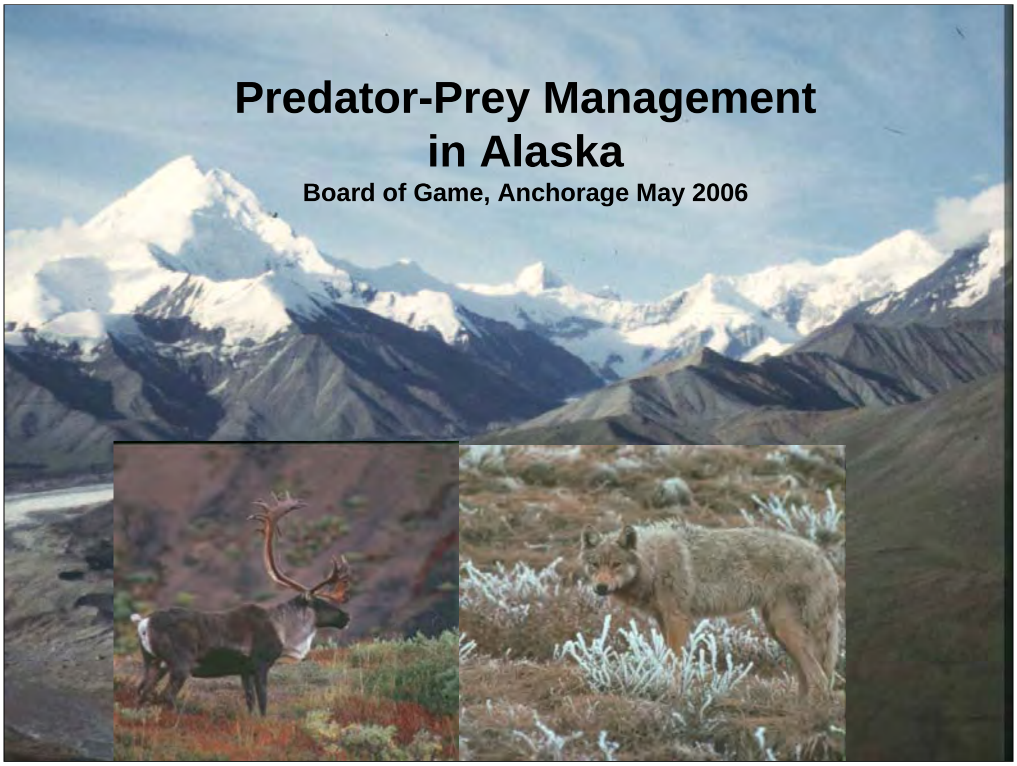


I am going to present an overview of predator-Prey management in Alaska

Purpose of this Presentation

- Present concepts that establish the biological reasoning for predator management in Interior and Southcentral Alaska.
- Identify factors that can influence efficacy of predator control in yielding a response in the prey population.

In this overview I will

Purpose (cont.)

•Present methods commonly used to estimate wolves, bears, moose and caribou.

•Discuss how we assess habitat capability.

•Discuss the magnitude of predator reduction needed to produce an effect.

•Explain how we use our survey information to estimate the harvestable surplus

The Role of Predation in Limiting Moose at Low Densities in Alaska and Yukon and Implications for Conservation
Gasaway et al. 1992

Reviewed data from 35 sites in Alaska and Yukon.

Why do moose remain at low densities relative to carrying capacity in lightly harvested systems?

Probably the most important concept that underlies the biology of predator management in Alaska was researched by Bill Gasaway and other biologists from the Alaska Department of Fish and Game. Their findings were published in an award winning Wildlife Monograph in 1992. The paper was entitled- the role of ….

Low Density Dynamic Equilibrium

(LDDE)
Definition

- The state of a predator-prey system defined for Alaska and Yukon where combined predation by wolves and bears maintain moose populations at low densities for extended periods.
- The condition is a dynamic equilibrium: fluctuations in moose populations occur but densities remain well below that which could be supported by food. (i.e., well below carrying capacity).

The key idea revolves around what they called LDDE or low density dynamic equilibrium. Which is

Conclusions

Gasaway et al. 1992

- Predation by lightly harvested wolf and bear populations appears to limit lightly harvested moose populations at a LDDE for extended periods in much of Alaska and Yukon.
- Of 24 sites examined in Alaska, elevated densities occurred only where humans had previously reduced predators.

Their findings for management were that

Conclusions (cont.)

- Predator management is needed in most cases to attain elevated moose abundance where moose, wolves, and bears are sympatric and moose are the primary prey
- Wolf and bear predation should be reduced simultaneously rather than intense management of one predator species.

In addition, they concluded

And recommended

Moose/Wolf Ratios

Can be a general indicator of potential limitation by wolves, but it does not reflect variability in:

- **Predation rates of wolf population**
- **Age structure of Prey**
- **Vegetation-Moose Relationships**
- **Vulnerability of Moose to Predation**
- **Alternate prey**
- **Presence of Alternate Predators**

However as a general guideline, if moose/wolf <30, wolf predation is often a significant factor preventing moose population growth.

(Gasaway et al. 1983)

One commonly quoted indicator of where a system lies relative to an LDDE state is the moose/wolf ratio. It can……

Carrying Capacity

- The number of animals that can be supported at equilibrium in a steady environment in the absence of time lags, harvest, and predation; nutrition is the primary limiting factor at carrying capacity (McCullough 1979).

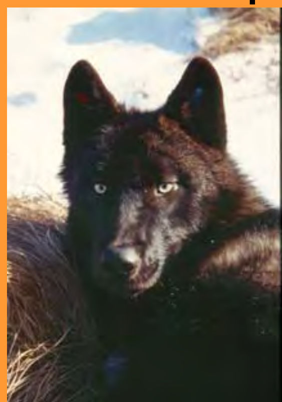
Another concept that is often discussed relative to predator prey relationships is carrying capacity, it is …

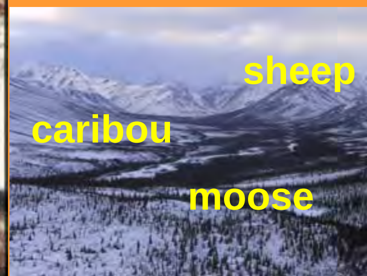
Productivity of moose and caribou decline as populations approach carrying capacity. Indicators of resource limitation include:

- **Twinning Rate**
- **Browse removal rates for moose; and**
- **Age at first reproduction-**
- **Weights of late winter calves**
- **Pregnancy (moose &caribou)**
- **(Valkenburg et al. 1996; Boertje et al. 2006 [in press] [review of 15 populations in Alaska]); Seaton et al., in prep)**

