The Case Against Wolf and Bear Control In Alaska

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March 2006

Abstract

The existing data do not support allegations of moose and moose-hunting problems in five large areas of Alaska where wolf-bear control is underway. The moose estimates are not good enough to establish current numbers and trends across any of the control areas or for interpreting otherwise ambiguous calf ratios and related recruitment indices. Moose harvest data from at least two of the control areas indicate good hunter success, relative to success in the state's best moose-hunting area in one case and to success during an earlier period of peak moose densities in the other. Wolf and bear estimates are of even lower quality than the moose estimates. They cannot ensure the specified percent reductions or minimum populations and together with the poor moose estimates make it next to impossible to evaluate the efficacy of the control actions.

There is no reliable evidence for a current low stable-state "predator pit" condition – the only condition that might necessitate predator control to provide sustainable moose yields – in any of the five areas. Claims about current low stable states are based on selective use of kill rates, moose-to-wolf ratios, calf ratios in the absence of adequate density estimates, and other discredited "indices" with long histories of providing misleading results. The control programs also assume that predator pit thresholds occur at fixed densities and that more moose means higher sustainable yields almost right up to habitat limits.

The sustained yield management requirements of the Alaska Constitution would be better served by switching the proximate emphasis in the five control areas and elsewhere from trying to maximize population yields to maximizing system capacities to absorb surprises – especially with more variable harvest strategies. And it is time for an honest accounting of the costs of control, particularly the biological, scientific, and ethical costs that are of such importance to the greater society.

Introduction

Five formal wolf control programs are underway via aerial shotgunning, same-day "land-and-shoot" aerial hunting, and other hunting and trapping methods across approximately 126,000 km^2 of Alaska – half the size of Wyoming - to produce more moose for hunters (*1*). This includes 22,000 km^2 authorized for control in Game Management Unit 19D east, from McGrath to the west boundary of Denali National Park in the upper Kuskokwim watershed, 26,000 km^2 in GMU 19A in the central Kuskokwim region of southwest Alaska, 21,000 km^2 in GMU 16B northwest of Anchorage, 40,000 km^2 in GMU 13 northeast of Anchorage, and 17,000 km^2 in GMU 20E/12, the "Fortymile area" of east-central Alaska. Fortymile also includes a 7,000 km^2 brown (grizzly)-bear control ("focus") area.

These programs specify wolf reductions of 60-80 percent for at least five years, though the numbers provided (*1*) indicate more arbitrary and in several cases more severe reductions (see Appendix). The bear control program specifies a reduction of up to 60 percent for at least five years, with an option to expand it beyond the 7,000 km^2. The total numbers of wolves and bears that will be killed are indeterminate if only because there is so little information on the numbers present in each area. As of early March 2006, 519 wolves had been killed by aerial and land-and-shoot hunting permittees alone, since control began in the McGrath and GMU 13 areas in winter 2003-04 and expanded to the other areas in 2004-05 and 2005-06. The formal bear control effort began in spring 2005. Nine bears had been killed as of early March 2006 – two by control permittees and seven by other hunters.

Additional tens of thousands of square kilometers have been designated for indefinite wolf and bear control for caribou as well as moose objectives. Wolf and bear killing seasons and limits have been greatly liberalized in these areas. Wolf hunters are allowed to use snowmobiles and bear hunters same-day airplane access. At least 1,500 wolves are killed each year in the formally designated control programs and via other public hunting and trapping throughout the state *(2)*, with little practical distinction between the former and latter except in the use of airplanes. Similar overlap clouds the distinction between bear control and bear hunting in many areas, for black as well as brown bears.

I begin with the premise (*2*) that large-scale broadcast control programs should be regarded as an unusual measure of last resort – that they place a heavy burden of proof on advocates, especially biologists, and should not proceed without surviving rigorous scientific review. The current wolf and bear control programs do not meet this standard. Following are some concerns about the five formal aerial control programs, at several interacting scales.

Problems At the "Nuts and Bolts" Level

All five of the aerial control programs are based on claims about low and/or declining moose numbers/densities, high wolf and bear numbers, and related moose-hunting problems (*1*). Given how easy it is even for experienced biologists and local hunters to completely misjudge moose numbers and trends when relying heavily on general observations, calf ratios, and "trend surveys" instead of organized censusing procedures (*3-8*), it is important to begin by asking if there are good enough data to confirm the alleged problems.

A. Moose population estimates

Direct counting can be used to estimate moose numbers if the area of interest is small enough to search systematically in its entirety and appropriate sightability corrections are applied for current conditions. Otherwise, it is necessary to use a sampling procedure. Alaska Department of Fish and Game (ADF&G) biologists recognize that stratified random sampling is the only way to do this accurately and with known precision (*9*). However, typically they census (sample) only portions of the areas to which estimates are applied – i.e., the estimated means are extrapolated to thousands of *additional* square kilometers even though they have no statistical validity or practical meaning outside the censused areas, because it is impossible to assign confidence limits.

This is a serious deficiency given that each control area supports multiple, independently changing moose populations and subpopulations – as is indicated, for example, by multiple, distinct migratory patterns and wintering areas (*1, 10-15*). While expanded estimates might accurately portray the status of some populations or subpopulations, for others they are just as likely to mislead biologists and policymakers into thinking there are low numbers or decreases where there are actually high numbers or increases, and vice versa.

GMU 13 control began in 2003 based largely on claims about moose numbers and trends across a 61,000 km^2 area, only 7 percent of which (1 area) has been censused, in 1994, 1998-2001, 2003, and 2005 (*1, 16-19*). Central Kuskokwim control began in 2004 based on claims about moose numbers across a 26,000 km^2 area, 10 percent of which was censused in 1998 (2 areas), 17 percent in 2001 (1 area), and apparently about 75 percent in 2005 ("the portion of the Unit south of the Kuskokwim River") (*1, 20-22*). McGrath control began in 2003 based on claims about moose numbers across a 22,000 km^2 area, 61 percent of which (1 area) was censused in 2000, 2001, and 2004, and varying (21%, 31%) portions in 1996 and 1999 (*1, 20-26*). Fortymile control began in 2005 based on claims about moose numbers across a 29,000 km^2 area, 41 percent of which (2 areas) was censused in 2003. The next census, in 2005, covered about 70 percent of the area to which it is being extrapolated, apparently because the size of the control area was reduced due to a court order (*1*, *27-28*).

