Appendix: Biological Evaluation of Spike-Fork/50" Moose Harvest in Southcentral Alaska

By

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Summary

The biological effects of harvesting moose under a spike-fork/50" (SF/50) strategy is evaluated. Harvest statistics, aerial survey data, and recent research reports are used to determine if SF/50 is meeting management objectives in Game Management Units 7 and 15 (Kenai Peninsula), 14 and 16 (Matanuska-Susitna Valleys and west side of Cook Inlet), and 13 (Nelchina Basin). Units 7 and 15 have had SF/50 since 1987. An initial evaluation of the harvest system after 5 years indicated that it was successful in improving bull:cow ratios, providing more mature bulls in the population, and allowing a hunt to take place even after severe winters. SF/50 also resulted in decreased hunter participation and a somewhat decreased annual harvest, but harvest was expected to return to pre-SF/50 levels. In 1993, based partly on the Kenai experience, SF/50 was implemented throughout Southcentral Alaska and was to be evaluated after a similar period. Since 1993 in Units 7 and 15, bull:cow ratios have remained favorable, hunter participation has increased, and the level of harvest is generally equal to pre-SF/50 years. Composition of the harvest based on antler size has not changed since the first evaluation was done. No biological problems exist in these units. In Units 14 and 16, it is apparent that more moose could be harvested, particularly in subunits 14B, 16A, and 16B where objectives for bull:cow ratios are being exceeded. Subunit 14A now draws more hunters than during pre-SF/50 years and hunter success rates have declined. This increase in hunters may be linked to the addition of late-season hunts for spike-fork bulls. In subunits 14B, 16A, and 16B, hunter participation is less than it was prior to SF/50 but is increasing. Success rates are low in subunit 14B, moderate in subunit 16A, and high in subunit 16B. If hunter participation can be increased in these subunits, particularly in Unit 16, harvest levels should increase. In Unit 13, dramatic increases in hunter participation and probable decreases in calf recruitment have caused bull:cow ratios to fall below prudent levels in subunits 13E, 13B, and particularly 13A. A high proportion of yearlings are legal under spike-fork regulations, and adult moose in this area tend to produce more brow tines than moose elsewhere. This causes higher exploitation rates of yearlings and mid-sized bulls, thereby decreasing the number of bulls reaching maturity. Harvest must be decreased in subunits 13A, 13B, and 13E at a minimum to allow bull:cow ratios to reach the 20–25:100 range. Viable options for reducing the harvest in Unit 13 are: 1) reduction of hunter effort by reducing season length, or 2) reducing the number of bulls defined as legal by either a) raising the definition of a legal bull to 4 brow tines, or b) confining yearling harvest to spikes only. The impact of a reduction in season length is impossible to determine, although it is expected to result in some level of harvest decline. Of the two methods involving changes in the definition of legal animals, a computer simulation revealed little difference between the two. Based on the

assumptions of the model, both of these harvest strategies produced declines of approximately 20% in harvest and brought bull:cow ratios within the range of 20–25:100.

Purpose

This analysis of the biological ramifications of the spike-fork/50 (SF/50) moose season was prepared at the request of the Alaska Board of Game. It constitutes an evaluation of this new harvest strategy after the initial 5-year period in the Matanuska-Susitna valleys and the Nelchina Basin. Implementation of this selective harvest system in GMUs 11, 13, 14, and 16 occurred in 1993. SF/50 had been implemented in GMUs 7 and 15 in 1987.

Background

Spike-fork/50 is one of many moose management alternatives that fall under the general category of selective harvest strategies (SHS). These SHS are designed to apportion the harvest of moose among certain sex and age classes to optimize both harvest and population objectives. SHS have been implemented successfully in other jurisdictions (Timmerman and Buss 1998), and the prototype SHS incorporating antler architecture as harvest criteria was implemented in British Columbia in 1980 (Child 1983, Child and Aitken 1989).

The SF/50 program is based loosely on the British Columbia program and is intended to create a more natural age structure among males by increasing the number of mature bulls in the population. Mature bulls are necessary to ensure the timely breeding of females (i.e., the breeding of all females on their first estrus). This leads to birth synchrony and possibly to greater juvenile survival in the subsequent winter. Creating a protected class of animals, including vigorous yearlings and many animals aged 2–4, increases the prevalence of mature bulls in the population. These bulls are given the time to develop and mature so that they can be more effective breeders. SF/50 also allows mature bulls to be harvested once they reach a minimum size, which can serve to increase hunter satisfaction. The specific objectives of SF/50, delineated during its implementation on the Kenai Peninsula (Units 7 and 15) in 1987, are: 1) increase bull:cow ratios; 2) increase the number of prime bulls in the population; 3) increase the opportunity to view bull moose; 4) maintain hunter opportunity; and 5) promote hunter ethics. This analysis pertains to objectives 1, 2, and 4.

Schwartz et al (1992) conducted an analysis of the effectiveness of SF/50 on the Kenai Peninsula and determined that, after 5 years, it was partially successful in meeting its objectives (Table 1). The most striking change noted was an increase in bull:cow ratios from a mean of 16:100 before implementation to a mean of 25:100 for the first 5 years of SF/50. Proportion of the harvest composed of bulls aged 2–3 declined significantly whereas proportional harvest of yearlings increased. Proportional harvest of animals ≥4 years old did not change. Total harvest declined significantly as did number of hunters, whereas success rate remained stable. Anecdotal evidence from hunters revealed two trends. Some hunters refused to hunt in the area due to dissatisfaction with the program. Other hunters expressed approval of the program because they observed more bulls, particularly large bulls, while hunting.

Aside from concerns about typical harvest statistics, questions were raised about potential long-term effects of SF/50 on antler size. Would this strategy alter the size of antlers expected of mature bulls in a given population? Hundertmark et al. (1993) examined the genetic consequences involved with SHS on the Kenai Peninsula. They incorporated local antler characteristics and population parameters into a computer model that simulated genetic changes and population processes influenced by harvest for 50 years under a variety of SHS. Results of that study indicated that harvest criteria could have a profound impact on genetic and population processes after 50 years. Harvesting only spike-fork yearlings tends to alter the gene pool by favoring genes that produce larger antlers. Conversely, any kind of minimum spread component (such as 50" or 36") had the opposite effect – genes favoring larger antlers declined. By combining these two criteria, some sort of balance was achieved depending on the minimum spread chosen for the upper end. The strategy where any bull was legal yielded the highest harvest but also was characterized by the lowest ratios of all bulls:100 cows and mature bulls:100 cows. These trends have been observed in many game management units in Alaska. The strategy that had only spike-fork animals legal yielded high bull:cow ratios but low harvest. SHS utilizing both the spike-fork and 50" strategies yielded the best compromise between harvest and bull:cow ratios. Any SHS that included a component that identified legal bulls based on brow tine architecture (the 3-brow tine rule) caused a decrease in genes favoring those brow tines. There was no strategy that could be added to the season that would balance this negative effect.

The trends noted in that study were for a population that was at or close to its nutritional carrying capacity, (i.e., a high-density population). A more recent modeling effort (Hundertmark et al. 1998) examined the same population processes in moose populations that are held below carrying capacity. In these populations, the increased nutrition available due to more abundant, high-quality food would cause antlers to grow faster and achieve larger size more quickly. Also, fewer yearlings would exhibit spike-fork antlers, but would instead be expected to produce small palmated antlers. In other words, the nutritional component of antler growth would be maximized. In these populations, the same genetic and population trends were observed as in the previous exercise, but rates of change were faster.

Game Management Unit Accounts

I. Kenai Peninsula (Units 7 and 15)

The size of moose populations on the Kenai Peninsula has not been assessed routinely in a manner having known statistical precision. The general trend in subunit 15A, however, is stable or declining, and the outlook is for a general decline if significant habitat alteration does not occur (Loranger et al. 1991). Subunits 15B and 15C have stable populations due in large part to the abundance of subalpine habitat. Unit 7 has small but stable populations.

To examine bull:100 cow ratios in these units, we concentrated on large count areas that are surveyed consistently. Only years in which all count areas were surveyed and yielded reliable data were used. Thus, our results differ somewhat from those reported by

Schwartz et al (1992). Bull:cow ratios in Unit 15 (Fig. 1) from 1971 to 1986 averaged 14:100, and averaged 16:100 from 1982 to 1986. Since inception of SF/50, bull:cow ratios have averaged 20:100, with a peak of 26:100 in 1996. Mean yearling bull:cow ratios since SF/50 was implemented is 7:100. For Unit 7, bull:cow ratios were between 10–15:100 throughout the 70s. In the early 80s, these ratios increased to between 27 and 34:100 but these surveys saw few moose overall and their reliability is questionable. Subsequent to SF/50, ratios have averaged 35:100, with a mean yearling bull:cow ratio of 9:100.

For the 5 years before the institution of SF/50 on the Kenai Peninsula in 1987, hunter participation averaged approximately 3600 hunters annually and was increasing (Fig. 2). Participation declined dramatically immediately after the change in regulations and averaged approximately 2700, a 25% decrease. Nonetheless, approximately 2000 hunters participated in the 1990 hunt, which followed an extremely severe winter, whereas other units experienced closures. After SF/50 was instituted regionwide in 1993, participation in the Kenai hunt increased, indicating perhaps that hunters had fled the Kenai to hunt in other areas, but returned after SF/50 became widespread. Schwartz et al. (1992) found no evidence for this trend, but it may have been masked by other factors. Mean number of hunters participating from 1993 to 1997 was 3374, which included a year (1995) following a severe winter when participation was down. Excluding this year, the average number of hunters participating was 3540, which is nearly equivalent to pre-SF/50 levels. Percent success remained relatively constant throughout the last 16 years, with no trend apparent relative to SF/50 (Fig. 2).

Harvest followed a similar pattern to participation (Fig. 3). A mean of 635 bulls was harvested annually for the 5 years prior to SF/50. For the first 5 years following institution of SF/50, a mean of 439 bulls was harvested. During the final 6 years of this analysis (1992–1997) the mean annual harvest was 579 bulls. Excluding the poor harvest of 1995 (following a severe winter) the mean harvest for the last 5 years was 665, equivalent to pre-SF/50 levels.

The percentages of antler classes in the harvest have remained relatively constant for the last 5 years (Fig. 4). Mean prevalence of spike/fork yearlings in the harvest was 61.2%, which is not different than the prevalence (64%) observed during the first 5 years of the program (Schwartz et al. 1992). Bull with antlers greater than spike/fork but less than 50 inches (harvested because they had ≥3 brow tines and hereafter referred to as mid-sized bulls) composed 15.8% of the harvest; 15% of those had ≥4 brow tines. Bulls with spreads of ≥50" (hereafter referred to as large bulls) comprised the remaining 26%, with 20% of these having ≥4 brow tines.

Conclusion

For Units 7 and 15, there is no compelling biological reason for altering the harvest strategy of SF/50. Bull:cow ratios are stable and within reasonable levels, the proportions of bulls of different sizes in the harvest also has remained stable, indicating that harvest is not altering the antler structure of bulls, at least at a detectable rate.

II. Matanuska Valley (Units 14A, 14B, and 16)

Management objectives for subunits 14A, 14B, 16A, and 16B are listed in Table 2. Objectives have been quantified for population size, harvest level, and bull:100 cow ratio.

Since implementation of SF/50, the proportion of the harvest comprised of the 3 different antler classes (S/F, mid-sized, and large) has remained fairly constant despite an increasing trend in harvest (Fig. 5). S/F yearlings (including yearlings that were unclassified) composed a mean of 43% of the harvest, midsized bulls composed 20% (19% of which had 4 or more brow tines), and large bulls composed 37% of the harvest (32% of which had 4 or more brow tines). The proportion of S/F animals in the harvest has not increased significantly in the last 3 years even though an additional late-season harvest of S/F yearlings was permitted in subunits 14A, 14B, and 16A.

Unit 14A

The trend in population size for subunit 14A is relatively stable (Table 3). Bull:100 cow ratios declined in this subunit after the severe winter of 1989–90 (Fig. 6). Ratios have increased since 1993 and are once again within the objective range of 20-25 bulls:100 cows. [ADD 1998 DATA] The ratio of yearling bulls:100 cows has decreased since 1993. In 1988 and 1989, this ratio was approximately 10:100, but in 1996 (last survey) it was 6:100. The relative proportions of small bulls and large bulls in post-hunt surveys are an important index of the success of antler-based SHS (Hundertmark et al. 1998).

For the 5 years prior to SF/50, a mean of 2619 hunters participated annually in the general moose hunt. If 1990 (severe winter) is removed from the analysis, this mean increases to 2828. For the 5 years following implementation of SF/50, a mean of 3194 hunters participated annually (Fig. 7). Numbers participating in 1996 and 1997 were the highest in the past 10 years. Hunter success declined after SF/50. Percent success prior to SF/50 averaged 16.6%, whereas it averaged 10.8% after SF/50, although it is increasing (Fig. 8).