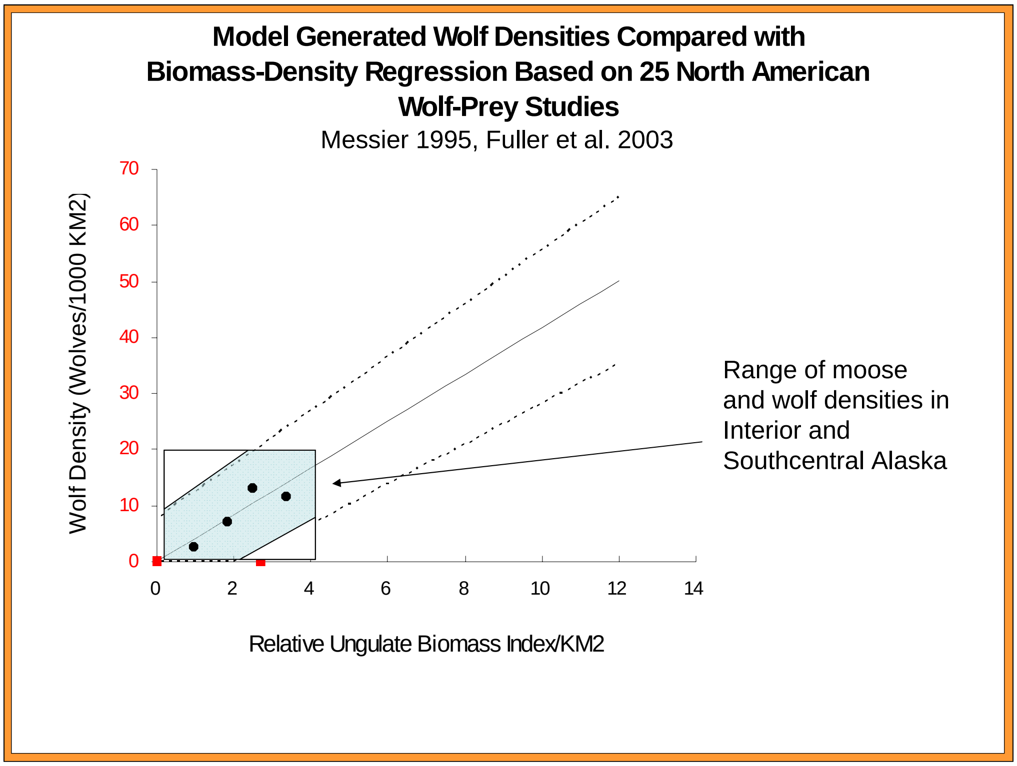
Although carrying capacity is something that can't be precisely measured, it is a useful concept because it is clear that as ungulate numbers increase beyond a certain point, their productivity declines and eventually population declines will result from nutritional limitation. The Department of Fish and Game has conducted considerable research on nutritional limitation in moose and caribou and we have found indicators of resource limitation including:

Carrying Capacity Applies to Both Predators and Prey





In terms of wolves, carrying capacity is determined by the abundance of prey. In many areas of interior and southcentral Alaska there are multiple prey occupying different habitat types, all of which are used by wolves.



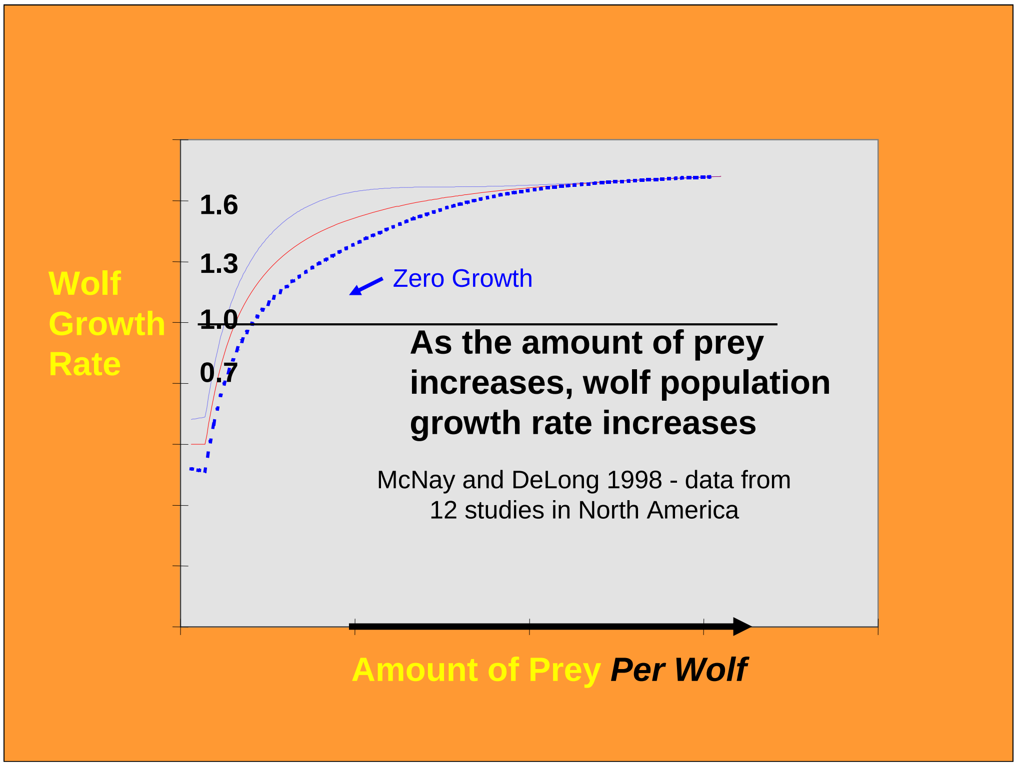
A review of most predator prey studies throughout North America reveals that you can closely judge the number of wolves that are likely to be in a system, based upon the number of ungulate prey.

The regression line and 90% confidence limits depicted here, describe this relationship. Its very simple, more wolves naturally exist in areas with more prey. Examples of ranges of wolf densities include Southeast Alaska 30, Minnesota and central Canada 40, Yellowstone where prey is extremely abundant wolves have reached densities in excess of 100/100km2.

The range of naturaly wolf densities in interior, southeast, and arctic Alaska is less than 20 wolves /1000km2.

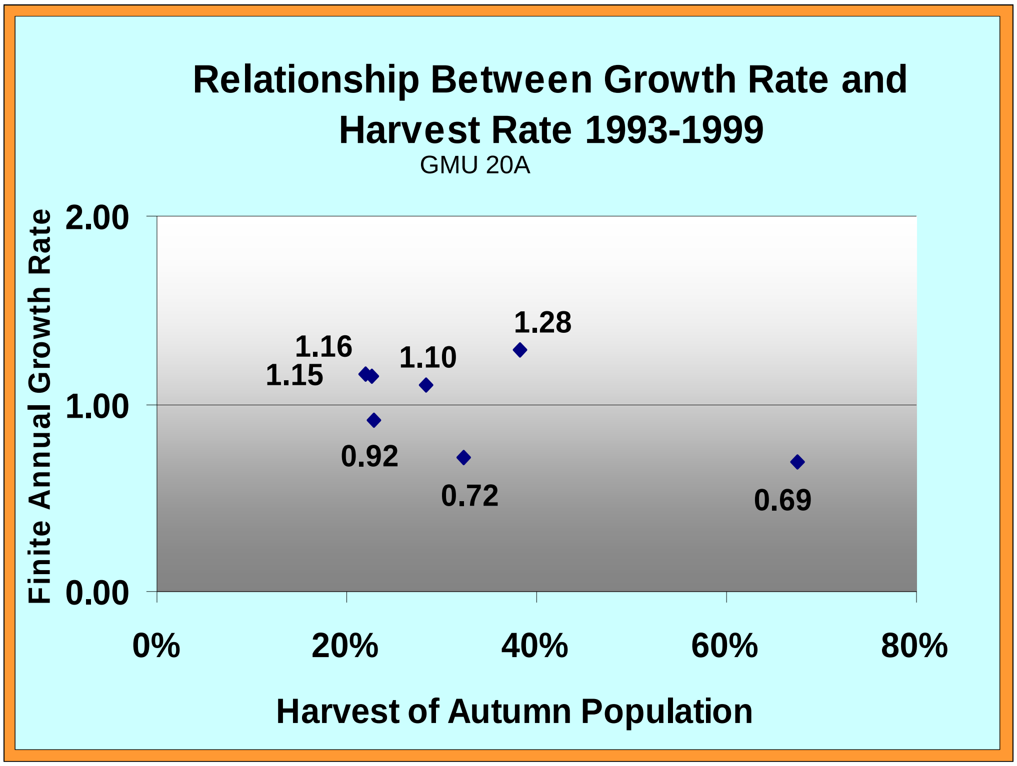
Wolf-Prey systems in interior and southcentral Alaska are found in this area of the curve. Wolf densities of 20 wolves per 1000 km2 are considered high.   If wolves are reduced they will tend to return to the density described by this regression line.