GMU 16B control began in 2004 based on claims about moose numbers across a 26,000 km^2 area. ADF&G management reports do not provide the sizes of areas that were censused within mainland 16B, only that it was divided into "northern," "middle," and "southern" survey areas amounting roughly to thirds of the 26,000 km^2 (north of the Skwentna River, north of the Beluga River and Beluga Lake to the Skwentna River, and south of the Beluga River and Beluga Lake) *(29*). Only the northern and middle areas were censused via stratified random sampling prior to 2004 (*29* – Table 1) - northern in 1990 and 1996 and middle in 1990 and 1999. Thus, through at least 2003, the only actual censuses were of about two-thirds of the area in 1990, then of about half of this (a third of the 26,000) in 1996 and of the rest in 1999. No information is provided about any censuses via stratified random sampling in 2004 or 2005, only that there was an estimate of “3193-3951” for 2005 and that this was “based on aerial surveys in 2003-2005 in the unit” (*1*).

In none of the five control areas have the moose-censusing areas been delineated in ways that ensure inclusion of all or even most of the annual ranges of the moose being estimated. Thus, all of the estimates of annual numbers and longer-term trends are vulnerable to additional major error because of unpredictable seasonal and annual migrations and shifts in distribution *(10-14, 17*). Moose range between upper and lower areas of watersheds in the Kuskokwim region as elsewhere, yet the McGrath and central Kuskokwim moose census areas include only the lower 30-60 percent or less of most tributary watersheds. Differing migrations/shifts from upper watershed areas are the most likely reason for the tripling (.06 to .17/km^2) of equally precise moose estimates in the McGrath census area from 2000 to 2001*(21)*.

A major winter 1992-93 moose migration in GMU 13 (*12*) illustrates the McGrath-central Kuskokwim problem in reverse with an added potential for misinterpreting changes in sex-age ratios within the count areas. The GMU 13 migration extended 35-50 miles down the Susitna River from traditional trend-count and census areas, which in this case are located in *upper* watershed areas (in subunits 13A, 13B, and 13E). The migration included substantial numbers of cows with calves. Many of the calves died non-predation deaths enroute and many older moose were unlikely to have returned by the 1993 calving period, if at all. Northward shifts of moose from GMU 13E similarly provided the best explanation for unexpected changes in numbers and sex ratios within adjacent Denali National Park in 1972-1973 (*30*).

The GMU 16B moose estimates present similar if not worse pitfalls. Subpopulations from 16B, 16A, 14A, and 14B are known to intermix seasonally (*1*). The few partial 16B censuses were not consistent in their timing – e.g., northern censused in 1990 and 1996, middle in 1990 and 1999. The northern and middle census areas included only portions of major watersheds.

Failure to consider these and other spatial issues (*13*) has likely confounded moose surveys and interpretations of moose population trends throughout the North, not just in the current Alaska wolf control areas. At minimum, there is no reliable substitute for careful censusing of entire contiguous watersheds based on some prior knowledge of moose migratory patterns.

B. Moose harvest data

Equivocal harvest data from several of the control areas raise further questions as to whether the alleged moose and moose-hunting problems are real. In the McGrath area, i.e., upper Kuskokwim, hunter success rates (percent moose hunters reporting success of the number of moose hunters reporting) have ranged from 29-44 percent since 1992, with a stable or increasing trend (e.g., 35-43 % from 2001-2005) (*1*, *25-26*). This is at least as high as reported from the state's best moose-hunting area, GMU 20A (e.g., 25-42% from 1990-

2003), where hunters are afforded relatively easy access and among the highest densities of moose in North America (*31*).

In GMU 13, a declining moose harvest since the mid 1990s has been cited as evidence of a moose population problem. However, the number of hunters going afield declined similarly through at least 2004 and success rates remained more-or-less stable at 16-17 percent. This compares to an average success rate of only 24 percent from 1983-1992 when GMU 13 moose densities were probably at or near an unsustainable peak (*1*, *12*, *18, 32-33*). Increasingly restrictive GMU 13 moose seasons, bag limits, sex and age limits, and requirements for subsistence-hunting permits (*1*) can explain much of the decline in harvests and numbers of hunters since the mid 1990s.

In the Fortymile area, where there are large expanses of good caribou but poor moose habitat, moose-hunter success rates averaged 25-30 percent from 1990-2000 with a general increase in the number of moose harvested. Success rates decreased to about 15-20 percent in 2001-2003 with a concomitant 50-85 percent increase in the number of hunters going afield (*34*) – an explosive increase in demand not likely to be accommodated very long (if at all) by *any* management action. ADF&G cites an average annual harvest of 27-28 percent for 1995-2004 (*1*). This is an error or the success rate went back up in 2004; harvest data have not yet been provided separately for 2004 and 2005.

C. Wolf and bear population estimates

Information on wolf abundance is long on extrapolations, calculations, second-hand observations, and anecdotal information and short on actual survey data, even moreso than the moose estimates. Consider, for example, ADF&G's estimate that about 610 wolves would have to be killed in winter 2004-05 in the five aerial control areas combined to achieve or maintain 80 percent reductions. Aerial hunters were able to kill only 273 wolves despite their experience, intensive effort, and excellent hunting conditions.

In the McGrath (19D east) wolf control area, there were two recent aerial surveys to estimate wolf numbers, in February 2001 and March 2005 (*1, 35*). The 2001 survey covered 13,478 km^2 and the 2005 survey 8,314 km^2, both of which were "extrapolated" to produce expanded estimates for the entire 22,000 km^2 wolf control area. The estimate for the actual (13,478 km^2) survey area in 2001 is itself of dubious value. I was flying in this survey area - searching for wolves, wolf tracks, and wolf kills - during one of several days of the ADF&G survey. Flying and tracking conditions were poor, and I listened to radio conversations between two nearby ADF&G survey pilots who (unaware of my presence) commented repeatedly about the poor conditions and resulting survey problems.