Harvest for Unit 14A has generally decreased since implementation of SF/50. Mean annual harvest pre-SF/50 was 486 bulls, whereas it decreased to a mean of 354 post-SF/50. The harvest has increased significantly in the past 5 years (Fig. 8) and this is due primarily to an increase in number of hunters. Harvest is significantly correlated to number of hunters both pre-SF/50 ($r = 0.96$, $P < 0.01$) and post-S/F50 ($r = 0.97$, $P < 0.01$). Harvest for both 1996 and 1997 was greater than the mean annual harvest prior to SF/50.

Unit 14B

This subunit contributes relatively few moose to the Unit 14 harvest and historically provides for limited hunter participation. Post-hunt surveys have not been conducted since 1994, and only 4 have been conducted within the last 10 years. The 1994 survey indicated an increase in population size compared with surveys from 1992 and 1990, indicating a rebound in size form the severe winter in 1989–90 (Table 3). Three surveys were conducted in the 5 years pre-SF/50, and had a mean bull:100 cow ratio of 26:100

(Fig. 9). The sole survey post-SF/50 yielded a bull:100 cow ratio of 31. The objective range for this subunit is between 20 and 25:100.

In 1988 and 1989, a mean of 955 hunters participated annually in this subunit. After the 1990 season, which was closed, hunter participation declined markedly (Fig. 10). During the 10-day seasons imposed in 1991 and 1992, a mean of 331 hunters participated. A similar number participated annually in 1993 and 1994 during 32-day SF/50 seasons. Since 1995, an additional 26 days has been added to the season for harvesting S/F bulls. For the 3 years when those regulations were active, a mean of 482 hunters participated annually. Prior to S/F50, hunter success averaged 15%. Post-SF/50, success decreased and has remained relatively constant, with a mean of 10% (Fig. 10).

As was the case with subunit 14A, harvest was related to hunter participation, both for pre-SF/50 ($r = 0.92$, $P < 0.01$) and post-SF/50 ($r = 98.5$, $P < 0.01$). Total harvest averaged 157 bulls for the 30-day seasons in 1988 and 1989 (Fig. 11). For the 10-day seasons of 1991 and 1992, the average was 43.5. Harvest has generally increased since SF/50 was implemented, but has remained much lower (mean = 43) than that of the late 80s. Proportions of the harvest comprised of the 3 antler classes have varied over the last 5 years. The one apparent trend is a slight increase in percentage of yearlings in the harvest. Mean proportions of the harvest composed of yearlings, sub-50", and ≥50" bulls are 38%, 20%, and 38% respectively (the total does not equal 100% due to a small percentage of nonclassified bulls).

Unit 16A

Population estimates indicate that this subunit lost perhaps 37% of its moose during the 1989-90 winter. Since that time, estimates have increased steadily but are still lower than the 1988 estimate (Table 3). Bull:cow ratios are high in this subunit, both before and after SF/50 (Fig. 12), and are exceeding the objective range of 20–25:100. The ratio of small bulls:100 cows has remained relatively constant, in the range of 10–12:100.

Total numbers of hunters in this subunit decreased after implementation of SF/50 (Fig. 13). Pre-SF/50 numbers averaged 1205 for the 30-day seasons held in 1988 and 1989. The season for 1990 was 10 days long and attracted 510 hunters. Fifteen-day seasons in 1991 and 1992 averaged 853 participants. Post-SF/50 seasons have averaged 650 hunters and generally have seen increases every year. Success rates decreased after the 1990 season (24% for 1988/1989 to 16% for 1991/1992) and remained low after implementation of SF/50 but generally have been increasing since 1993, approximately 20% (Fig. 13).

Harvest has followed the same trend as total hunters. Mean harvest for 1988 and 1989 was 291 (30-day season). This decreased to 153 (15-day season) for 1991 and 1992 after 37 were harvested in 1990. Post-SF/50 harvest has increased from 70 in 1993 to 141 in 1997 (Fig. 14). The dramatic jump in annual harvest seen between 1995 and 1996 is attributable only partially to the late season spike-fork harvest, but is also a result of the increase in hunters (these 2 factors are difficult to separate totally).

Unit 16B

This subunit is by far the least exploited of those considered in this study. Population estimates are few, but indicate a decrease in size due to the severe winter of 1989–90 (Table 3). No surveys have been conducted since 1994, at which time the population size was considered to be lower than at any time since 1988. Bull:cow ratios are very high, and do not seem to be affected by SF/50 (Fig. 15). Total bulls:100 cows averaged 36:100 prior to SF/50 and averaged 33 thereafter. Small bulls:100 cows averaged 10 prior to SF/50 and averaged 8 thereafter. Although this might seem like an effect of SF/50, the harvest level relative to the estimated population size is too small for this to be likely.

Total hunters averaged 1,022 annually prior to 1990 (44-day season) and 779 in 1991 and 1992 (34-day and 40-day seasons, respectively, Fig. 16). A 24-day season in 1990 saw 420 hunters. Success rates in this unit also are very high (Fig. 16), ranging from 16-30% prior to SF/50 and ranging from 23–32% thereafter. Success rates have been increasing since SF/50 was implemented. Annual harvest prior to 1990 averaged 305, and this decreased to 202 for 1991 and 1992 (Fig. 17). For the SF/50 years, harvest has been increasing but has not yet reached the levels observed prior to 1990.

Late-season spike-fork harvests

Beginning in 1995, a late season was opened in subunits 14A, 14B, and 16A to allow for additional opportunity to harvest spike/fork bulls. This season runs from 20 November through 15 December. Although this season adds another 26 days in which to harvest a spike/fork bull, the impact of this season on total harvest is not straightforward. In all subunits, the total harvest of yearlings increased after this season was added, but the chronology of harvest was unusual. Harvest of yearlings declined dramatically in all three subunits in the early season for 1995 and 1996 (Table 4). In 1997, early-season harvest in 14A and 14B returned to levels seen prior to implementation of the late season, but levels remained lower in subunit 16A. It seems, therefore, that the harvest from the late season hunt is not totally additive to total harvest.

Conclusion

For Units 14 and 16, bull:cow ratios and estimates of population size indicate that more bulls could be harvested in these units without jeopardizing population status, particularly subunits 14B, 16A, and 16B. Methods for increasing harvest in these areas include reducing the number of bulls classified as illegal by antler type (e.g., return to an any-bull season, or reduce the 50" minimum to some lower threshold), or increase hunter opportunity by extending the season. Return to an any-bull season in heavily exploited areas, such as Subunit 14A, has the potential to lead to excessive harvests that would lower bull:cow ratios below objective levels, particularly in seasons following severe winters. For unit 16, an any-bull season may not be unreasonable from a biological perspective. Reduction of the minimum spread threshold would likely cause a decrease in genetic potential for antler growth, particularly if harvest and participation continue to increase.

III. Nelchina Basin (Unit 13)

Unit 13A

Between 1985 and 1992, regulations for this subunit differed markedly from those for the remainder of the unit. Through 1989, a spike-fork season for residents and nonresidents was in place, and this was restricted to residents only from 1990-1992. One hundred drawing permits for any bull were made available in 1987. This was increased to 200 any-bull permits in 1988 as well as 25 permits for cows. Additionally, subsistence permits were first made available in 1988. In 1989, 300 any-bull permits were available and subsistence bull permits were issued as registration permits. In 1990, the 20-day spike-fork season was reduced to 5 days, and a Tier II season was instituted in December. In 1991 and 1992, the subunit was divided into two sections, with one having a SF/50 season and the other remaining spike-fork.

Before 1993, harvest in this subunit was limited, primarily by confining harvest to spike-fork animals. This resulted in a large percentage of large bulls being accumulated in the area, which is evident in bull:cow ratios. These ratios increased from about 11:100 in 1980 to about 39:100 early in this decade (Fig. 18). Of interest is the lack of increase in small bull:cow ratios, due to the harvest of these animals. In fact, these ratios show a declining trend. In 1993, after implementation of SF/50, Bull:cow ratios declined to 22:100, and declined again the next year. From 1994-1998, these ratios have averaged 13.7:100. Ratios of small bulls:100 cows continue to remain low, ranging between 1 and 6 for the last 4 years. Moose seen per hour of aerial survey time is a good index of population size in this unit. In subunit 13A, moose per hour varied generally between 60 and 80/hour throughout the 1980s and early 1990s. This declined to 55 and 52 in 1997 and 1998, respectively (Fig. 19).

Number of hunters in this subunit increased slowly but steadily throughout the 1980s, but declined in 1990 due to the effects of a severe winter, and remained low through 1992 (Fig. 20). When SF/50 was instituted, a doubling in hunter numbers was observed. This most likely can be attributed to the large number of mature bulls available in this unit due to past management practices. Hunter numbers stayed high in 1994 (above 2000) but have declined slowly since then, with 1551 hunters participating in 1997. Success varied considerably throughout the 1980s, but was usually within 15–20% (Fig. 20). Success rates increased during the years 1990–1992 when there were low levels of participation. Success remained high in 1993 when the large bulls were made legal, but dropped precipitously in 1994 to 12%, where it has remained.

Harvest of bulls in this subunit ranged from 100 to 200 annually during the 1980s and early 1990s (Fig. 21). Harvest of spike-fork yearlings in 1989 was 99, with an additional 175 bulls taken by drawing permit and subsistence permit holders. Total harvest declined during 1990–1992 due to the elimination of drawing and subsistence permit hunts as mandated by the McDowell decision. Harvest in 1993 was 500 bulls, which represented the taking of an accumulation of mature bulls built up due to prior regulations. Following that year, harvest has declined every year, with 185 moose taken in 1997.

Unit 13B

Population density, as inferred from moose/hour estimates, peaked at about 80 moose/hour in the mid to late 1980s and began to decline before implementation of SF/50

(Fig. 19). Since 1992, the moose/hour estimates have varied between 50 and 60. Bull:cow ratios followed a similar pattern, peaking in 1985 (35:100) and declining until 1994 (18:100). It rose to 20:100 in 1997 and 1998 (Fig. 22). Ratios of large bulls:cows was more highly correlated to total bulls:100 cows (r = 0.9) than was small bull:cow ratios (r = 0.6), indicating that although both components were changing, abundance of large bulls accounted for most of the change in bull:cow ratios.

Hunter numbers increased steadily in this unit in the early and mid 1980s and stabilized somewhat at about 1250 hunters in the late 1980s (Fig. 23). From 1990 to 1992, numbers declined to between 734 and 830. Since inception of SF/50, hunter numbers have varied between 1296 and 1693. The slight rise in hunter numbers seen after 1994 may be associated with a corresponding decrease seen in Subunit 13A. Success rates varied between 25 and 30% during the mid 1980s to early 1990s. In 1992 success declined to 22%, and success has remained at approximately 15% since 1993 (Fig. 23).

Harvest followed a similar pattern to hunter numbers: rising throughout the 80s to peak between 300 and 400 annually from 1986 to 1989 (Fig. 24). Harvest was down from 1990 to 1992 but increased again in 1993, the first year of SF/50, and has generally increased since then, with a maximum of 274 bulls harvested in 1996.

The decline in harvest seen in Subunit 13B halted the decline in bull:cow ratios and caused them to stabilize. This, in association with a 28% decline in moose/hour since the peak in the late 1980s, indicates a declining population. Low ratios of yearling bulls:100 cows indicate poor recruitment. Thus, any modifications in bull harvest strategy should keep harvest at the current level or decrease harvest to maintain or increase bull:cow ratios.

Unit 13C

Moose densities in subunit 13C rose from approximately 60 moose/hour in 1977 to a peak of 110 moose/hour in 1988. Densities declined to a low of 59 moose/hour in 1992, remained between 75 and 80 moose/hour from 1993 to 1997, and declined to 54/hour in 1998. Bull:100 cow ratios ranged between 25:100 and 32:100 in the late 1970s and early 1980s but have ranged from 20 to 28:100 since 1990 (Fig. 25). Changes in bull:cow ratios are closely correlated to ratios of small bulls:100 cows (r = 0.71), but not to ratios of large bulls:100 cows (r = 0.24). This indicates that changes in bull:cow ratios in this subunit are heavily dependent on yearling recruitment that varies annually.

Hunter participation and harvest correlate strongly in this subunit (r = 0.82), with an increase through the late 1980s, a low period from 1990 to 1992, and an increase during the SF/50 years (Fig. 26). Success has ranged generally between 30 and 45%, varying annually as the reverse of the trend in hunter numbers (Fig.26). The mean annual harvest for the years 1993–1996 (149) is exceeded only by the mean for 1986–1989 (159, Fig. 27).

Unit 13D

Moose/hour peaked in 1984 (53) and has decreased since that time, with an estimate of 20 in 1998. Such low densities tend to dissuade hunters; therefore, bull:cow ratios are very high with a maximum of 89:100 in 1993 (Fig. 28), which is a ratio expected in an unhunted population. Yearling bull:100 cow ratios have remained relatively constant, between 7 and 9:100.

Number of hunters increased from 264 in 1978 to 533 in 1986 and decreased to 244 in 1992 (Fig. 29). The first year of SF/50 saw a large increase in hunter participation (492 total hunters), that decreased to 348 in 1994 and increased to 384 in 1996. There is no clear trend in success rates, which have varied between 16 and 31% and have stayed between 18 and 25% since SF/50 was instituted (Fig. 29).