Reducing wolves increases the potential growth rate of the wolf population



I used data from 12 different studies in North America to define this relationship. This describes why the numerical response of wolf populations is so rapid following wolf control. When food is scarce wolf populations will decline based on resource limitation alone (the horizontal line represents zero growth, below the line is a population decline, above it is population growth

However as the amount of food available per wolf increases, the growth rate of the population increases. Therefore if wolves are reduced, and prey increases, the potential for wolf population growth increases. A population with a normal annual growth potential of about 25%, would have an annual growth potential of 60% of the amount of food per wolf was increased. That is what happens when wolves are reduced, held at low levels with wolf control, and prey numbers increase. Wolf control invokes this potential explosive growth.



As a result, it is common to see different responses of wolf populations to similar levels of exploitation under different situations of prey availability. In this graph the horizontal line represents zero growth a declining population below the line, and increasing above the line.

From a stable pre control population of GMU 20A, the population declined during 2 years of wolf control 1993 &1994 when harvest rates were about 70% and 37%

Then because the amount of prey per wolf was high the wolf population responded and grew rapidly. In one year the population grew 28% in despite a harvest of 40%. In 3 other years the population grew by 10-16% despite annual harvests of greater than 20%.

That is why substantial reductions in wolf populations of about 70-80% of precontrol wolf numbers are recommended in studies or reviews of wolf-prey systems.

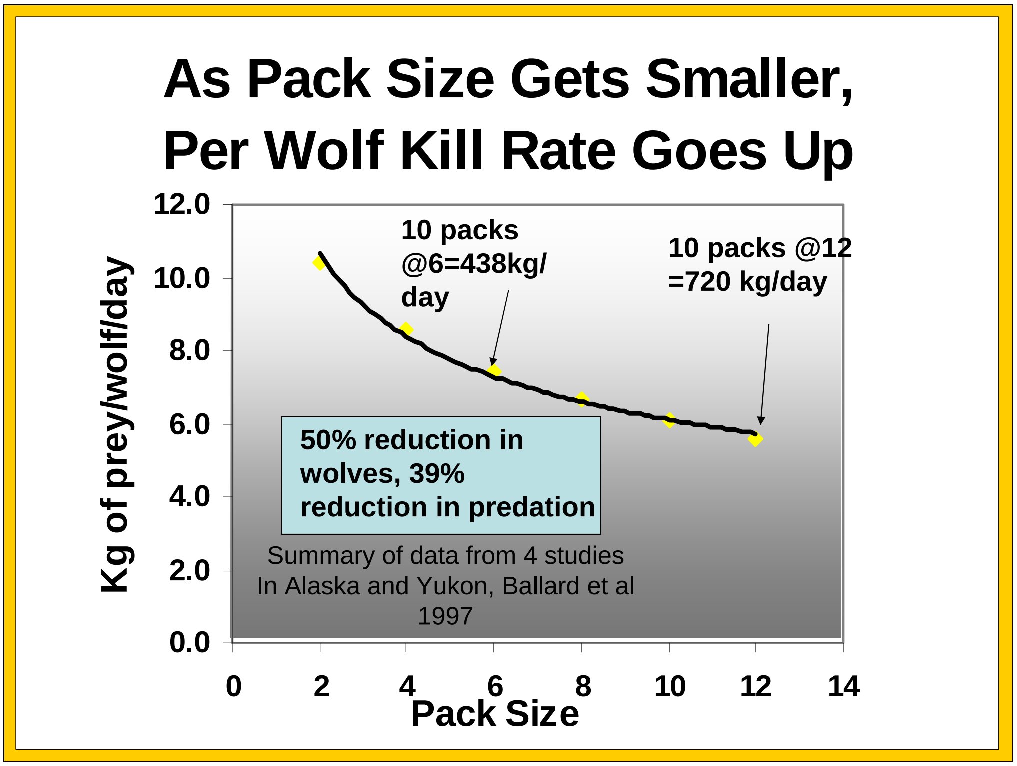
When food is Abundant, Wolves' Numerical Response is Rapid

- **Response is via both reproduction and immigration.**
- **In Unit 20A following wolf control in 1993-94, 20-40% removal of the wolf population during 3 winters resulted in a 15-28% increase in the number of wolves the following autumn.**

The rapid numerical response occurs as a result of both reproduction and immigration

In Addition to a Rapid Numerical Response, Wolves can Exhibit a Pronounced Functional Response when the Population is Reduced

Functional response refers to the per wolf kill rate or consumption rate,



The functional response kicks in when wolf numbers are reduced, but the number of packs is not reduced. Wolf packs are the predator unit, but we often refer to reductions in wolf numbers. This graph shows why efficacy of predator control is more linked to wolf packs.

When wolf packs are reduced in size, the efficiency of their use of large prey such as moose declines. If a small pack kills a moose, they cannot totally consume it before scavengers eat large portions of it. So they kill another moose. As a result, wolf control that reduces pack size, but does not eliminate entire packs is less effective at reducing predation.

For example, a 50% reduction in wolf numbers will rarely if ever result in a 50% reduction in predation rate. For example take 10 packs each of 12 wolves at 6 kg /wf/day= 720 kg/day,

with 50% reduction in wolves, pack size of 6 they kill 7.3kg /wf/day = 430 kg/day a reduction of 39% in kill rate despite 50% reduction in wolves.

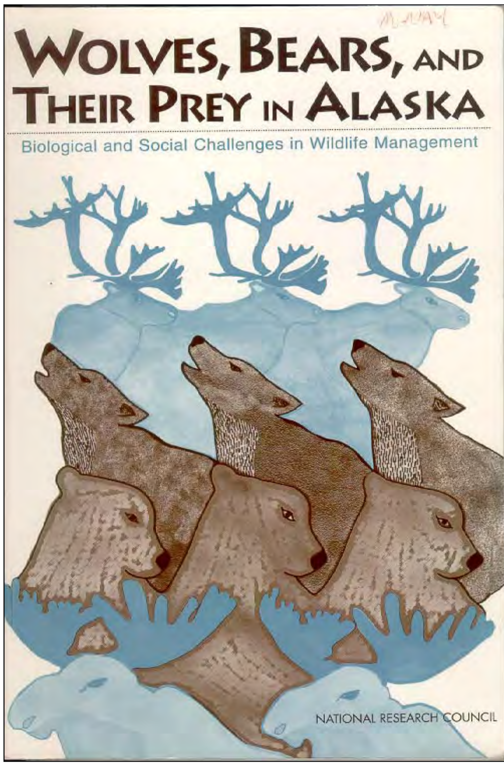
Therefore because of the rapid numerical response, and because of the non linear functional response, it requires a substantial and long term commitment to increase prey numbers with wolf control alone.