The latest reported wolf estimate for the central Kuskokwim (19A) wolf control area – for 2004 – is based on an extraordinary series of extrapolations and calculations but no actual survey data from this control area (*1, 35*). First, the results of the (poor quality) 2001 survey described above, within 13,478 km^2

of the neighboring McGrath control area, were used in combination with "wolf research data" from GMU 20A (240 km to the east), sealing records, and information from hunters and trappers to derive a 2002 estimate for the 225,000 km^2 entirety of GMUs 19 and 21! An estimate was somehow separated from this for the 26,000 km^2 central Kuskokwim portion. The resulting 2002 central Kuskokwim estimate was then used in combination with "sealing records and anecdotal observations" to arrive at the 2004 central Kuskokwim estimate.

There was a late fall 2005 wolf estimate for the GMU 13 wolf control area, but no details are given about methods other than that it was "based on wolf and track sightings gathered from staff biologists, hunters, trappers, and pilots, adjusted for documented harvest" (*1*). Fall observations are of an incidental nature. They involve staff biologists who happen to see wolves while conducting moose trend counts primarily in portions of subunits 13A and 13B that add up to less than 20 percent of GMU 13 (*16-17, 36-37*).

The only other recent GMU 13 wolf estimates were in winters 2000-01 and 2001-02 (*37* – Table 1). There was also an estimate for early winter 2002-03 but this was based on a calculation rather than any 2002-03 survey information. The other pre-2005 estimates were derived from a mix of incidental observations by biologists doing other surveys, track surveys over portions of GMU 13 (but none unitwide), and information from hunters, trappers, and sealing records.

There was a fall 2005 wolf estimate for the GMU 16B wolf control area (*1*), but this, too, was provided without details about its derivation. The only recent pre-2005 wolf estimates with at least some basis in field surveys were in winters 1998-99 and 2001-02 (*38*). The 1998-99 estimate was based on extensive unit-wide aerial wolf surveys undertaken in conjunction with an effort to control a lice infestation. The 2001-02 estimate was derived in the more familiar way, from much less survey data and much more supplementary information ("reports from trappers, staff, public and late winter pack survey").

The most recent wolf estimate for the Fortymile (GMU 20E) wolf control area was in 2004 (*1, 39*). The only other estimate since 1998 was in winter 2002-03. In addition to aerial track surveys, information from pilots and trappers, anecdotal observations, and sealing records, the Fortymile estimates involved periodic monitoring of radio-collared wolves (wolves have been radio-collared throughout most of the control area since the early 1990s).

The Fortymile wolf control area differs from the other control areas in a fundamental way: The wolves of this area and surrounding areas are more heavily dependent on caribou; thus many more migrate seasonally in response to caribou migrations. Up to 45,000 Fortymile and 5,000-30,000 Nelchina caribou winter within the Fortymile wolf control area. My year-round wolf research throughout the upper Tanana-Fortymile-Yukon-Charley region via aerial radio-tracking since 1993 (*40-43*) indicates that wolf numbers can increase substantially in this area, albeit with considerable winter-to-winter variation, as wolves from as far as 150-250 kilometers away arrive to hunt caribou. Unless they are killed, migrant family groups and breeding pairs return to their natal territories by

April or early May. At least some non-breeding migrants follow Fortymile caribou to their spring calving areas, which often coincide with the natal territories.

The first six "Fortymile" wolves shot by aerial control permittees in winter 2005-06 were from an established, radio-collared family group of 14 wolves that had migrated more than 200 kilometers to the control area from its natal territory in Yukon-Charley Rivers National Preserve. This group was an extension of a resident Yukon-Charley group that I began studying in 1993; it migrated to the control area in previous winters as well.

ADF&G reports and Board of Game proceedings (*1, 39*) do not mention anything about the prominent wolf migrations of this area. Failure to consider these migrations and inclusion of "border packs" readily explain why the ADF&G estimates of resident Fortymile wolf densities are much higher than mine (e.g., twice as high in 39 vs. 2 for the same years). Inflated estimates are the most obvious consequence but there are also major consequences for wolf populations and wolf-prey systems far-removed from the control area.

The Fortymile bear control area lies within this wolf control area. Little needs to be said about the quality of the latest bear estimate, for June 2004. This estimate was derived from 18-year-old data from only a portion of the control area and a comparison with 7-24-year-old data from GMU 20A, 160 kilometers away (*1, 44*).

Without reliable wolf and bear estimates, and given the discrepancies in wolf reduction goals (Appendix), there is no basis for specifying percentage reductions, for ensuring that certain minimum numbers will remain afterward, or – especially in combination with the poor moose information - for evaluating the efficacy of the control actions.

Problems At a Broader Level

A. Recruitment patterns

Populations increase, decrease, or remain stable from year-to-year primarily because of any differences between the number of young that survive to one year of age, i.e., “recruits,” and the number of older animals that are lost during the same 12 months. These differences vary unevenly and often counterintuitively. It is important to understand how and why they vary in order to evaluate predator control, other management issues, and for insights about natural changes in general.

Interactions between wolves, bears, and ungulates and within most other systems involve multitudes of variables that are effectively integrated by a much smaller number of key control (“slow”) and behavior (‘fast”) variables. Examples of natural variables that control behavior of major management interest in wolf/bear-ungulate systems, i.e., changes in moose numbers/density, include predation levels, abundance of other prey, reproductive responses, and habitat quality. Hunting is the most important human-related control variable.

Thirty years ago associates and I introduced an approach for examining stability properties of wildlife systems that focuses on key control and behavior variables (*30, 33, 45-49*). We did this via stochastic simulations based on a large amount of wolf-ungulate and environmental field data from Denali National Park. Figure 1 summarizes the essence of this analysis and Figure 2 shows examples of actual simulations generated from the field data.