Harvest generally increased from 1978 to 1988, peaking at 125 bulls, and declined to 61 in 1992. Since SF/50, harvest has varied between 67 and 98 and has been fairly constant since 1994 with no apparent trend (Fig. 30).

Unit 13E

Moose/hour increased three-fold from 1975 to 1989 (32–94 moose/hr) and decreased to 37 moose/hour in 1998. Bull:cow ratios peaked at 33 in 1985 and have declined steadily to a low of 12 in 1998 (Fig. 31). Changes in abundance of yearlings ($r = 0.78$) and large bulls ($r = 0.76$) contribute equally to changes in overall bull:cow ratios.

Number of hunters increased through the late 1980s, peaking at 935 in 1989 (Fig. 32). From 1990 to 1992 the number of hunters averaged 532, and a great increase was noted once SF/50 was implemented. Mean annual number of hunters participating since 1993 is 1103. Success rates were fairly constant during the pre-SF/50 years, varying between 25 and 35% (Fig. 32), yielding a relatively constant harvest that averaged 204 bulls/year. From 1990 to 1992 harvest averaged 153, and since SF/50 was implemented harvest has averaged 211 annually (Fig. 33).

Unit analysis

The annual composition of the harvest under SF/50, broken down by antler size, indicates that the harvest of spike-fork yearlings increased from 1994 to 1997 (Fig. 34). Subunits 13B and 13E were the source for most of these additional yearlings, which may be the result of the increase in hunt participation in these units. Preliminary data for 1998 indicate that this increasing trend has ended. Conversely, the number of harvested midsize and large bulls peaked in 1995 and declined during the next 2 seasons. (Data from 1993 are excluded from the analysis of large bulls because of the bias introduced by the harvest of these animals Subunit 13A.) Preliminary data for 1998 indicate that harvest for these 2 size classes will exceed that for 1997 and may indicate a leveling-off. The percentage of midsize bulls has varied between 31 and 41%, with no apparent trend. Of harvested midsize bulls, a mean of 24% had 4 or more brow tines. This has varied little since 1993. Of those harvested large bulls, a mean of 43% has had 4 or more brow tines. This percentage peaked in 1994 (49%) and has declined to 31% in the preliminary 1998 data.

According to data collected from any-bull seasons held in Unit 13 from 1983 to 1985, 55% of yearlings had spike-fork antlers. In the 1998 composition count, however, 61% of bulls identified as yearlings in November were legal under spike-fork regulations. These data indicate that a proportion greater than 55% of yearlings in the pre-hunt population is legal. Preliminary harvest ticket returns compiled for 1998 indicate that 58% of harvested yearlings had at least a fork on one side. These animals represented 20% of the total harvest.

Changes in mean annual harvest between the pre-SF/50 years and those post-SF/50 indicate that harvest has decreased in all subunits except 13A (Fig. 35). To conduct this analysis we calculated the mean harvest from 1993 to 1997 and compared it to the mean from 1985 to 1989. The years 1990–1992 were not used because they represent unusually low harvests due to changes in permit systems. Additionally, data from Subunit 13A in 1993 were excluded from the analysis because of the unusually large harvest of mature bulls in that year. Subunit 13A yields a mean of 39 more moose annually since SF/50 was implemented, representing a 20% increase. Subunit 13B showed the largest decrease in mean annual harvest, 99 moose (33%). Subunits 13C and 13D showed small declines in mean annual harvest after SF/50, with slightly higher harvest of yearlings and large bulls counterbalanced by lower harvests of midsize bulls (Fig. 36). Subunit 13E showed the second largest absolute decrease in mean annual harvest (52 bulls, 20%), but 13D showed the second largest percentage decrease (26%). Yearling harvest is up in all subunits except 13D, with 13B and 13E showing the largest increases (Fig. 36). All subunits exhibited a decrease in mean annual harvest of midsize bulls, with the Subunits 13B and 13E having the largest decreases. Harvest of large bulls is up in all subunits, with the largest increase (37) in Subunit 13A.

Comparison of antler structure with other areas

Comparison of the prevalence of different antler types in the harvest indicates the differences among these units (Fig. 37). As a percentage of total harvest, Units 7 and 15 and 14 had similar levels of yearling harvest (62% vs. 63%), substantially higher than those in Unit 16 (21%) and Unit 13 (27%). Conversely, Units 7 and 15 had the fewest midsized bulls, (16%) as opposed to 36% for Unit 13. In Unit 16, 56% of the harvest is large bulls, whereas 37% of the Unit 13 harvest was large bulls. Large bulls made up less than 25% of the harvest in Units 7 and 15 and 14. For large bulls, 52% of those in Unit 13 had ≥4 brow tines, whereas those in Units 14 and 16 composed 30% with ≥4 brow tines (Table 5). Of animals in the midsize class, 23% of those in Unit 13 had ≥4 brow tines, and 19% of those in Units 14 and 16 had ≥4 brow tines. Units 7 and 15 had 17% of midsize bulls and 22% of large bulls with ≥4 brow tines.

Conclusion

For Unit 13, harvest should be reduced, at least in Subunits 13A, 13B, and 13E due to less than optimal bull:cow ratios. Methods available for reducing harvest include reducing hunter opportunity by a shortened season length, classifying fork-antlered bulls as illegal, and reducing the number of large legal bulls by raising the legal minimum number of brow tines to 4 from 3.

Reduce season length: Reduction of season length, particularly a reduction of at least 10 days, probably will reduce hunter numbers, but it is difficult to predict the extent of the decrease.

Spike-50" season: Eliminating fork-antlered bulls from the harvest will increase bull:cow ratios. Based on preliminary harvest data for 1998, 58% of harvested yearlings would become illegal. This equates to 143 animals, 20% of the total harvest. It is difficult to predict the effect of this strategy on numbers of mature bulls in the population. Surely there will be some increase, but some proportion of the conserved yearlings will become legal before reaching 50" because of brow tines.

Increase brow tines from 3 to 4: Increasing the minimum number of brow tines to 4 would be expected to decrease harvest of midsize bulls by approximately 77% (218 bulls annually, based on harvests from 1994 to 1996). Additionally, some proportion of large bulls would escape harvest. These would be animals that would not be harvested because they were too close to the 50" limit and had only 3 brow tines. After one year of such a program, the harvest of older bulls probably would increase as animals conserved in the midsize class from the prior year became legal, either with 4 or more brow tines or with spreads greater than 50".

A computer model was developed by W. Testa (ADF&G, Anchorage) to determine the effect of these additional antler restrictions on total harvest and bull:cow ratios in Unit 13. The results of this exercise are informative concerning the relative effects of the different harvest strategies, but we do not wish to place too much emphasis on absolute numbers. The first simulation compared the current regulations (SF/50/3 brow tines) to SF/50/4 brow tines. Bull:100 cow ratios for Unit 13 remained constant at 16 under the current regulations. Under SF/50/4, this ratio increased to 20 over a period of 3 years and remained stable thereafter (Fig. 38). The second simulation evaluated the effect of spike/50/3 versus spike/50/4 strategies. S/50/3 produced an increase in bull:100 cow ratio to 21 over a 4-year period, whereas S/50/4 produced an increase to 26 over the same period (Fig. 39). S/50/4 probably would be too restrictive, so further comparisons are restricted to SF/50/4 and S/50/3. These two strategies produce similar results concerning bull:100 cow ratios (Fig. 40) and harvest reduction (Fig. 41). One difference between the two is the slightly larger increase in ratio of mature (≥ 4 years old) bulls:100 cows provided by SF/50/4 (Fig. 42).

The genetic ramifications of increasing the legal minimum for brow tines have not been determined, but a previous modeling effort (Hundertmark et al. 1993) determined that any SHS with a brow tine component would result in a decline in genes favorable for brow tine growth.

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Fig. 1

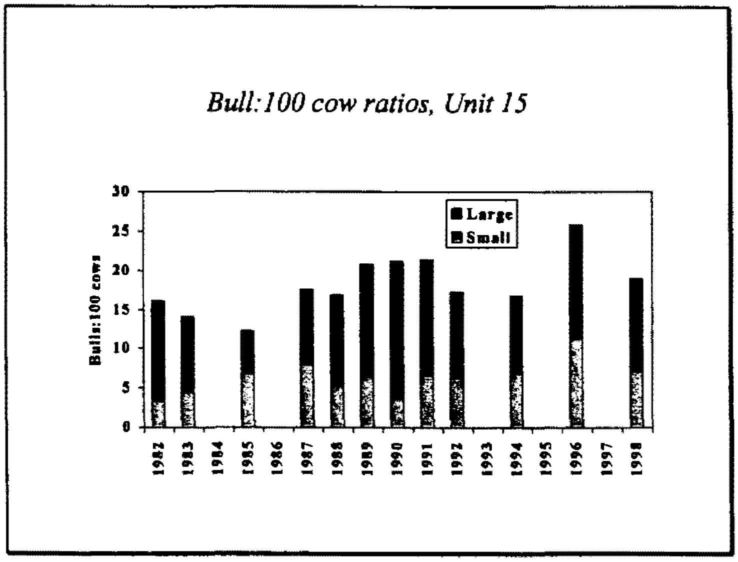

Bull:100 cow ratios, Unit 15
Large
Small
Bulls:100 cows
30
25
20
15
10
5
0
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998

Fig. 2

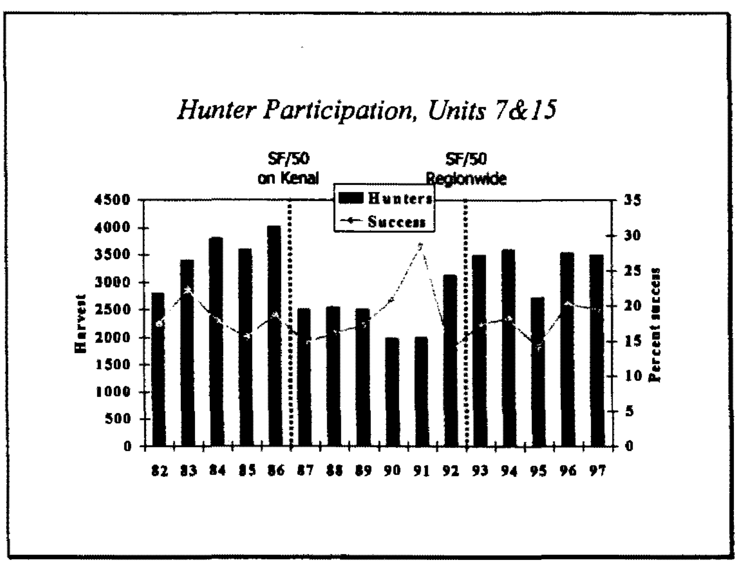

Hunter Participation, Units 7&15
SF/50
on Kenai
SF/50
Regionwide
Hunters
Success
Harvest
Percent success
4500
4000
3500
3000
2500
2000
1500
1000
500
0
35
30
25
20
15
10
5
0
82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97

Fig. 3

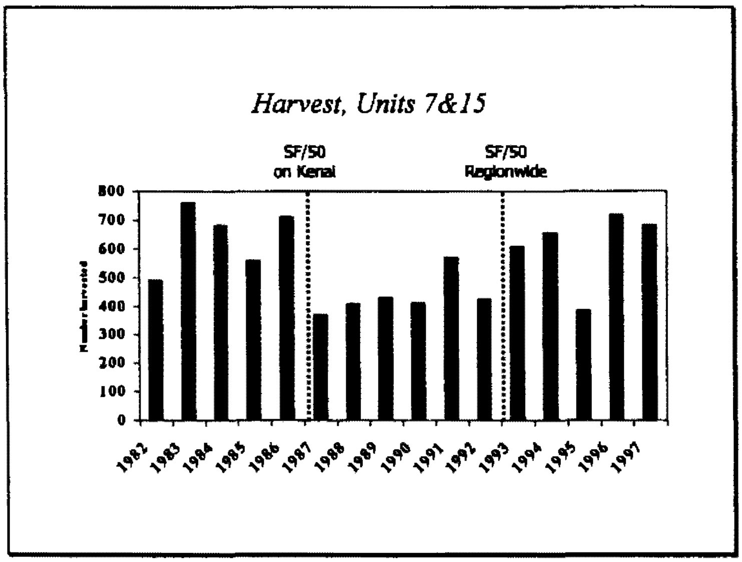

Harvest, Units 7&15
SF/50
on Kenai
SF/50
Regionwide
800
700
600
500
400
300
200
100
0
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997