Predator Control may not result in either Increased Prey Numbers or an Increase in the Harvestable Surplus of Prey if:

- The duration and degree of predator reduction is inadequate to allow a persistent increase in recruitment and survival of prey .
- The habitat is inadequate to support higher numbers of prey.
- Multiple predators exist, but only one is controlled
- Hunting causes sufficient mortality to preclude an increase in the prey population

(Gasaway et al. 1992, NRC 1997, Bertram and Vivion 2002, Valkenburg 2004)

The National Research Council of the National Academy of Sciences reviewed some wolf control programs that were not successful, Predator control …



1997 National Research Council Study Reviewed 11 Wolf Control Programs in North America

Wolves and bears in combination can limit prey populations

Found examples where predator control did not result in increased numbers of prey or harvest of prey.

If predator control is used, must be both intensive and frequent. There is no factual basis for assumption that a period of intensive control for a few years can result in long-term changes in ungulate population densities.

Before conducting predator program should evaluate the status of the predator and prey populations, and the carrying capacity of the habitat

The NRC review concluded that:

Rates of Wolf Removal where an Increase in Prey was Documented

	Removal rate	Time period	Bear population
• 20A-	41-79%;	6 years	not controlled
• Finlayson-	49-87%;	6 years	not controlled
• N. BC-	72-89%;	3 years	not controlled
• Aishihik-	69-83%;	6 years	not controlled

(National Research Council 1997, Hayes et al. 2003)

The NRC review found 4 studies where wolf reduction resulted in increased ungulate numbers, in each of these studies bears were not controlled, but in at least the 20A study bears were considered to exist at low densities.

High Bear Predation Rates Found in Most Studies of Radiocollared Moose and Caribou Calves in Alaska and Yukon.

However, High bear predation rates **are** found in most studies of radiocollared moose and caribou calves in Alaska and Yukon

Bears (black and grizzly) Killed 40%-63% of Calves Produced

	Bear	Wolf
Gasaway et al. 1992(grizzly)	55%	12-15%
Larsen et al. 1989 (“ “)	63%	25%
Ballard et al. 1991 (“ “)	46%	2%
Osborne et al. 1991 (black)	43%	9%
Bertram and Vivion 2002 (“ “)	40%	1%
Keech et al. 2005 (“ “)	42%	17%

In most studies bears are the most significant predator on calves.

Levels of bear reduction necessary to reduce calf mortality

- Unit 13: 60% 1-year reduction in bears, 78% reduction in calf mortality birth to November (Ballard and Miller 1990, 1979 study)
- Unit 19D: 2 year 60-80% removal; 55% reduction in calf mortality to November (2004, 2005)
- Lochsa elk (Idaho): 75 bears removed (125 mi^2), 50% reduction in calf mortality to late winter (Schlegel 1986)

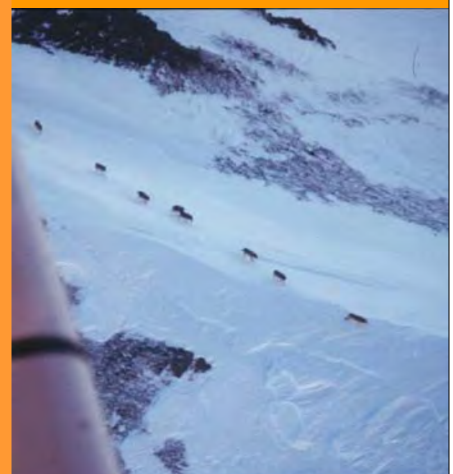
The question then arises regarding the level of bear reduction necessary to reduce calf mortality.

As with wolves, we believe the composition of the harvest of bears is important in determing the effectiveness of bear removal in creating a decline in population size. Programs that remove a large proportion of female bears are more likely to effective than those that do not.

Response of Wolves to Reduction

- Increase growth rate and rapid recovery

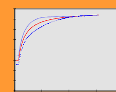
In studies reviewed by National Research Council, wolf populations rebounded to 88-112% of precontrol populations size within 3-5 years after wolf control ended.



The response of wolf populations following wolf control is rapid

Response of Wolves to Reduction (cont)

- Review of 12 Studies of Wolf Population Growth Showed Higher Rates when Ungulate Biomass per Wolf was High (McNay and DeLong 1998)



- “No available data suggests that the killing of wolves by humans has adversely affected the long-term social organization, reproductive rates, or population dynamics of the species.” (NRC 1997).

As I pointed out earlier, that is because the growth rate of wolf populations is higher when the amount of prey per wolf is high.

There have been concerns expressed about long term effects on wolf social structure or population viability. The NRC addressed that question with the response that ,

Response of Bears to Reduction

- Currently we are conducting a study in Unit 19D East to document repopulation of the Experimental Micro Management area, by black bears.
- If bears are moved rather than destroyed many will return, unless they are moved several hundred miles. In the Unit 13 study (Ballard and Miller 1990), 60% of the brown bears translocated in the spring had returned by autumn.

Response of Bears to Reduction (cont.)

- Reproductive rates and immigration rates of bears are low, therefore killing bears rather than translocating could result in more efficient control because controlled reductions last longer.

Predator Control Alternatives

- **The following methods have been shown to be effective in at least temporarily reducing predation on moose and/or caribou:**

Sterilization of wolves accompanied by relocation of wolves (Hayes et al, 2003)

Diversionary feeding of wolves and bears (Boertje et al. 1987)

Relocation of bears (Stewart et al. 1985, Crete and Jolicouer 1987, Ballard and Miller 1990, Keech et al. 2005)

Advantages and Disadvantages of Alternative methods

All are labor intensive and costly, requiring government personnel to conduct the alternative method.

All of the methods at least initially are nonlethal, but translocation of animals may result in higher mortality rates than if animals were not moved or dispersed naturally.

Diversionary feeding is very short term, any reduction in predation ceases immediately upon cessation of feeding.

Diversionary feeding could contribute to increased net productivity of the predator species.

Sterilization, difficult to implement, may require translocation sites for subordinate pack members, and requires maintenance of the population in a sterilized state, therefore may require closure of hunting and trapping.

Population
Estimation
Methods

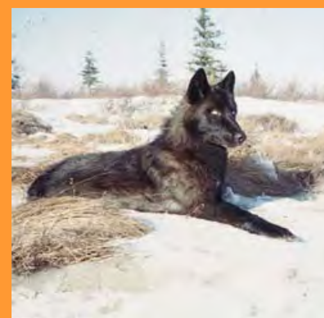
Caribou:
Photo Census
Composition surveys

Moose:

Stratified random sampling (Gasaway et al. 1986)
Repeated Count Areas (Unit 13)
Complete counts- in McGrath Emma
Geospatial Population estimator (Ver Hoef 2000; Kellie and DeLong, in prep)

Wolves

- **Reconnaissance surveys (Stephenson 1975, Ballard et al. 1995)**
- **TIP survey (Becker 1991, Ballard et al. 1995)**
- **SUPE Survey (Becker et al. 1998)**
- **Combination of reconnaissance survey, trapper reports, harvests, and wolf control activities.**



In combination with reconnaissance and other surveys we also use information from trapper and pilot reports, harvest, and wolf control activities.