The simulations indicated a common form of system behavior referred to as “multiple stable states” or “multiple equilibria.” In this case, a moose population fluctuates within one of two regions (“domains”) of stability and at varying intervals may shift between them. In Figure 1, moose densities fluctuate either above or below the unstable equilibrium, U, but within each of these regions tend to return toward a stable equilibrium at either H or L (H, U, and L are equilibria

Figure 1. Moose recruitment patterns. Differing recruitment scenarios (1-4) may generate potential stable (H and L) and unstable (U) moose population equilibria and a “predator pit” (between L and U) at varying areawide moose densities.

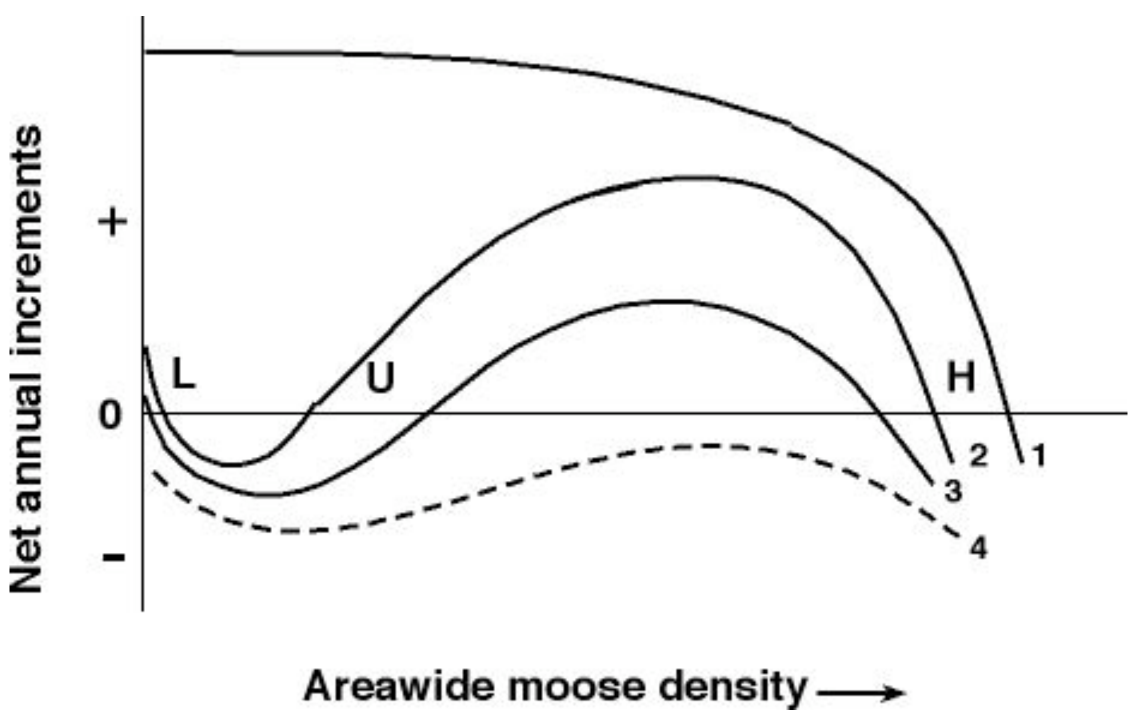
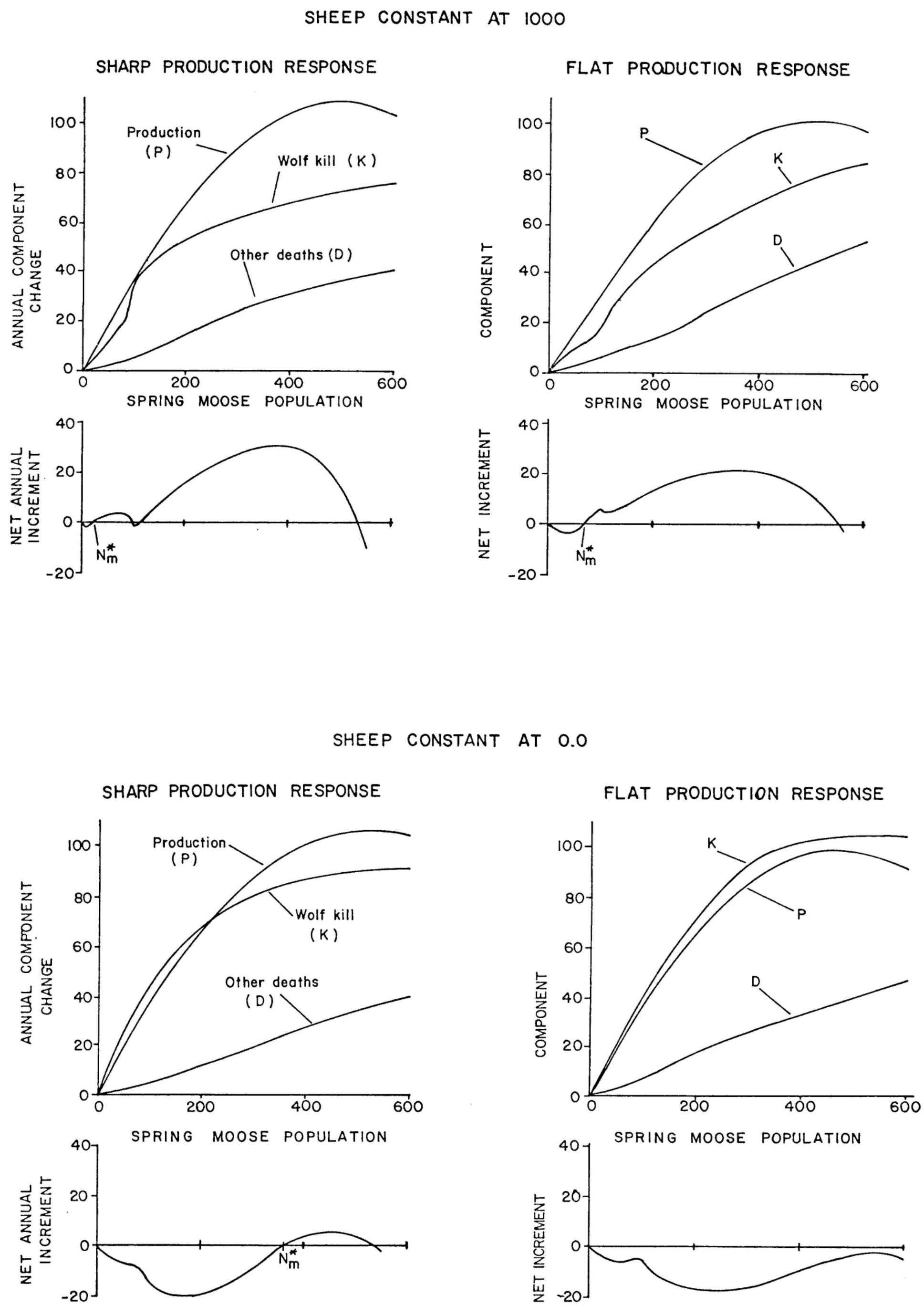