Fig. 4

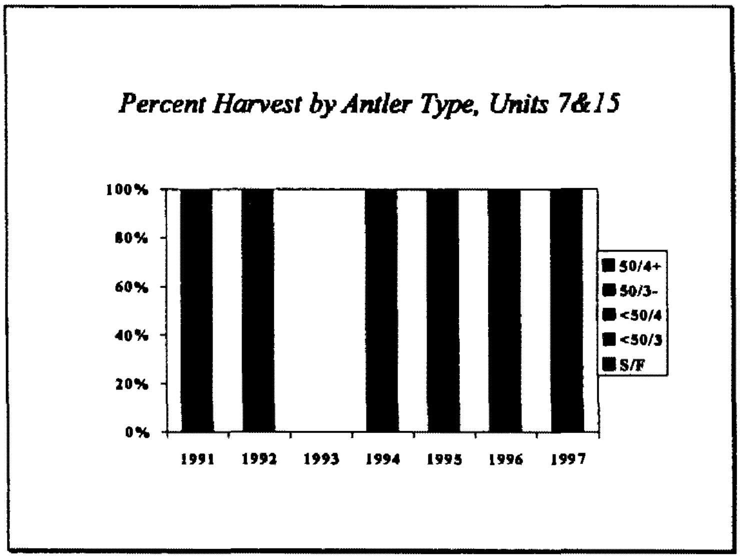

Percent Harvest by Antler Type, Units 7&15
100%
80%
60%
40%
20%
0%
1991
1992
1993
1994
1995
1996
1997
50/4+
50/3-
<50/4
<50/3
S/F

Fig. 5

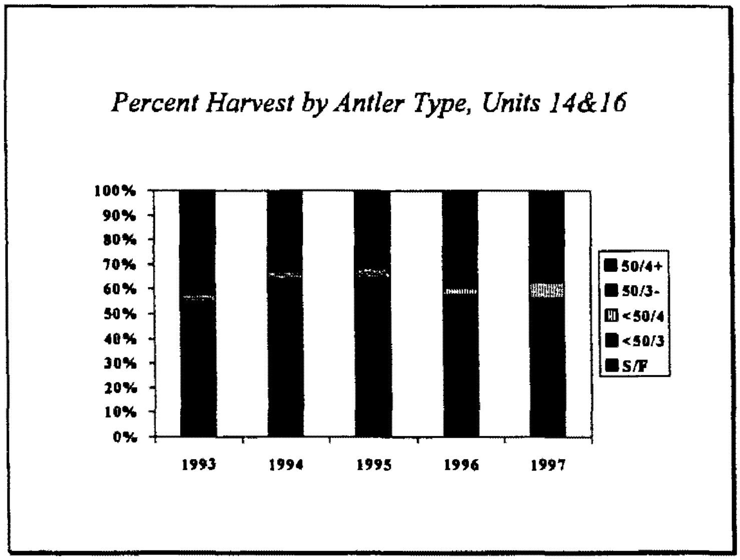

Percent Harvest by Antler Type, Units 14&16
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1993
1994
1995
1996
1997
50/4+
50/3-
<50/4
<50/3
S/F

Fig. 6

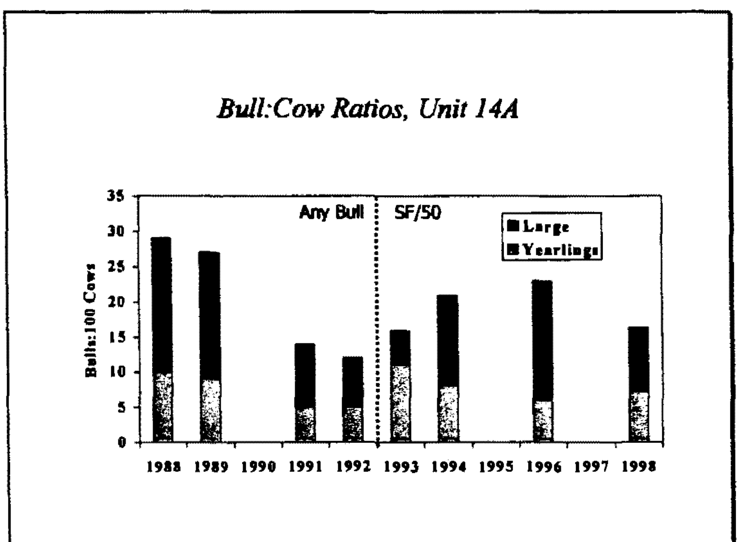

Bull:Cow Ratios, Unit 14A
Bulls:100 Cows
35
30
25
20
15
10
5
0
Any Bull
SF/50
Large
Yearlings
1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998

Fig. 7

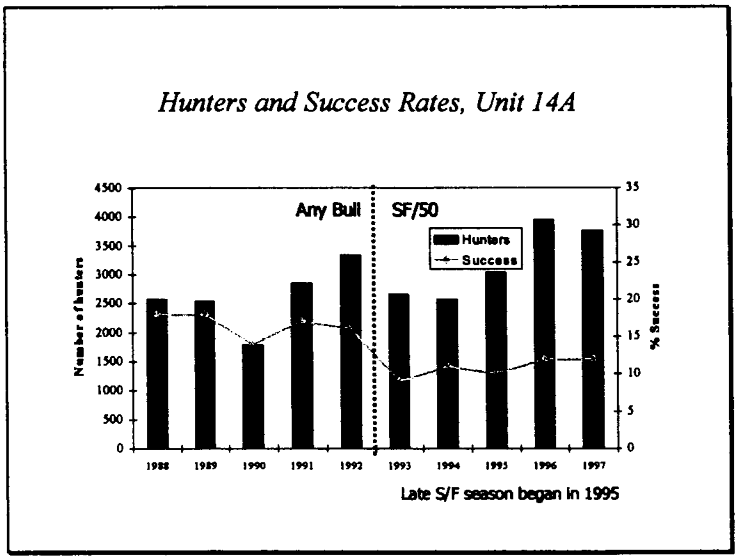

Hunters and Success Rates, Unit 14A
Any Bull
SF/50
Hunters
Success
Number of hunters
% Success
Late S/F season began in 1995

Fig. 8

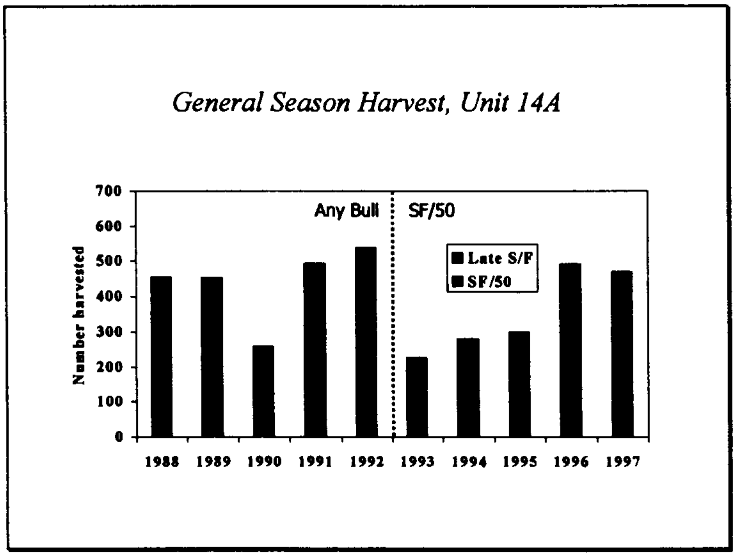

General Season Harvest, Unit 14A
Any Bull
SF/50
Late S/F
SF/50
Number harvested
1988 1989 1990 1991 1992 1993 1994 1995 1996 1997

Fig. 9

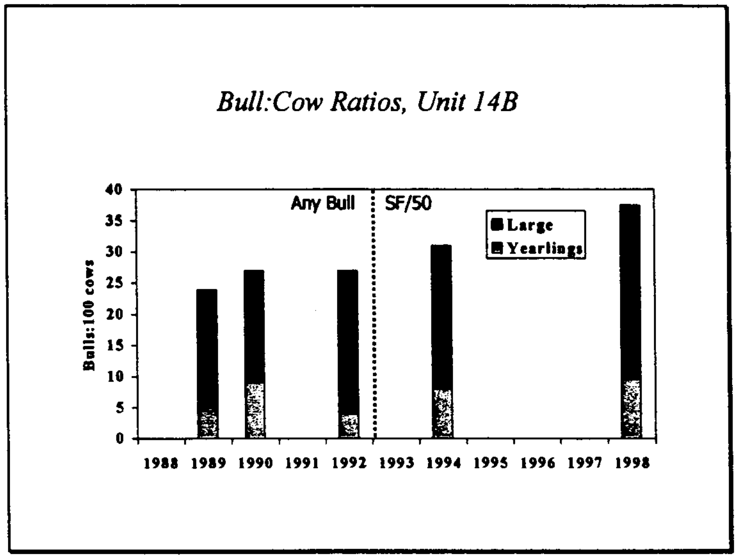

Bull:Cow Ratios, Unit 14B
Any Bull
SF/50
Large
Yearlings
Bulls:100 cows
40
35
30
25
20
15
10
5
0
1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998

Fig. 10

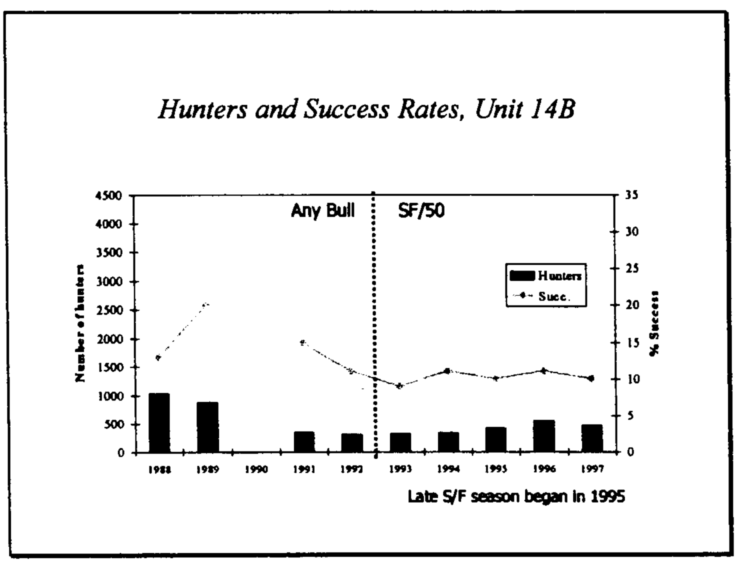

Hunters and Success Rates, Unit 14B
Any Bull
SF/50
Hunters
Succ.
Number of hunters
% Success
4500
4000
3500
3000
2500
2000
1500
1000
500
0
35
30
25
20
15
10
5
0
1988 1989 1990 1991 1992 1993 1994 1995 1996 1997
Late S/F season began in 1995

Fig. 11

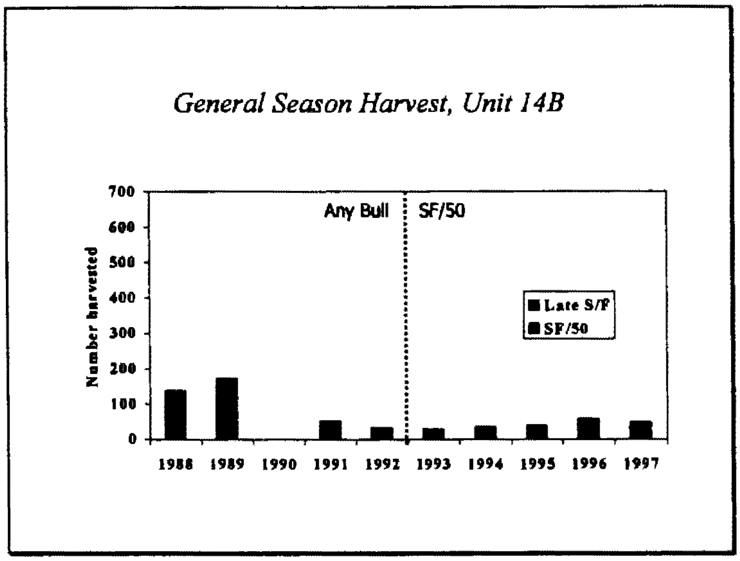

General Season Harvest, Unit 14B
Any Bull
SF/50
Number harvested
700
600
500
400
300
200
100
0
Late S/F
SF/50
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997

Fig. 12

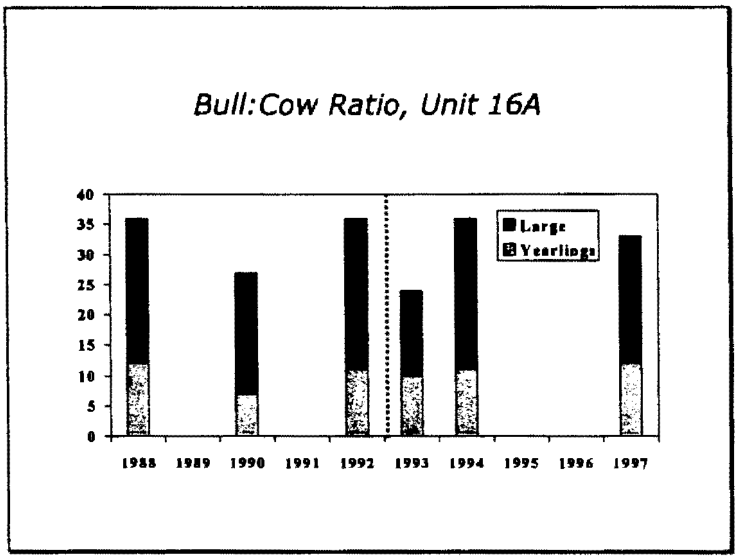

Bull:Cow Ratio, Unit 16A
40
35
30
25
20
15
10
5
0
Large
Yearlings
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997