Bear Population Estimation

- **Radiotelemetry with replicated mark-resight techniques-** **(Miller et al. 1997)**
- **Transect survey with double-count data. (Becker and Quang, in prep)**
- **DNA mark-recapture using hair traps (Boulanger et al. 2002)**
- **Radiotelemetry monitoring of grizzly populations (Boertje et al. 1987)**
- **Total removal experiments- McGrath (Ballard and Miller 1991, Keech et al. 2005)**

Other Methods

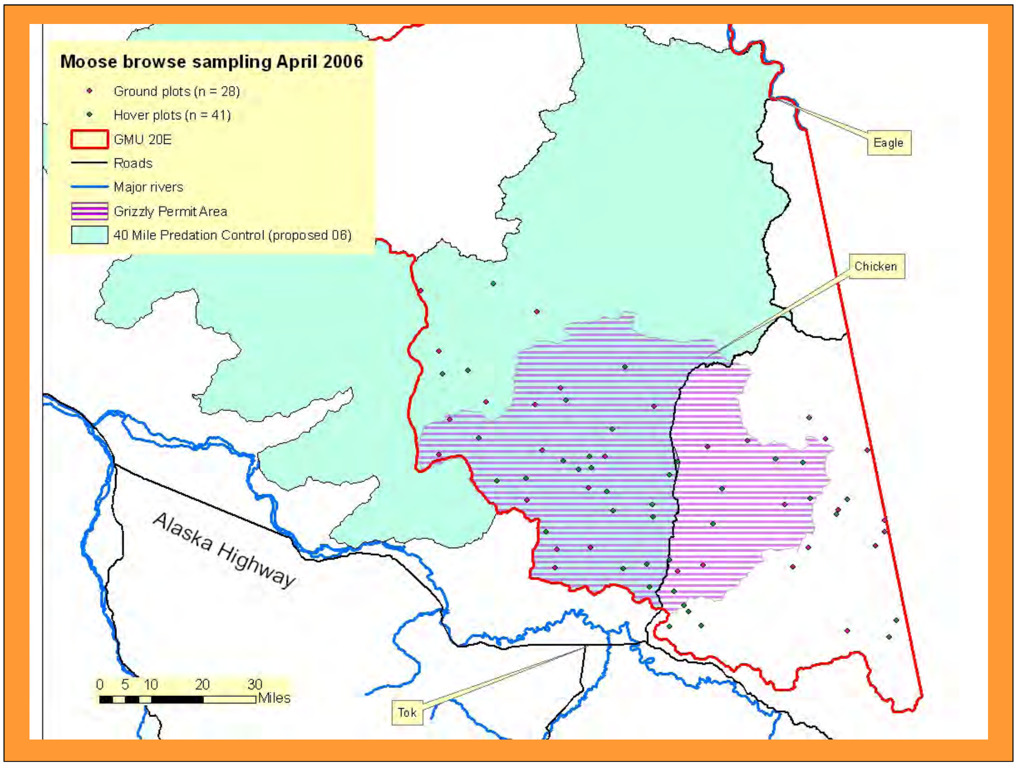
- Extrapolation of prey or predator populations from surveys done in nearby areas with similar habitat.

- Extrapolations are necessary because cost precludes surveys in all areas an annual basis.

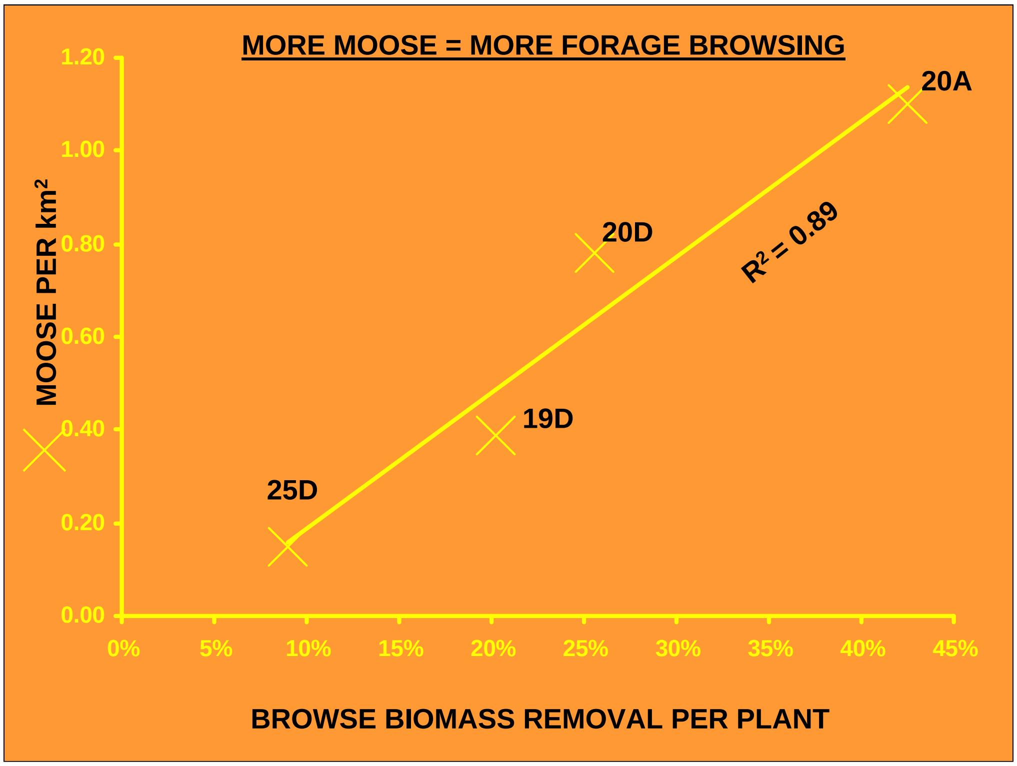
- Extrapolations are often considered interim estimates until more standardized methods can be applied.

Evaluating Habitat Capability

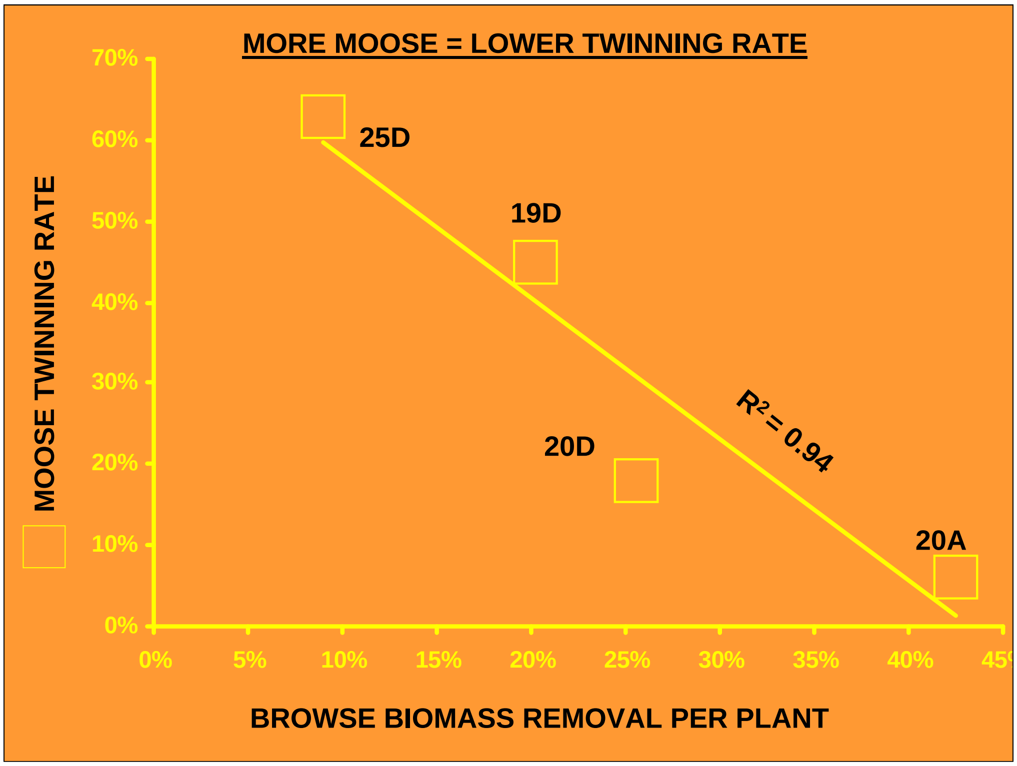
During the last few years we have increased our efforts on habitat work. We have done systematic surveys to identify browse utilization and abundance. The purpose of this work is to develop an index to relative habitat potential for moose in areas where intensive management is being considered.