Figure 2. Examples of moose recruitment simulations from field data. Contrasting assumptions about the availability of secondary prey (sheep) and moose reproductive responses within a 1,500 km^2 wolf territory. N_m^* - the predator pit threshold - is the same as U in Figure 1. (Figs. 62-63 from reference #30).



because increments are zero at these densities. H and L are “stable” because increments corresponding to adjacent lower densities are positive and to adjacent higher densities are negative. U is unstable for the opposite reason – increments are negative below and positive above; moose densities easily move *away* from this point into either the lower or upper stability region). Once the moose population decreases below U, for whatever reason, it is within a predator pit: Disproportionately heavier predation (depensation) leaves too few recruits to replace other losses (net annual increments are negative) and moose numbers continue to decrease toward L.

Without any predation – trajectory 1 in Figure 1 - there is no depensatory effect at low moose densities and thus there is a potential only for a high stable state. Recruitment declines at high densities, near habitat limits, due mainly to declining net production (e.g., declining moose births and calf survival related to nutrition/competition). With normal predation – trajectory 2 – a potential low stable state and predator pit appear, and the upper stable equilibrium shifts to a somewhat lower density. As predation increases – trajectory 3, perhaps because of a learning-related increase in bear predation as happened in eastern Denali National Park beginning in the late 1970s (*33, 49*), the predator pit broadens to a higher threshold and the upper equilibrium shifts downward again (Denali moose eventually stabilized at a lower density following the bear predation increase, almost certainly because of a downward shift of the upper equilibrium, H, rather than a shift of the population to L or even U (*33*)). In rare cases – trajectory 4 (e.g., following removal of alternative prey where there is also a flat moose reproductive response) – predation could become so heavy that the moose population could not outproduce it at any density and would eventually disappear.

The Figure 2 simulations show that much more than predation alone can and is likely to produce these moose recruitment, equilibria, and predator pit changes. Recruitment trajectories (bottom panels in each set of 4 curves) shifted progressively downward about the same way as in trajectories 2-4 of Figure 1 as we first flattened the reproductive response, then eliminated other prey, then did both together. Changes in habitat quality would also raise and lower the curves. In most cases these and other control variables operate in varying combinations, directly and indirectly. It was a trivial matter in our simulations to add human hunting to the mix in order to explore the impacts of this control variable in combination with the others and determine sustainable yields.

ADF&G's observations of moose-related events and changes in GMU 20A over the past several decades (*10, 15, 50*) provided an opportunity to disprove the central – i.e., multiple stable states - hypothesis arising from our simulations, though multiple stable states have already been identified in many other kinds of biological systems (*51-53*). Despite potentially confounding management actions (*12*), the 20A recruitment sequences have varied in the way our simulations from neighboring Denali data predicted: There was a predator pit at low moose density, high productivity and steady growth in the presence of relatively high wolf abundance at moderate densities, and habitat-limited stability (via declining moose production) at high density, still in the presence of relatively high wolf abundance. 20A vs. Denali differences in the moose recruitment trajectories and equilibrium densities are consistent with differences in bear abundance, availability of other prey, and prevalence of good moose habitat.

B. Recruitment-related management implications

Five important management conclusions follow from Figures 1-2:

1. Predator control might become necessary after a moose population decreases below U in Figure 1 (below N_m* in the Fig. 2 simulations) but not above this threshold. At areawide densities between U and H, net annual increments are positive and thus the population can increase on its own, although in some cases it might be necessary to temporarily reallocate portions of any existing moose harvest for this purpose.

2. There is little if any basis for claims about a "low density dynamic equilibrium" within a range of .04-.40 moose per km^2 (*1, 15, 50*), where ADF&G considers predator control to be necessary. Presumably ADF&G is referring to the predator pit, U-L (Fig. 1), rather than L. Given the within- and between-system variations to be expected in this threshold and the other equilibria (e.g., between Denali and GMU 20A), any supposed rule-of-thumb about where they will occur is virtually meaningless. If there were a rule-of-thumb, the Figure 2 simulations would place U within a lower range of densities, at about .03-.20 moose per km^2. The moose population would be less likely to slip into a predator pit than ADF&G thinks.

3. ADF&G's arguments for predator control (*1*) also rely heavily on claims about wolf kill rates of moose. ADF&G is interpreting these kill rates in isolation from other major control variables and the many variables they integrate (*30, 33*). A similarly narrow focus on kill rates led to dire predictions by ADF&G and others of a major moose decline in eastern Denali National Park during the record severe winter of 1970-71; but the net fall 1970 to fall 1971 decline was only about 8 percent (*30*). The were similar predictions, emphasizing kill rates, for much of Interior and southcentral Alaska during the severe winter of 1992-93; and again they were wrong (*12*). The simulations described above illustrated the importance of considering *interactions* among the control variables, at multiple scales. The Figure 2 recruitment curves were generated from simultaneous changes in wolf kills (functional responses) (K), other moose deaths (D), and prey production (P), not just from K. And P, D, and K integrated many other field variables and stochastic effects from the prey-population, wolf-group, wolf-prey-interaction, and snowfall-variation submodels of the overall simulation model.