Fig. 13

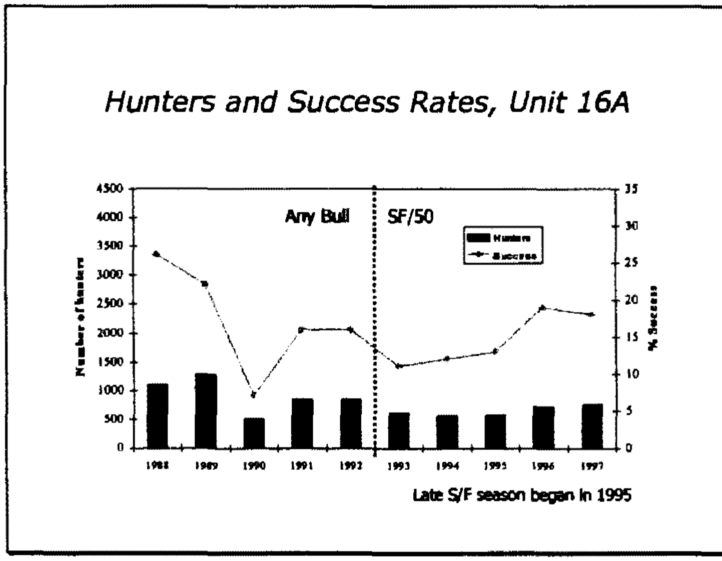

Hunters and Success Rates, Unit 16A
4500
4000
3500
3000
2500
2000
1500
1000
500
0
35
30
25
20
15
10
5
0
Any Bull
SF/50
Late S/F season began in 1995

Fig. 14

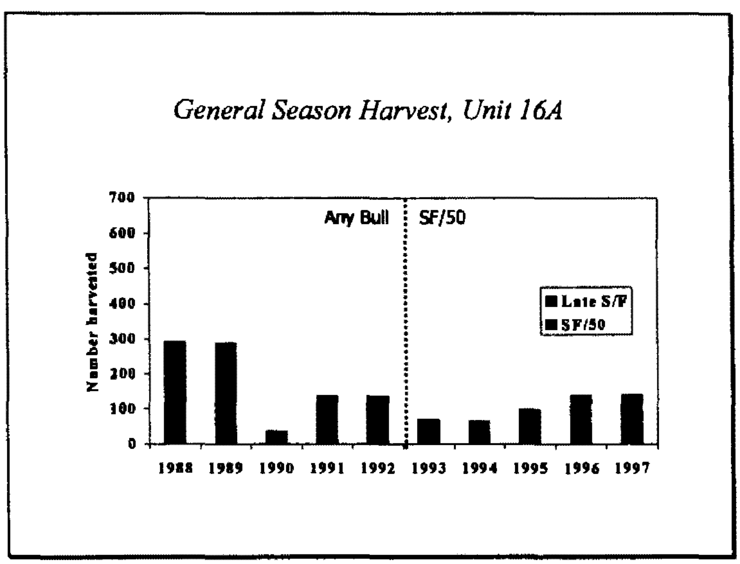

General Season Harvest, Unit 16A
Number harvested
700
600
500
400
300
200
100
0
Any Bull
SF/50
Late S/F
SF/50
1988 1989 1990 1991 1992 1993 1994 1995 1996 1997

Fig. 15

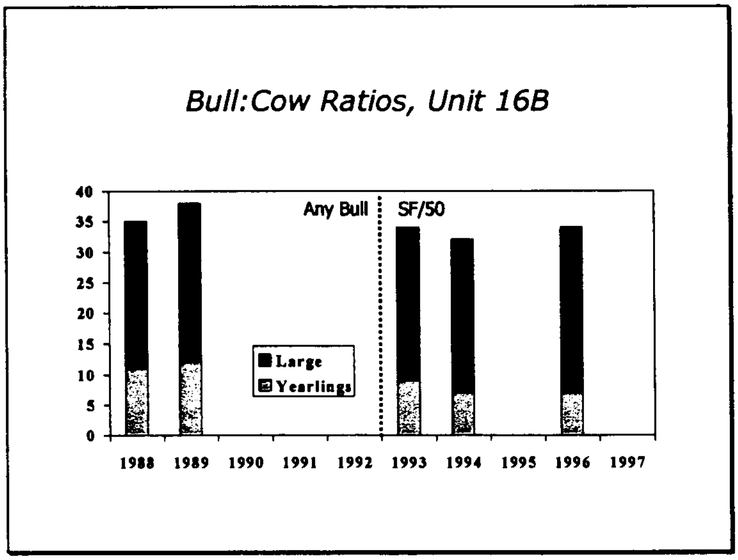

Bull:Cow Ratios, Unit 16B
40
35
30
25
20
15
10
5
0
Any Bull
SF/50
Large
Yearlings
1988 1989 1990 1991 1992 1993 1994 1995 1996 1997

Fig. 16

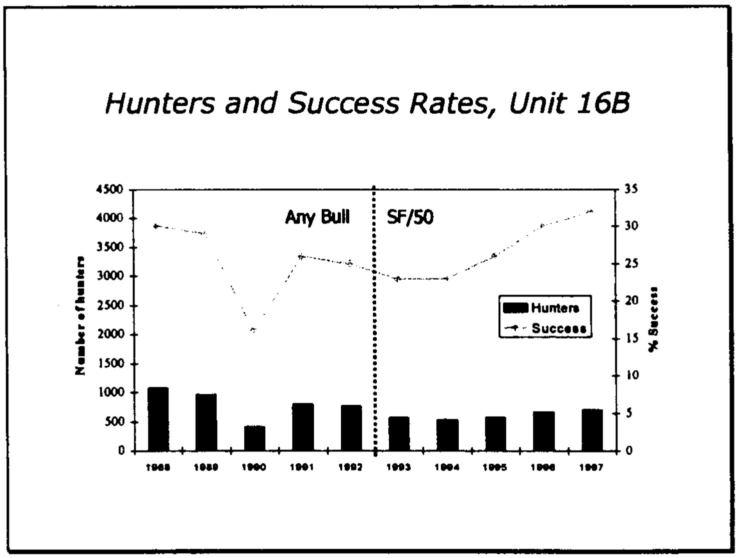

Hunters and Success Rates, Unit 16B
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Number of hunters
Any Bull
SF/50
Hunters
Success
35
30
25
20
15
10
5
0
% Success

Fig. 17

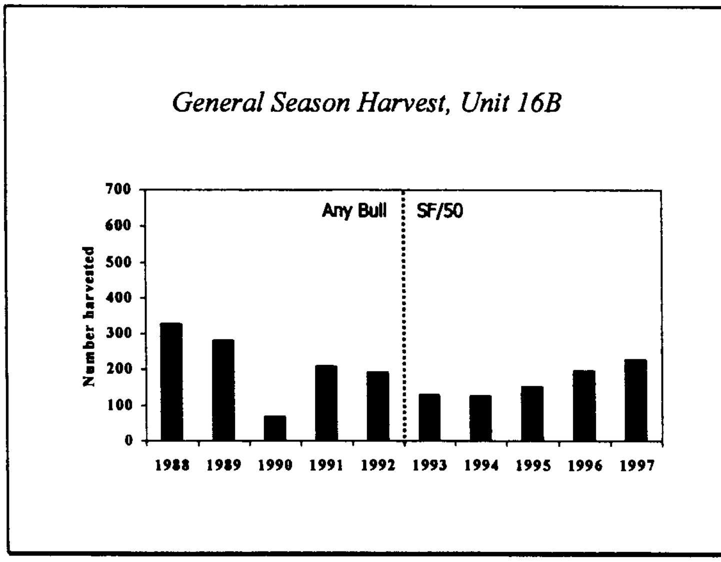

General Season Harvest, Unit 16B
Any Bull
SF/50
Number harvested
700
600
500
400
300
200
100
0
1988 1989 1990 1991 1992 1993 1994 1995 1996 1997

Fig. 18

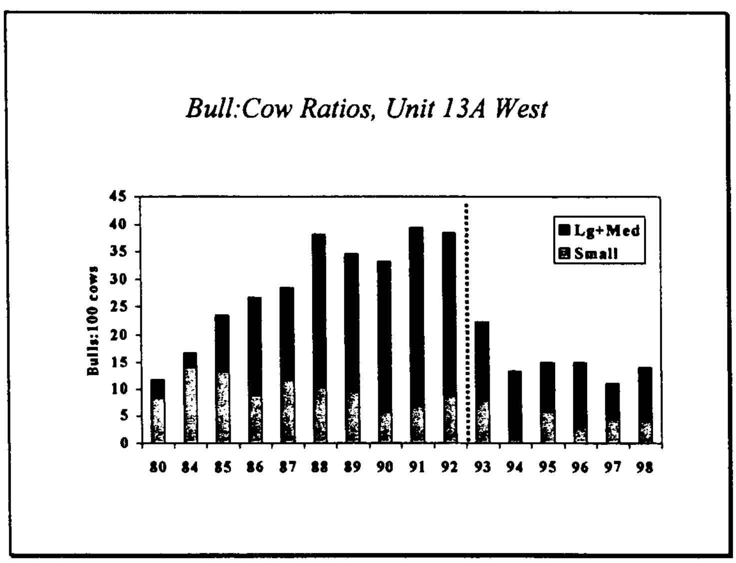

Bull:Cow Ratios, Unit 13A West
Lg+Med
Small
Bulls:100 cows
45
40
35
30
25
20
15
10
5
0
80 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98

Fig. 19

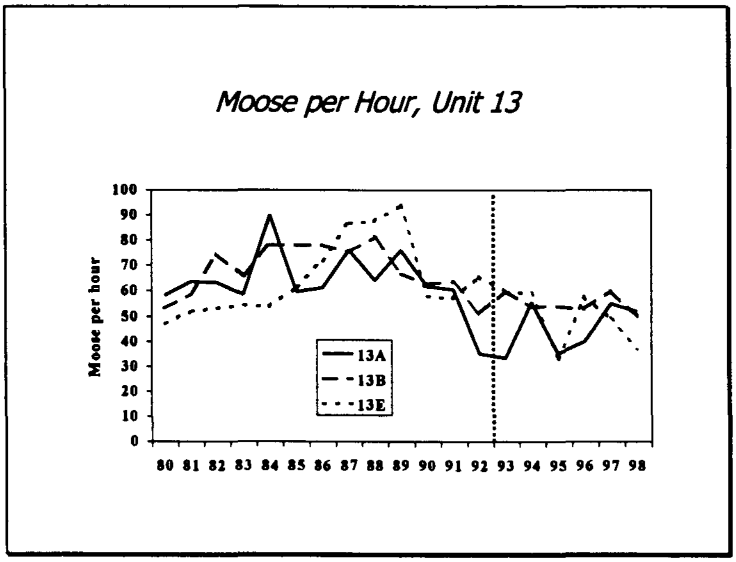

Moose per Hour, Unit 13
Moose per hour
100
90
80
70
60
50
40
30
20
10
0
13A
13B
13E
80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98

Fig. 20

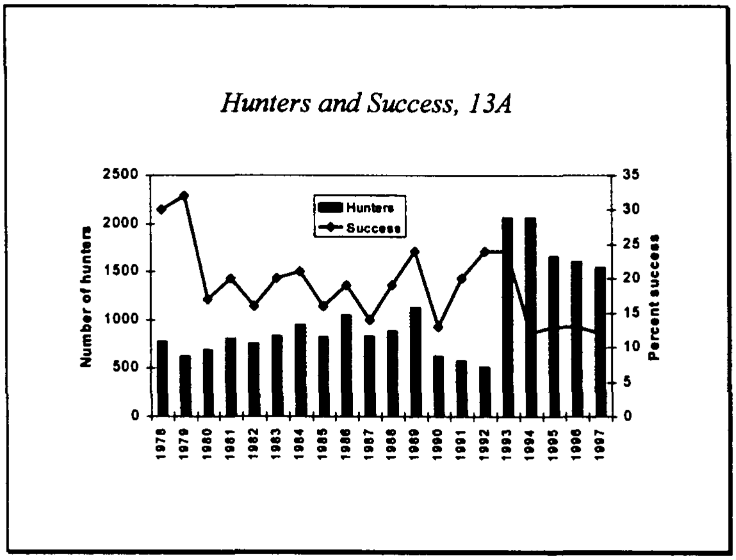

Hunters and Success, 13A
Number of hunters
2500
2000
1500
1000
500
0
Hunters
Success
Percent success
35
30
25
20
15
10
5
0
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997