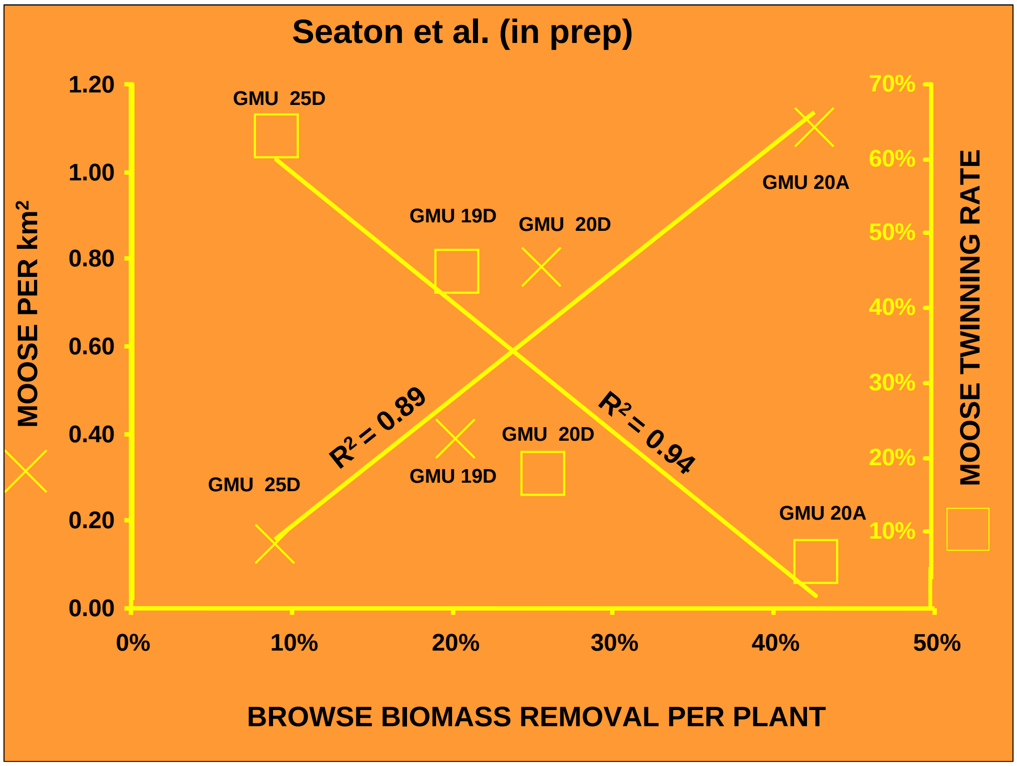
To date we have sample browse production and utilization by moose in 7 subunits. This past spring we sample in 20E, 21E, and 19A. We plan to continue that sampling completing about subunits a year. This slide gives you an idea of the dispersion of our sampling in GMU 20E surrounding the Brown Bear Control Area. Each dot represents a site where we selected a ground sampling plot



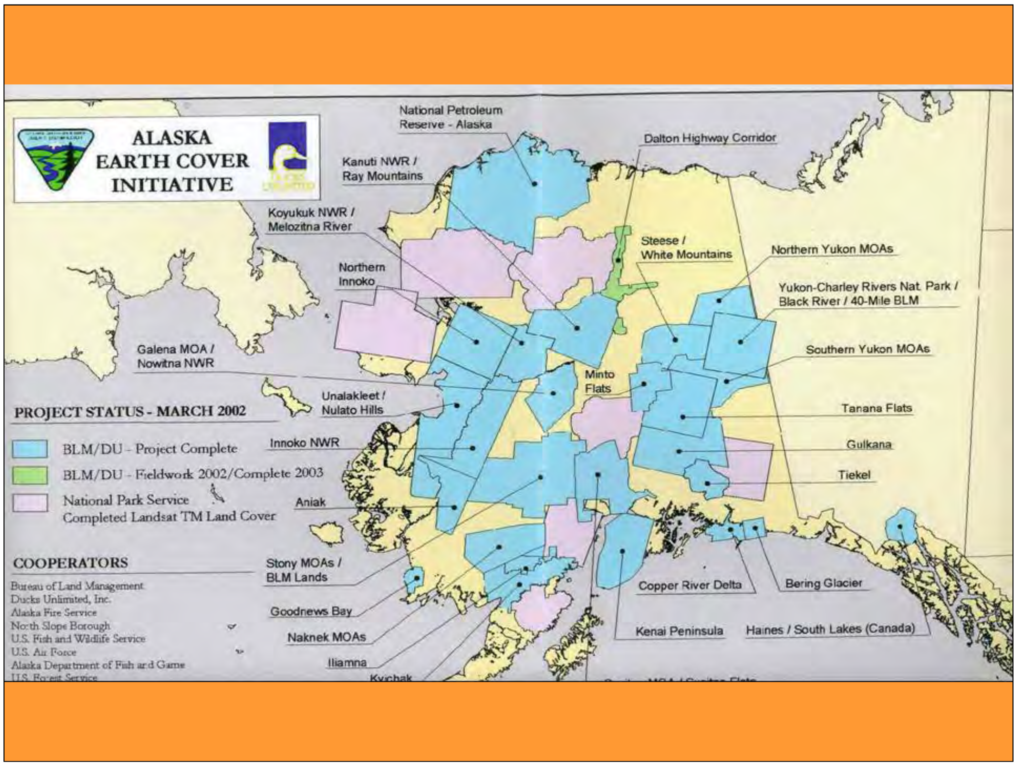
Here is an example of the results from sample plots. This data is from the Master's thesis of Tom Seaton, he also has a publication in preparation. Here sampling was completed in 4 subunits, where density of moose is high, our measure of browse biomass was high. We would expect that relationship to also show in nuturitional condition of moose