4. Moose calf ratios and related recruitment statistics should increase almost immediately during a predator control action, if moose are a major prey item. But by itself this says nothing about the efficacy of the action, because the moose population could already be at a high density. Proximate recruitment responses would look much the same above H (Fig. 1) as between U and L, and between H and U as below L. They can be interpreted accurately only with good moose population (density) estimates.

5. If moose hunting is a primary management objective, short of adopting a Scandinavian approach - *ongoing*, *nearly-complete* suppression of wolves and bears in combination with intensive habitat and moose age-structure manipulations - it makes no sense to promote moose increases above densities corresponding to the highest net annual increments of the Figures 1-2 recruitment curves (beneath their humps). In most cases recruitment and thus sustainable yields will peak at least 30-40 percent below habitat limits, which occur somewhere just above H in Figure 1. Predator control carried out for a moose population at or near habitat limits should increase the population's net annual increments and thus potential yields, although only for as long as the control action continues. However, similar or higher increments and yields are likely to be available without predator control at the population's lower, most productive size.

None of the current Alaska wolf-bear control programs would survive a necessity or logic test on any of these five counts. Foremost, the moose population estimates are far short of what is needed to interpret calf ratios and other information so as to determine recruitment status (e.g., whether the population is above or below U in Fig. 1). Even without adequate population estimates there are better reasons to question than accept the claims that moose populations of all five areas are currently trapped in predator pits.

It would be next to impossible for any moose subpopulation of the McGrath "EMMA" management area to be trapped in a predator pit at a density of .39 moose per km^2 "*and increasing*" (*1*). This is at the high end of ADF&G's own (over)estimate, i.e., .04-.40, of the predator pit threshold. Even at supposedly lower moose densities in the late 1990s, calf ratios were high enough to produce positive net annual increments over much of the McGrath control area (*26*).

There is moose census data for only about 7 percent of GMU 13. But the decline observed in the census area - from about .77 moose per km^2 in the mid 1990s to about .39 as of the early 2000s – is more indicative of a decline from near H to somewhere above rather than below U in Figure 1, especially when considered with the harvest data (earlier) and indications of poor calf survival unrelated to predation in winter 1992-93 (*12*). If only to be consistent, ADF&G would reach the same conclusion from its claims about predator-pit thresholds at .04-.40 moose per km^2 (and likewise regarding its tendency to extrapolate census results, which in this case would produce a current estimate of almost 24,000 moose unitwide - at or above the stated objective).

The weakest case for a current predator pit condition is in the Fortymile control area. It is not a foregone conclusion that Fortymile moose are trapped in a predator pit if their numbers are currently at least 33-63 percent of the habitat capacity of this area (*1*), especially given the high availability of caribou and absence of any observable response in moose numbers or calf ratios following an 80 percent wolf reduction across much the same area in 1997-2001 (*54)*. The 1997-2001 control area included large northern and northwestern sections of the present control area and the present area's 5,036 km^2 "Tok West" moose census area (*27, 55*). The ADF&G regional supervisor admitted in testimony at a January 25, 2006 Board of Game meeting that the real intent of this control program is to *prevent* (by being "proactive") rather than respond to a predator pit condition. He was replying to a board member who wondered why non-residents were still allowed to hunt moose from this allegedly predator-suppressed population.

ADF&G contends that an overall moose: wolf ratio of less than 20-30:1 implies a predator pit and that all of the control areas are below this threshold (*1, 10, 20, 26, 56*). Like the "low density dynamic equilibrium" rule-of-thumb (#2), this ignores the within- and between-system variations that should be expected routinely for predator-pit thresholds, other equilibria, and recruitment trajectories. It also overlooks known exceptions and contradictions (*30, 33*) and the fact that wolf predation changes much more as a function of the number of groups ("packs") than with group sizes and total numbers of wolves (*2, 30, 48, 57*). And it assumes, without basis (first section), that moose and wolf population estimates are good enough to determine moose: wolf ratios in the first place.

ADF&G refers to recent calf survival increases in two control areas – McGrath and GMU 13 – as if they provide evidence of release from predator pits or indicate something else about the efficacy of the control actions (*1*). If moose are the primary prey, a reduction in predation should raise calf survival at least temporarily across the full range of moose densities, above as well as below the predator pit threshold. Per #4, without reliable population estimates these calf survival responses cannot be distinguished from each other.

ADF&G continues to selectively emphasize wolf kill rates in all five control programs (*1*) despite a long track record of mistaken conclusions about predator pits and much else from this kind of reductionist thinking (#3). The kill rates themselves – 4-7 moose per wolf per winter - were derived selectively. They ignore the largest, most detailed body of subarctic wolf predation rate data available (*30*), which would lead to substantially lower, more variable estimates. Especially noteworthy is the absence of any mention of winter scavenging. Established groups of Denali wolves ate at a moose, sheep, or caribou carcass on average once every 2.0-2.6 days from October-April and scavenged rather than killed 47-48 percent of these prey animals. Nor does ADF&G allow for any replacement effects of predation (*30*).

Finally, ADF&G has not distinguished between the highest moose population it thinks the habitat can support and the population at which productivity is likely to be highest and hence where on average the highest yields are likely to be generated. Per #5, these are not the same – the latter is typically at least 30-40 percent lower; see also (*58*). Yet in each of the five control programs ADF&G has provided the moose population it thinks the habitat can support (an issue on its own) and has set this or something close as the moose population goal (*1*).