Fig. 21

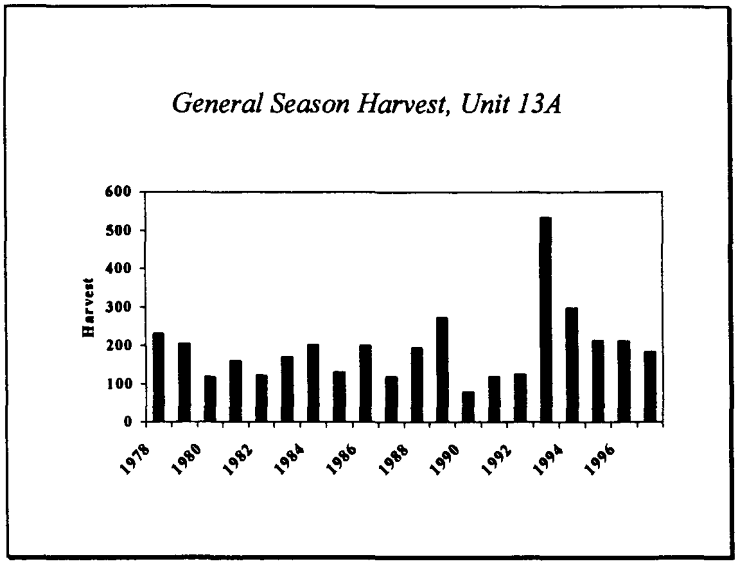

General Season Harvest, Unit 13A
Harvest
600
500
400
300
200
100
0
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996

Fig. 22

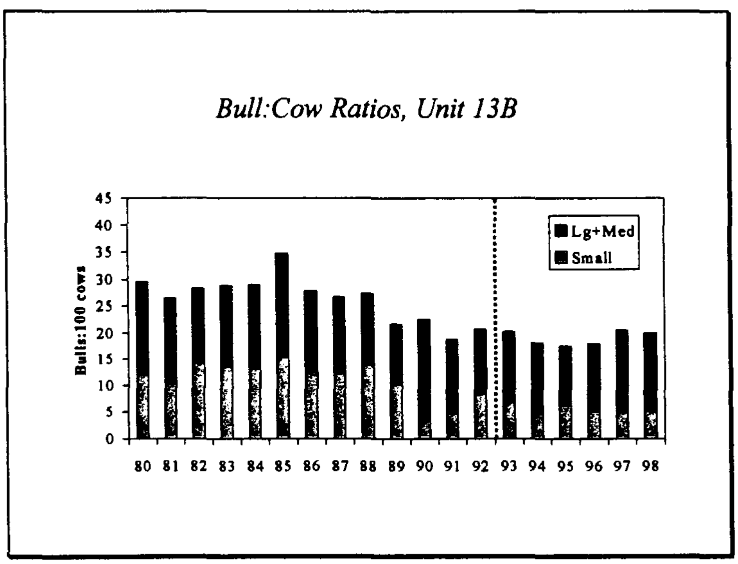

Bull:Cow Ratios, Unit 13B
Bulls:100 cows
45
40
35
30
25
20
15
10
5
0
Lg+Med
Small
80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98

Fig. 23

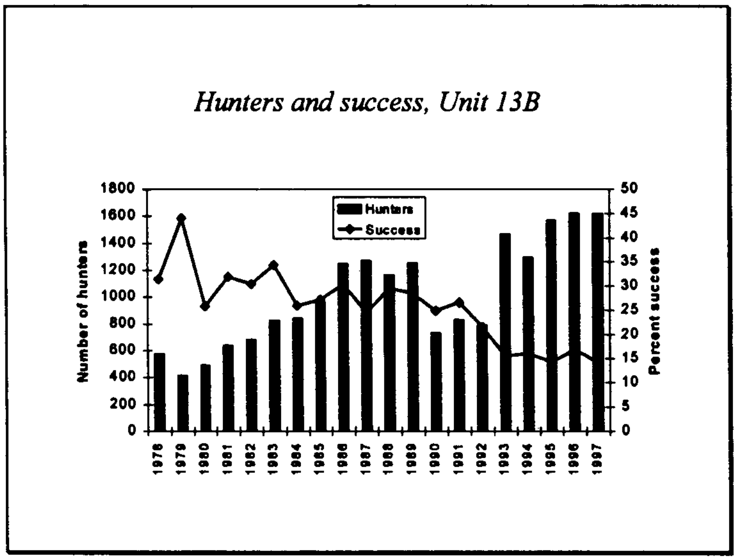

Hunters and success, Unit 13B
Hunters
Success
Number of hunters
Percent success
1800
1600
1400
1200
1000
800
600
400
200
0
50
45
40
35
30
25
20
15
10
5
0
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997

Fig. 24

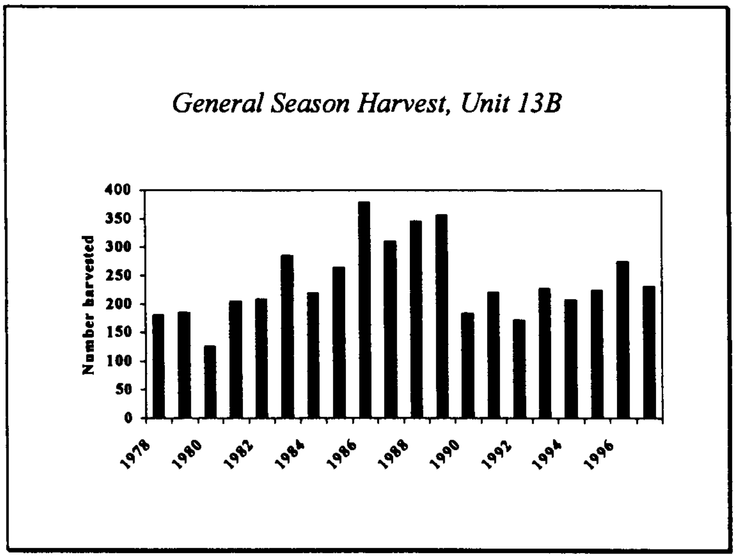

General Season Harvest, Unit 13B
Number harvested
400
350
300
250
200
150
100
50
0
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996

Fig. 25

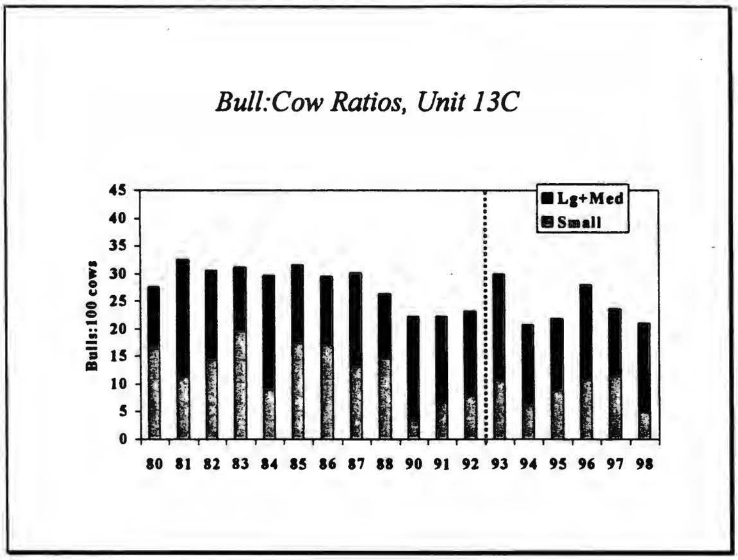

Bull:Cow Ratios, Unit 13C
Bulls:100 cows
45
40
35
30
25
20
15
10
5
0
Lg+Med
Small
80 81 82 83 84 85 86 87 88 90 91 92 93 94 95 96 97 98

Fig. 26

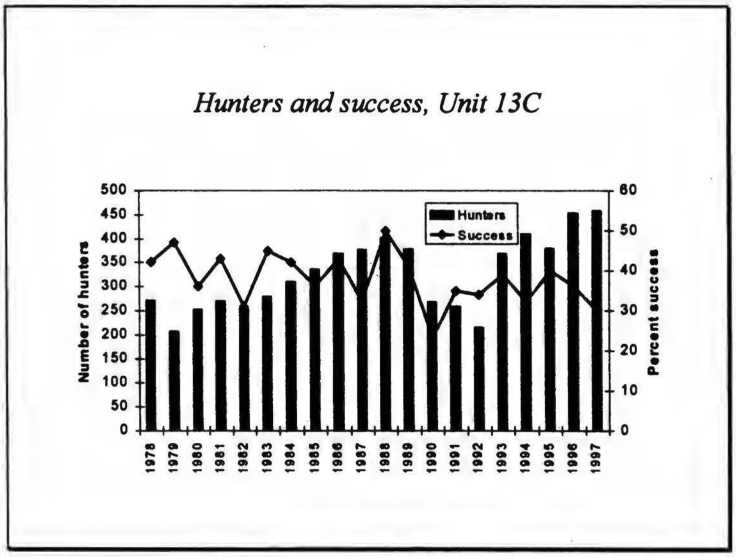

Hunters and success, Unit 13C
Number of hunters
500
450
400
350
300
250
200
150
100
50
0
Hunters
Success
Percent success
60
50
40
30
20
10
0
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997

Fig. 27

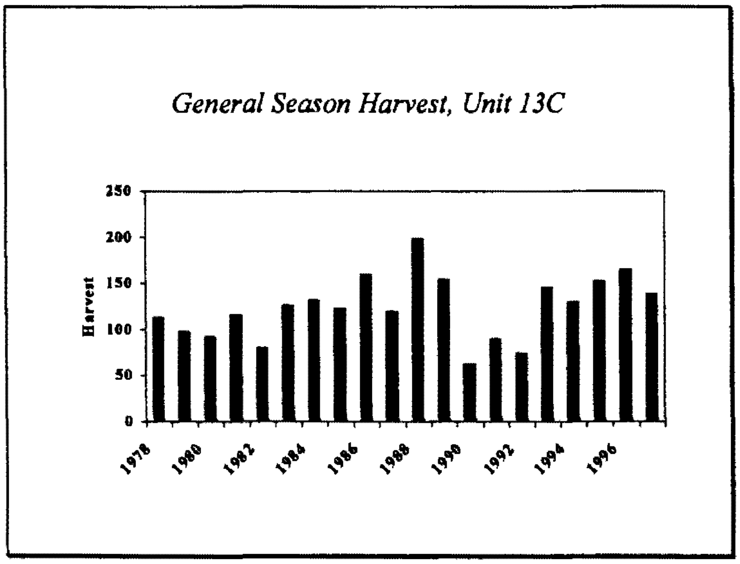

General Season Harvest, Unit 13C
Harvest
250
200
150
100
50
0
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996

Fig. 28

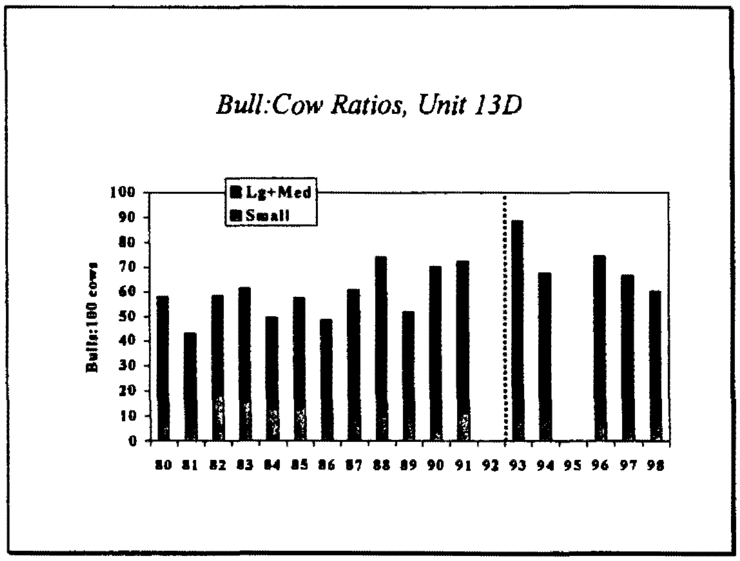

Bull:Cow Ratios, Unit 13D
Lg+Med
Small
Bulls:100 cows
100
90
80
70
60
50
40
30
20
10
0
80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98

Fig. 29

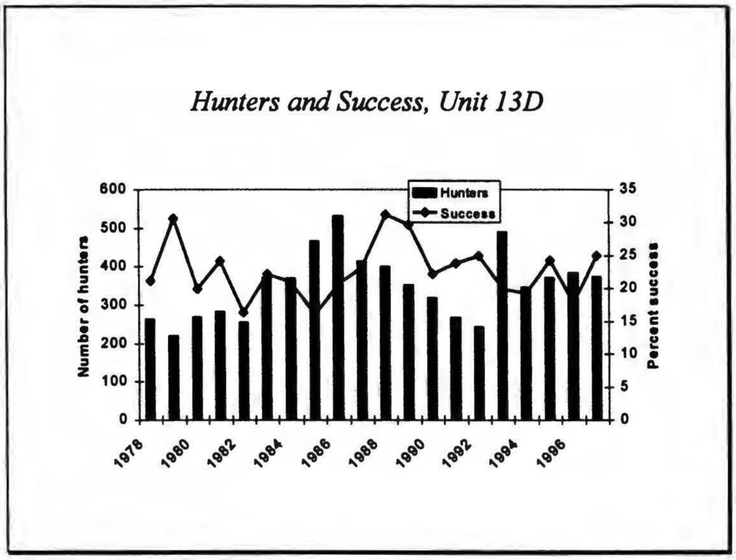

Hunters and Success, Unit 13D
Hunters
Success
Number of hunters
Percent success
0
100
200
300
400
500
600
0
5
10
15
20
25
30
35
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996