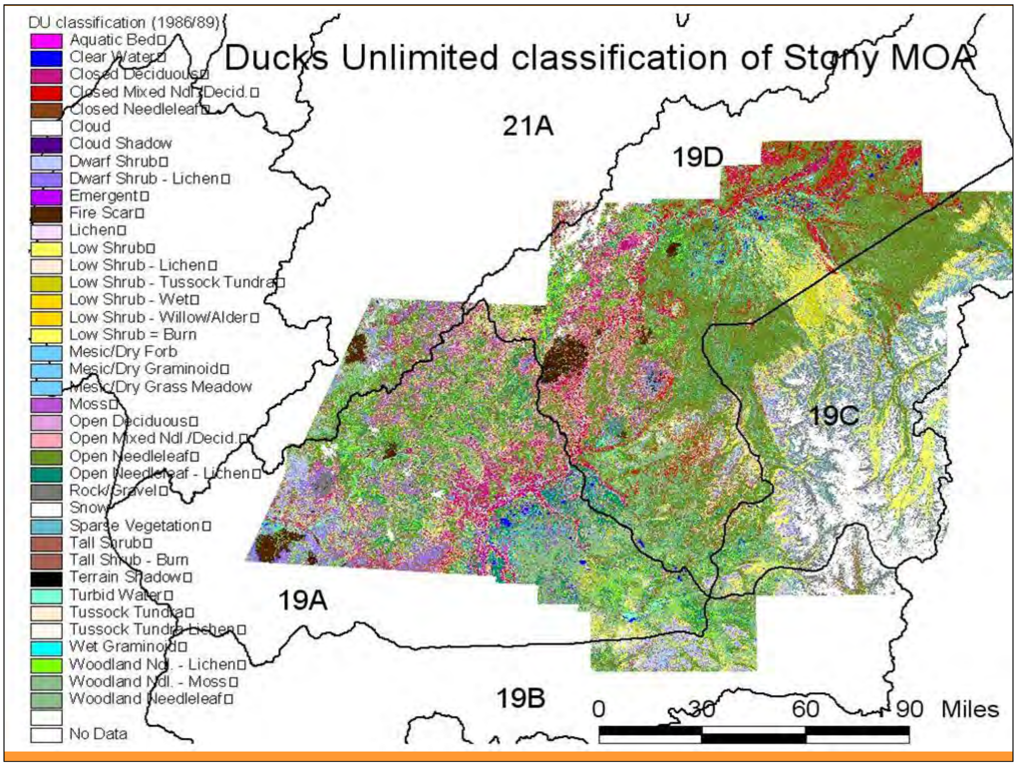
When we compare browse removal with twinning rates we see the exptected result, where browse is heavily used, twinning rates are low. Therefore browsing and twinning rates are good indicators of the potential for a given habitat to support more moose.



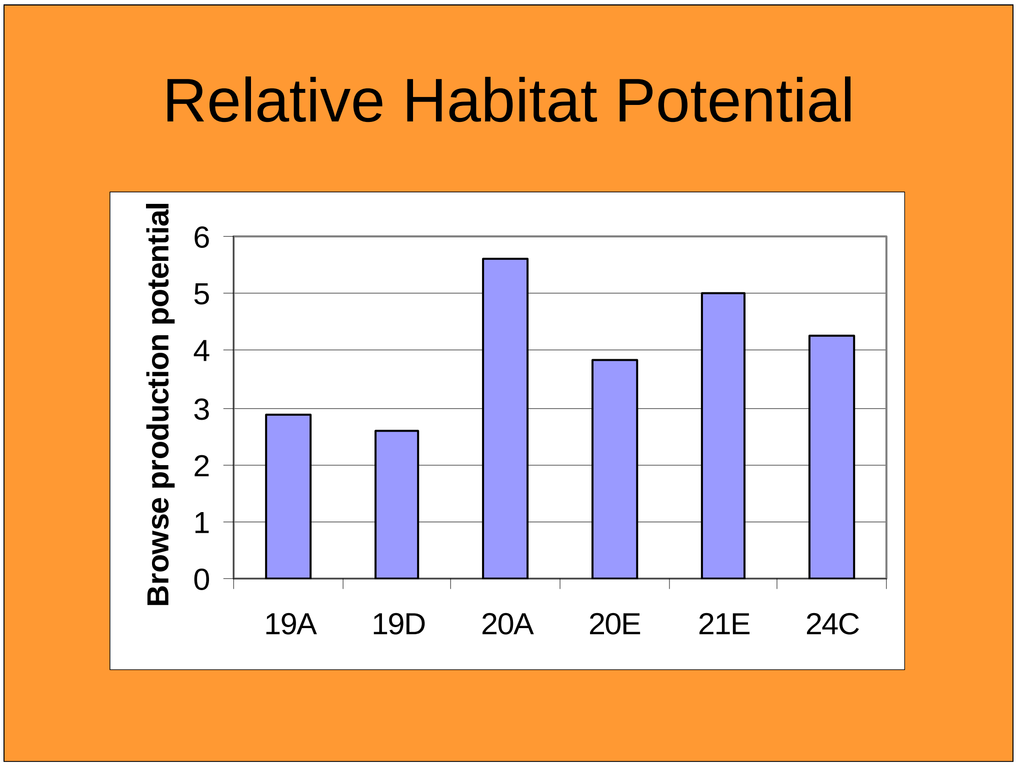
The graph combines the indicators. We are expanding this work and will in the next few years develop an index for Relative Habitat Potential several more subunits. Measurements were taken in units 19A, 20E, and 21E this year, and 3 more units will be measured next year.



We are also using satellite imagery to develop indices of habitat capability. Satellite imagery is currently available for a good portion of the state. This slide shows areas covered by satellite photos were vegetation classifications have been made as part of a cooperative project between the BlM and Ducks Unlimited.



vegetation classifications are depicted on those images within each of thousands of 30m pixels.



Tom Paragi our habitat biologist in Fairbanks, used the satellite imagery to calculate the proportion of good quality habitat in a given area, and also looked at the burn history in good and poor habitat types. He calculated a weighted index for Habitat Potential. We will compare the data collected from the field this year and in past years to evaluate this index to habitat quality.

This graph shows that in units 19A and 19D, the unitwide proportion of moose habitat is lower than in the other measured units. However, our ground sampling showed that the habitat that is available is not being fully utilized. Therefore, those units do not have the potential to produce the number of moose that can be produced in say for example GMU 20A, they do have the potential to produce more moose for harvest by the people who hunt in units 19A and 19D.

Harvestable Surplus

Estimating harvestable surplus of ungulates for hunting is an important part of the management process. Although allocation of the harvestable surplus is the responsibility of the board of game and based on differing public values , determining the biological yield from a population is an objective process.

Modeling- (Gasaway et al. 1992, McNay and DeLong 1998)

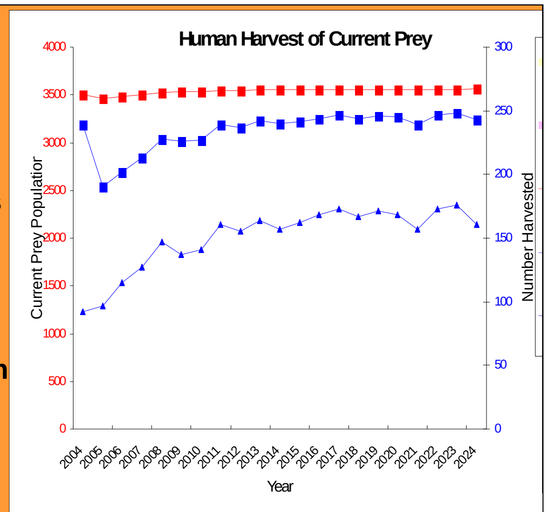
•Enter population size and composition data from surveys

•Enter estimates of predator populations and kill rates

•Enter objectives for population growth and bull:cow ratios

•Review outputs relative to recent harvests and trends in population size and composition

•Recommend seasons and bag limits to achieve desired harvest



❖Annually adjust estimates of harvestable surplus based on observed trends in populations size and population composition.