Problems At the Broadest Level

A. Maximum sustained yield

What drives wolf and bear control perhaps more than anything is reliance on "maximum sustained yield" as a guiding principle. In Alaska, this thinking is expressed in several intensive management ("IM") statutes. These statutes were enacted by the state legislature primarily at the behest of the Alaska Outdoor Council, the state's most powerful hunting-trapping lobbying organization whose wildlife positions have long been guided by retired and active ADF&G biologists.

Proponents think it should be possible to keep moose and caribou numbers in each management area at relatively high, stable levels for ongoing high yields, by manipulating natural predation and other variables. It is assumed that management units encompassing thousands of square kilometers generally coincide with meaningful ecological units, that what happens within these units can be viewed at a single spatial-temporal scale (primarily involving "populations"), and that essentially all major ungulate declines are a problem.

But systems operate at multiple interacting scales, with much time-series variation due to "internal" behavior - fluctuations/shifts within/between stable states, periodic and aperiodic oscillations, chaos - and external influences (drivers, stochastic effects, noise, etc) (*30, 33, 46-48, 51, 59-62*). This includes natural as well as human-caused ungulate declines into low stable states, though documenting these is another issue (previous section).

Trying to replace these patterns of change with artificially high, stable conditions to generate high, constant yields stands to diminish a system's resilience over time (*51-52*). The system becomes less able to absorb unpredictable, uncontrollable major natural and human-caused disruptions. There is a higher potential for sudden unnatural shifts to system states with even lower yields and unforeseen consequences for other valued natural features and ecosystem services (*63-64*).

This argues for more scientific creativity in devising ungulate-harvesting strategies, in particular for strategies that feature much more spatial and temporal variation (*47*). It indicates another way to fulfill the sustained-yield requirement of the Alaska Constitution, by switching the proximate emphasis from maximizing population yields to maximizing system capacities to absorb surprises. True sustainability recognizes the importance of natural system processes. Maximum sustained yield, command-and-control management does not.

B. Adaptive management

It is often claimed (*23, 65*) that the Alaska wolf-bear control actions provide a good opportunity to learn through adaptive management. But there is a difference between intelligent probing in the face of incomplete information (*66*) and broadcast control with results that cannot be measured because the information is far too "incomplete" (*57, 67-68*). Nor does incomplete information about system responses provide a good opportunity for adaptive management when there is also a low likelihood – as in expansive wildlife systems - of controlling these responses adequately for experimental manipulation (*69*).

C. Costs of wolf and bear control

Good decision-making requires reasonable consideration of potential costs and benefits. The alleged benefits of the current control programs are emphasized almost to the complete exclusion of their costs, which makes it much easier to sell these programs. Following is a summary of some of the costs – biological, scientific, ethical - that warrant serious consideration.

1. Biological costs

Wolves feature two unusual evolutionary strategies - cooperative breeding and cooperative hunting – that operate primarily through sophisticated interactions and interdependencies within family groups. These close, complex, cooperative relationships cannot be expected to withstand heavy predation, natural or otherwise. Human killing at annual rates of 15-20 percent or higher appears to produce lingering biological impacts even when numbers recover to prior levels. Important underpinnings related to social structure and other behavior, hunting patterns, distribution, and genetics differ for the survivors and recolonizers vis-à-vis the earlier population. Annual mortality rates change in unexpected ways and sometimes increase sharply well after the killing decreases sharply or has ended. These and other observations warn that heavy killing endangers the very sociality that sets wolves and a handful of other species apart and makes them so interesting, and that it could sharply reduce long-term abundance (*2, 30*).

The response (*57*) to this view is that there is a high natural rate of turn-over in wolf populations – "nearly as high as [in] most control efforts," such that heavy human killing is "similar" to and largely "substitutes for" the natural losses. This and the ability of wolf numbers to rebound due to reproduction and dispersal means that control has no significant biological consequences for wolves.

Apart from its silence about the comparative data from various studies (*2*) that suggest the foregoing impacts, this argument overlooks two critical distinctions. First, the example provided (*57*) to illustrate annual losses under natural conditions - 38 percent - is within the widely accepted range of 35-40 percent. The specified Alaska wolf control reductions of 60-80 percent hardly "substitute for" these losses. They double them.

Second, within- and between-group losses are distributed much differently in aerial (and other) control actions than they are under natural conditions, even when the control losses are at lower rates. Aerial hunters are at least as likely to kill the core, dominant group members as pups and subadults, whereas under natural conditions pups and subadults contribute most of the annual losses (due to death and dispersal). Aerial hunters are much more likely to find and kill the larger, established core groups, whereas under natural conditions it is the smaller, less stable offshoot and other "satellite" groups, pairs, and singles that contribute most heavily to annual losses (*2*, *30, 70*). "Core" individuals are likely to contribute heavily to mortality in the latter units under both conditions simply because most of these units consist only of one or a few adults.

Brown bears reproduce at such low rates as to leave even numerical recovery in doubt following heavy human killing (*57*). Extended and ongoing control programs also raise questions about ultimate effects on ungulates given the role of predation pressures in maintaining overall vigor, alertness, and other important and valued characteristics.

2. Scientific costs

Aerial hunters decimated the well-established Copper Creek family group of 12 wolves only six days after control began in the Fortymile area in January 2005, despite pleas to ADF&G to spare this group because of the long-term research insights it was providing (*71*). The same happened to the Yukon Fork/Cottonwood family group of 14 wolves in November 2006, another group that National Park Service biologists and I had been studying (separately) since 1993. This group was hit by aerial hunters while it was in a major caribou wintering area more than 200 kilometers from its home (natal) territory in Yukon-Charley Rivers National Preserve. It had migrated to this area to hunt caribou in previous winters as well.

Both groups were providing long-term streams of information about many aspects of ecology and behavior, including their fascinating migrations that among other things illustrated prior knowledge of distant caribou wintering areas and details of large extraterritorial areas in general (e.g., wolves traveled more-or-less directly to distant, varying caribou areas without following or tracking the caribou). Both groups, especially Copper Creek in combination with Toklat/East

Fork of Denali National Park, were providing rare insights from the wild about the underpinnings of cooperative behavior, one of the most important areas in all of scientific inquiry (*71-73*).