Fig. 30

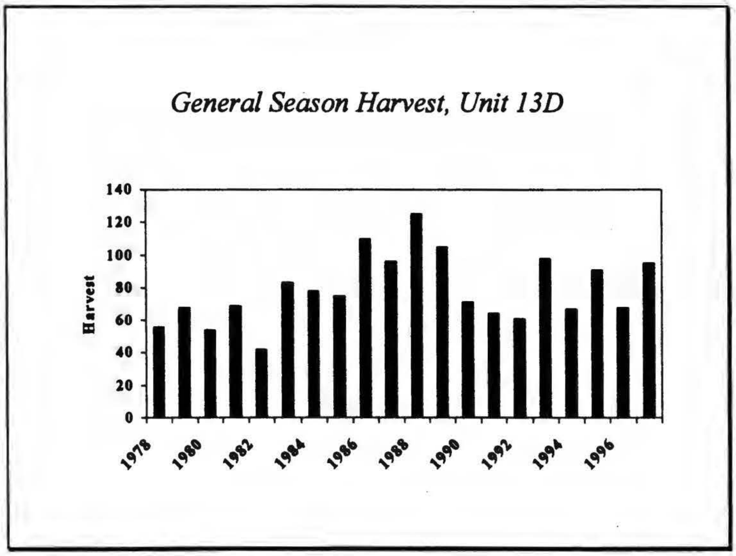

General Season Harvest, Unit 13D
Harvest
0
20
40
60
80
100
120
140
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996

Fig. 31

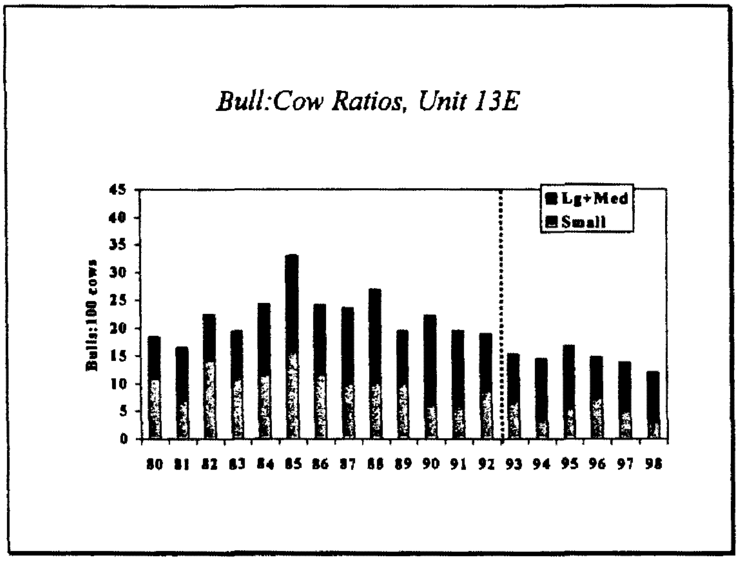

Bull:Cow Ratios, Unit 13E
Bulls:100 cows
Lg+Med
Small
0
5
10
15
20
25
30
35
40
45
80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98

Fig. 32

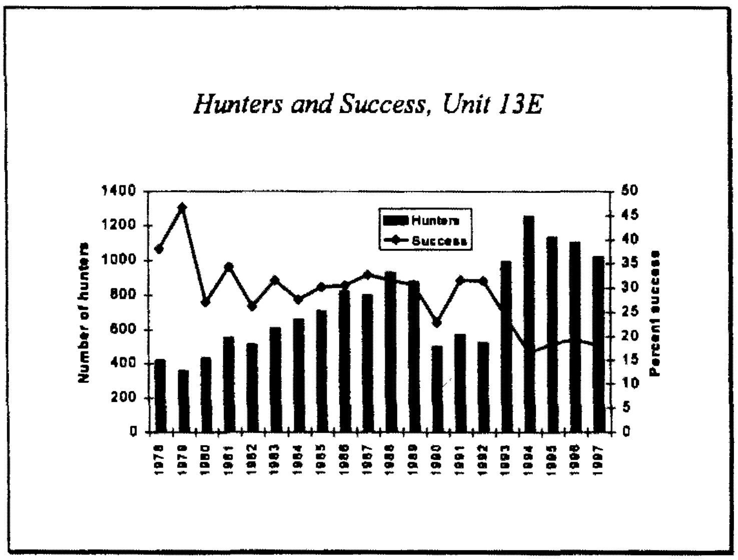

Hunters and Success, Unit 13E
Number of hunters
Percent success
Hunters
Success
0
200
400
600
800
1000
1200
1400
0
5
10
15
20
25
30
35
40
45
50

Fig. 33

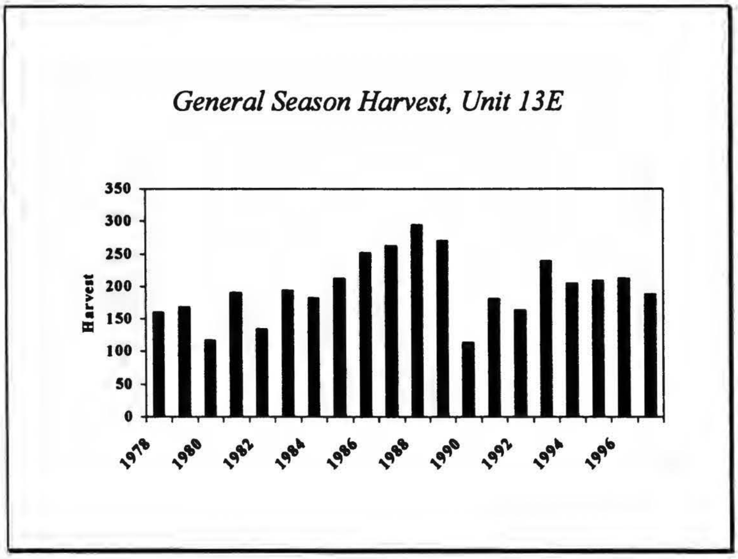

General Season Harvest, Unit 13E
Harvest
350
300
250
200
150
100
50
0
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996

Fig. 34

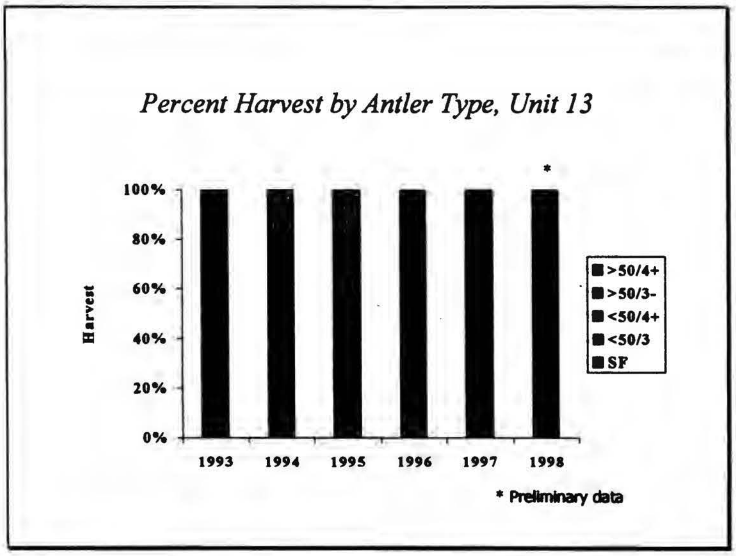

Percent Harvest by Antler Type, Unit 13
*
Harvest
100%
80%
60%
40%
20%
0%
1993
1994
1995
1996
1997
1998
>50/4+
>50/3-
<50/4+
<50/3
SF
* Preliminary data

Fig. 35

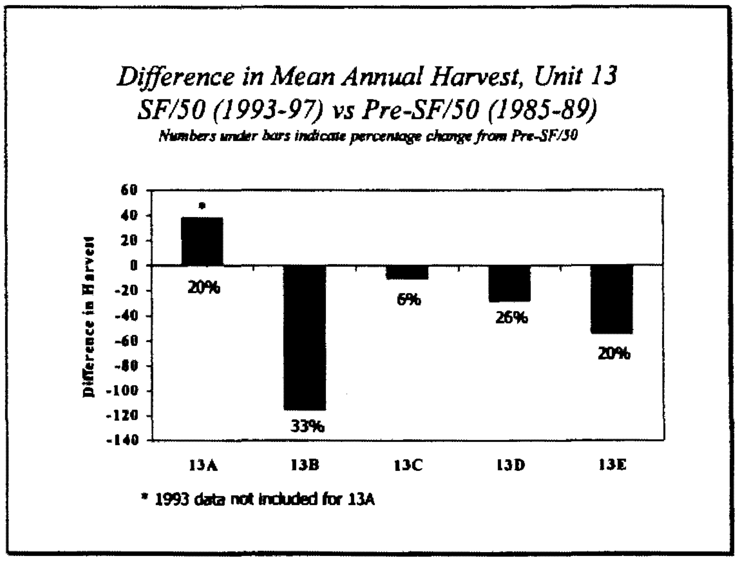

Difference in Mean Annual Harvest, Unit 13
SF/50 (1993-97) vs Pre-SF/50 (1985-89)
Numbers under bars indicate percentage change from Pre-SF/50
Difference in Harvest
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
20%
33%
6%
26%
20%
13A
13B
13C
13D
13E
* 1993 data not included for 13A

Fig. 36

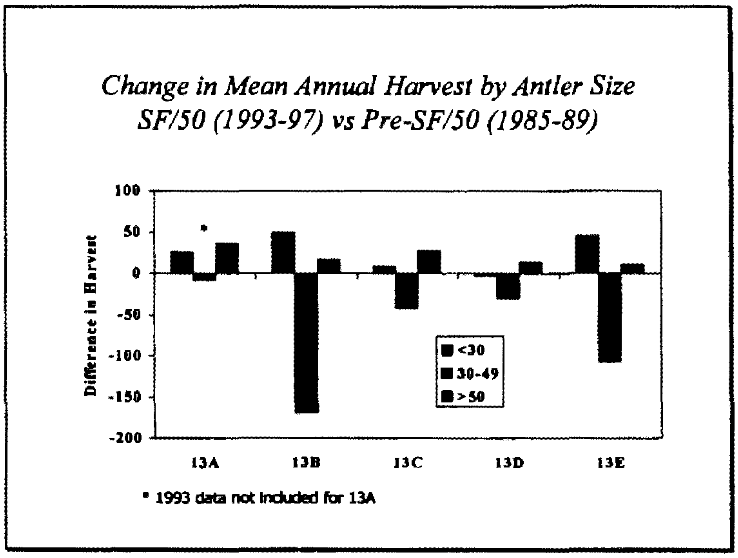

Change in Mean Annual Harvest by Antler Size
SF/50 (1993-97) vs Pre-SF/50 (1985-89)
Difference in Harvest
100
50
0
-50
-100
-150
-200
<30
30-49
>50
13A
13B
13C
13D
13E
* 1993 data not included for 13A

Fig. 37

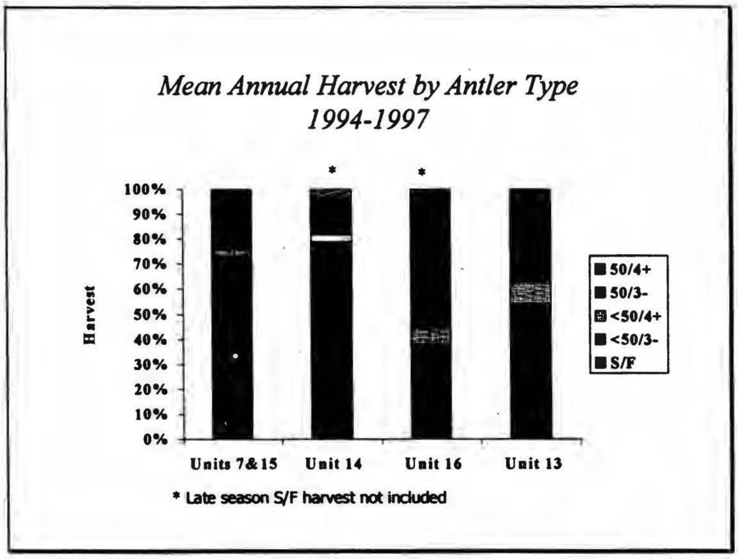

Mean Annual Harvest by Antler Type
1994-1997
Harvest
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Units 7&15
Unit 14
Unit 16
Unit 13
50/4+
50/3-
<50/4+
<50/3-
S/F
* Late season S/F harvest not included