We often use modeling as an aid to developing estimates of harvestable surplus. It is basically an accounting exercise where we use estimates of population values from our surveys and calculate how many animals are born, how many die, and how many need to be carried forward to meet population objectives. WE have mathematical calculators, or prepared models that make the work less cumbersome and more consistent. To operate those models the biologist enters:

For those values that are not measure biologists sometimes extapolate from other studies, for example kill rates of neonates by various predators.

Literature Cited

Ballard WB, LA Ayres, PR Krausman, DJ Reed, and SG Fancy. 1997. Ecology of wolves in relation to a migratory caribou herd in Northwest Alaska. Wildlife Monographs 135:1–47.

Ballard WB, ME McNay, CL Gardner, and DJ Reed. 1995. Use of line-intercept track sampling for estimating wolf densities. Pages 469–480 *in* LN Carbyn, SH Fritts, and DR Seip, editors. Ecology and conservation of wolves in a changing world. Canadian Circumpolar Institute, Occasional Publication 35.

Ballard WB and SM Miller. 1990. Effects of reducing brown bear density on moose calf survival in Southcentral Alaska. Alces 26:9–13.

Ballard WB, JS Whitman, and CL Gardner. 1987. Ecology of an exploited wolf population in South-central Alaska. Wildlife Monographs 98:1–54.

Ballard WB, JS Whitman, and DJ Reed. 1991. Population dynamics of moose in South-central Alaska. Wildlife Monograph 114:1–49.

Becker EF. 1991. A terrestrial furbearer estimator based on probability sampling. Journal of Wildlife Management 55:730–737.

Becker EF and PX Quang. In prep. Aerial surveys using contour transects, with double count and covariate data.

Becker EF, MA Spindler, and TO Osborne. 1998. A population estimator based on network sampling of tracks in the snow. Journal of Wildlife Management 62(3):968–977.

Bertram MR and MT Vivion. 2002. Moose mortality in eastern Interior Alaska. Journal of Wildlife Management 66:747–756.

Boertje RD, WC Gasaway, DV Grangaard, and DG Kelleyhouse. 1987. Predation on moose and caribou by radio-collared grizzly bears in east central Alaska. Canadian Journal of Zoology 66:2492–2499.

Boertje RD, KA Kellie, CT Seaton, MA Keech, DD Young, BW Dale, and LG Adams. In press. Resource limitation in Alaska moose populations and management implications. Journal of Wildlife Management.

Boertje RD, P Valkenburg, and ME McNay. 1996. Increases in moose, caribou, and wolves following wolf control in Alaska. Journal of Wildlife Management 60(3):474–489.

Boulanger J, GC White, BN McLellan, JG Woods, MF Proctor, and S Himmer. 2002. A meta-analysis of grizzly bear DNA mark–recapture projects in British Columbia. Ursus 13:137–152.

Crete M and H Jolicouer. 1987. Impact of wolf and black bear removal on cow:calf ratio and moose density in southwestern Quebec. Alces 23:61–87.

Fuller TK, LD Mech, JF Cochrane. 2003. Wolf population dynamics. Pages 161–191 *in* LD Mech and L Boitani, editors. Wolves, behavior, ecology, and conservation. University of Chicago Press, Chicago, Illinois, USA.

Gasaway WC, RD Boerjte, DV Grangaard, DG Kelleyhouse, RO Stephenson, and DG Larsen. 1992. The role of predation in limiting moose at low densities in Alaska and Yukon and implications for conservation. Wildlife Monographs 120:1–59.

Gasaway WC, SD DuBois, DJ Reed, and SJ Harbo. 1986. Estimating moose population parameters from aerial surveys. Biological Paper 22, University of Alaska Fairbanks.

Gasaway WC, RO Stephenson, JL Davis, PEK Shepherd, and OE Burris. 1983. Interrelationships of wolves, prey, and man in Interior Alaska. Wildlife Monographs 84:1–50.

Hayes RD, R Farnell, RMP Ward, J Carey, M Dehn, GW Kuzyk, AM Baer, CL Gardner. and M O'Donoghue. 2003. Experimental reduction of wolves in the Yukon: ungulate responses and management implications. Wildlife Monographs 152:1–35.

Literature Cited (cont'd)

Keech MA, RT Bowyer, JM Ver Hoef, RD Boertje, BW Dale, and TR Stephenson. 2000. Life-history consequences of maternal condition in Alaskan moose. Journal of Wildlife Management 64:450–462.

Keech MA, P Valkenburg, TA Boudreau, and K Beckmen. 2005. Factors limiting moose at low density in Unit 19D East, and response of moose to wolf control. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Research Final Performance Report. Grants W-27-5 and W-33-1 through W-33-3. Project 1.58. Juneau, Alaska, USA. <http://www.wildlife.alaska.gov/index.cfm?adfg=pubs.report> Accessed 27 Apr 2006.

Kellie KA and RA DeLong. In prep. GeoSpatial survey operations manual. Alaska Department of Fish and Game. Fairbanks, Alaska, USA.

Larsen DG, DA Gauthier, and RL Markel. 1989. Causes and rate of moose mortality in the southwest Yukon. Journal of Wildlife Management 53:548–557.

McCullough DR. 1979. The George Reserve deer herd: population ecology of a K-selected species. University of Michigan, Ann Arbor, Michigan, USA.

McNay ME and RA DeLong. 1998. Development and testing of general predator–prey computer model for use in making management decisions. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Research final report. Grants W-24-1 and W-24-5. Study 1.46. Juneau, Alaska, USA.

Messier F. 1995. On the functional and numerical responses of wolves to changing prey densities. Pages 187–197 *in* LN Carbyn, SH Fritts, and D Seip, editors. Ecology and conservation of wolves in a changing world. Canadian Circumpolar Institute, Occasional Publication 35.

Miller SD, GC White, RA Sellers, HV Reynolds, JW Schoen, K Titus, VG Barnes, Jr, RB Smith, RR Nelson, WB Ballard, and CC Schwartz. 1997. Brown and black bear density estimation in Alaska using radiotelemetry and replicated mark–resight techniques. Wildlife Monographs 133:1–55.

National Research Council. 1997. Wolves, bears, and their prey in Alaska. National Academy Press, Washington, D.C., USA.

Osborne TO, TF Paragi, JL Bodkin, AJ Loranger, and WN Johnson. 1991. Extent, cause, and timing of moose calf mortality in western interior Alaska. Alces 27:24–30.

Schlegel M. 1986. Movements and population dynamics of the Lochsa elk herd. Study 1, Job 3. Factors affecting calf elk survival in the Lochsa elk herd. Federal Aid in Wildlife Restoration, Job Completion Report, Project W-160-R. Idaho Department of Fish and Game, Boise, Idaho, USA.

Seaton CT, RD Boertje, TF Paragi, CL Fleener, SD DuBois, and DB Griffith. In prep. Relationships between removal of browse biomass and moose productivity and density.

Stephenson RO. 1975. Wolf report. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Research progress and final report. Projects W-17-7, Job 14.3R (2nd half) and W-17-3 through W-17-7, Jobs 14.4R and 14.5R. Juneau, Alaska, USA.

Stewart RR, EH Kowal, R Beaulieu, and TW Rock. 1985. The impact of black bear removal on moose calf survival in east-central Saskatchewan. Alces 21:403–418.

Valkenburg P, ME McNay, and BW Dale. 2004. Calf mortality and population growth in the Delta caribou herd after wolf control. Wildlife Society Bulletin 32:746–756.

Ver Hoef JM. 2000. Predicting finite populations from spatially correlated data. Proceedings on statistics and the environment of the American Statistical Association. pp. 93–98.