Director