The loss of these and other opportunities to ultimately learn more about ourselves and much else constitutes a major societal as well as scientific cost of wolf control.

3. Ethical costs

Extraordinary intelligence, expressiveness, and emotional depth enable wolves to maintain their sophisticated bonds as cooperative breeders and cooperative hunters. This same high sentience that is so integral to their biology also provides an ethical basis for challenging the current control programs. Many people recognize the importance if not preeminence of ethical considerations in determining how we should interact with other species, especially animals of such high sentience. Many scientists now also feel this way and recognize how integral intelligence, emotions, personalities, traditions, culture, and other previously ignored aspects of sentience are to the biology of non-human social animals (*74-76*). So prominent has this thinking become in the greater society that it must be treated as a major societal cost to be considered explicitly before deciding about wolf control or other such actions.

Scientists in particular are obliged to recognize and be guided or constrained by the ethical implications of their work. It remains for many Alaska biologists – who regularly emphasize that, "we manage wolves [and other wildlife] for populations, not individuals or groups" - to see this ethical light. But by no means are they the only biologists still floundering in the dark. The 13 National Academy of Sciences panelists who reviewed Alaska's wolf, bear, and ungulate management programs in 1997 (*57*), only one of which was an NAS member, provided a good example of the inconsistent, superficial thinking of scientists on the dark side of this issue. The panel's response (p. 54) to my ethics argument (*2*) was simply that, "Arguments that harvest of wolves is ethically unacceptable because of the intelligence and social complexity of wolves can be neither supported nor rejected on scientific grounds."

Later in the same report (p. 178), the panel had no difficulty supporting an ethics argument about the treatment of *dead* animals - removing a tooth from a dead bear's skull – and in emphasizing that this is an affront to some Alaska natives who hold the bears "in great respect." According to the panel, "the ethical treatment of animals" involves "less tangible, but equally important [vis-à-vis scientific] issues." Apparently this doesn't hold without "scientific grounds" (which *have* been provided (*2*)) when it comes to shotgunning hundreds of wolves from airplanes and offending millions of people, including many Alaska natives.

Bekoff's comment (*75-76*) is appropriate: "While ignorance may be bliss, ignoring questions about our ethical responsibilities to animals compromises not only their lives and our integrity, but also the quality of scientific research."

References and Notes

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Appendix. Conflicting wolf reduction objectives.

Per the following, the wolf reduction objectives provided in Alaska Board of Game Finding of Emergency 2006-161-BOG (FE) and in the accompanying 5 AAC 92.125 predation control implementation plans (IP) – referenced at #1 (above) – conflict with each other.

<u>GMU 12/20E (Fortymile) control area</u>

According to the IP, there were 147-181 wolves in this control area in fall 2005. The FE sets the objective for the number of wolves to be killed during the current control period (October 2005-April 2006) by trappers, hunters, and aerial permittees combined at 97-131. The IP specifies that there will be at least 50 (50-65) wolves in the area afterward. However, (147-181) minus (97-131) leaves 16-84 wolves, not a minimum of 50. Nor does this reduction (54-89%) conform to the percent reduction guidelines of 60-80% or less (IP).

<u>GMU 19A control area</u>

According to the IP, there were 125-175 wolves in this control area in fall 2005. The FE sets the objective for the number of wolves to be killed during the current control period by trappers, hunters, and aerial permittees combined at 85-135. The IP specifies that there will be at least 40 (40-53) wolves in the area afterward. However, (125-175) minus (85-135) leaves 0-90 wolves, not a minimum of 40. Nor does this reduction (48-100%) conform to the percent reduction guidelines of 60-80% or less (IP).

<u>GMU 16B control area</u>

According to the IP, there were 85-114 wolves in this control area in fall 2005. The FE sets the objective for the number of wolves to be killed during the current control period by trappers, hunters, and aerial permittees combined at 40-92. The IP specifies that there will be at least 22 (22-45) wolves in the area afterward. However, (85-114) minus (40-92) leaves 0-74 wolves, not a minimum of 22. Nor does this reduction (35-100%) conform to the percent reduction guidelines of 60-80% or less (IP).

<u>GMU 19D east (McGrath) control area</u>

According to the IP, there is no fall 2005 wolf population estimate for this control area. The most recent ("extrapolated," "calculated") estimate – 103 wolves - is for fall 200<u>4</u>. The FE sets the objective for the number of wolves to be killed during the current control period by trappers, hunters, and aerial permittees combined at 8-12. The IP specifies that there will be at least 40 wolves in the area afterward. The IP indicates that the total number of wolves killed each winter from 1997-98 through 2004-05 ranged from 14-39. There is no explanation in the FE or IP as to how a population of 103 wolves in fall 2004, a total kill of 39 wolves in winter 2004-05, normal production of pups in spring 2005, and the specified kill of 8-12 wolves for winter 2005-06 could translate into anything even close to the target minimum of 40 at the end of winter 2005-06, especially if "There is no evidence that natural mortality factors significantly limit wolf population growth" (IP). In other words, specifying a total kill objective of 8-12 wolves is not consistent with setting a minimum target of 40 wolves.

The Board added comments to each of the IPs indicating that it feels ADF&G could quickly respond with emergency closures if the specified total kill objectives (FE) and minimum remaining populations (IPs) are achieved prior to the expiration of aerial permits on April 30. A fundamental problem with this assumption compounds the problems discussed above and earlier with regard to the wolf population estimates. This problem also applies to the GMU 13 control area, which is not discussed above. According to the IPs, since control began in winters 2003-04 and 2004-05 the reported trapping-hunting kills have comprised about half of each winter's total kill (by trappers, hunters, and aerial permittees combined). But trappers and hunters are not required to report their kills until 30 days <u>after</u> the end of the regulatory seasons; these seasons and the aerial permits expire on April 30. Thus ADF&G would have no way of knowing when the specified total kill objectives and minimum remaining populations were achieved. This could be determined for certain only well after the fact, on May 30.