Fig. 38

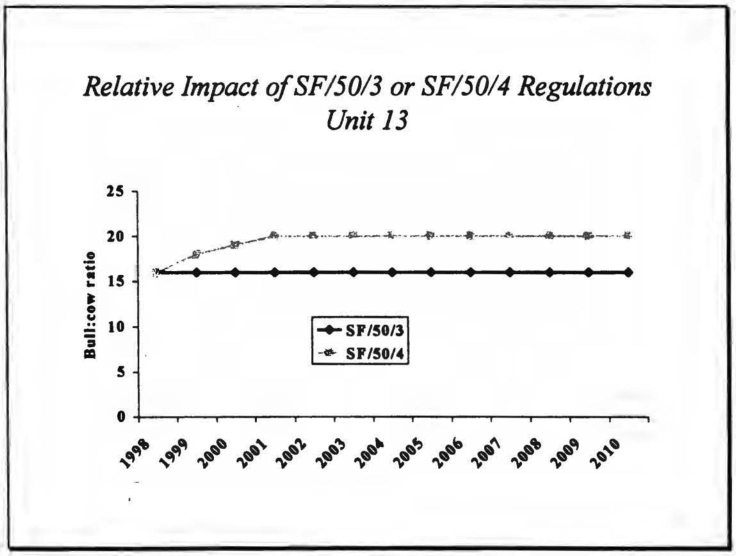

Relative Impact of SF/50/3 or SF/50/4 Regulations
Unit 13
Bull:cow ratio
25
20
15
10
5
0
SF/50/3
SF/50/4
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

Fig. 39

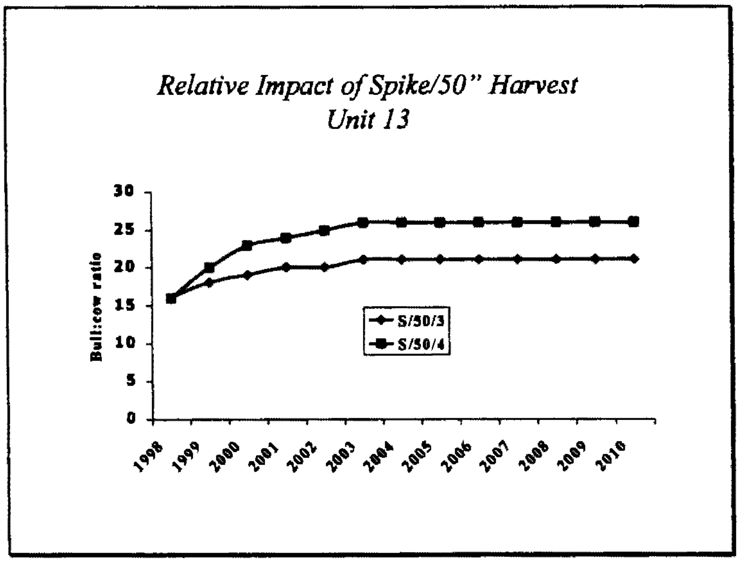

Relative Impact of Spike/50" Harvest
Unit 13
Bull:cow ratio
30
25
20
15
10
5
0
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
S/50/3
S/50/4

Fig. 40

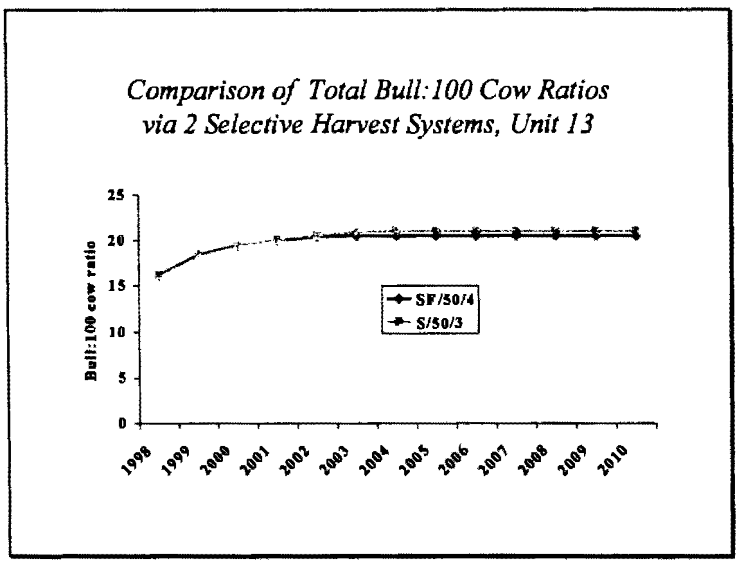

Comparison of Total Bull:100 Cow Ratios
via 2 Selective Harvest Systems, Unit 13
Bull:100 cow ratio
25
20
15
10
5
0
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
SF/50/4
S/50/3

Fig. 41

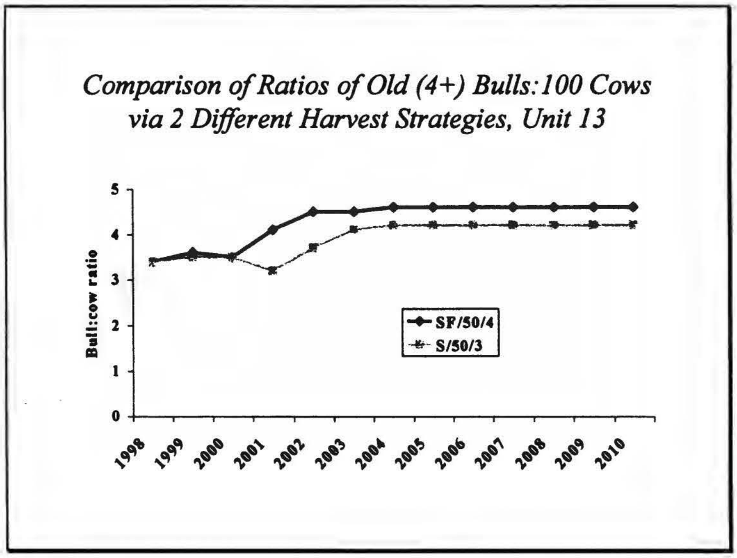

Comparison of Ratios of Old (4+) Bulls:100 Cows
via 2 Different Harvest Strategies, Unit 13
Bull:cow ratio
0
1
2
3
4
5
SF/50/4
S/50/3
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

Fig. 42

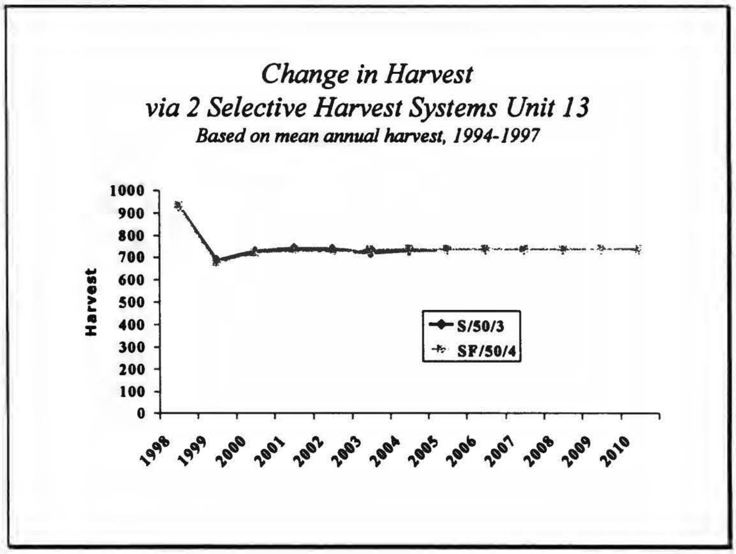

Change in Harvest
via 2 Selective Harvest Systems Unit 13
Based on mean annual harvest, 1994-1997
Harvest
0
100
200
300
400
500
600
700
800
900
1000
S/50/3
SF/50/4
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

Table 1. Characteristics of the hunt and the moose population on the Kenai Peninsula from 1982-1986 (pre-SF/50) and 1987-1992 (post-SF/50), from Schwartz et al. (1992).

Parameter	Pre-SF/50	Post-SF/50
Post-hunt bull:100 cow ratio*	16	25
Annual harvest*	636	443
Mean number of hunters*	3602	2605
Percent success	18%	16%
Percent yearlings in harvest*	46	64
Percent ages 2-3 in harvest*	38	17
Percent ages 4-5 in harvest	11	12
Percent ages ≥6 in harvest	5	7

*Values differ significantly ($P \leq 0.05$)

Table 2. Management objectives for Units 14A, 14B, 16A, and 16B.

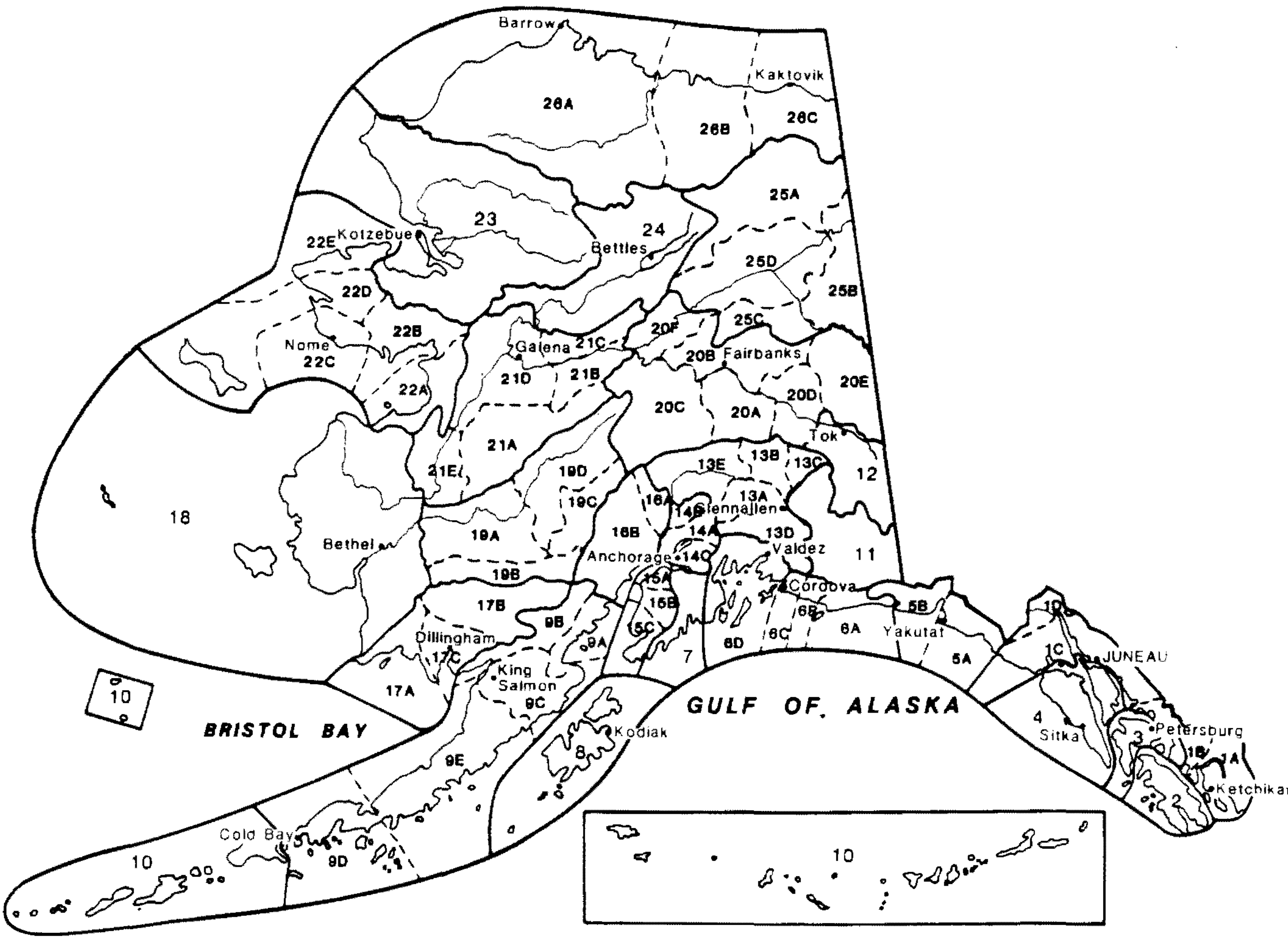
Unit	Population size	Bull:100 cow ratio	Harvest (3-yr. mean)
14A	5,000 – 5,500	20 – 25	600 – 700
14B	2,500 – 2,800	20 – 25	100 – 200
16A	3,500 – 4,000	20 – 25	≥ 250
16B	≥ 6,500	20 - 25	≥ 300*

* Additional subsistence harvest objective of 160-180 north of the Beluga River, and 39-47 south of the Beluga River

Table 3. Estimates of moose population size in Units 14 and 16 and, where applicable, the 80% confidence interval on those estimates.

Year	14A	14B	16A	16B
1988	5137 ± 895		4750 ± 750	8600
1989	5250 ± 750	2760 ± 550		8600
1990		1795 ± 247	2960 ± 256	7400 ± 100
1991	5885 ± 706			
1992	5700 ± 500	1528 ± 178	2900 ± 564	
1993	5672 ± 798		3284 ± 903	6700 ± 1600
1994	6000 ± 500	2337 ± 527	3300 ± 300	6660
1995				
1996	5750 ± 250			
1997			3636 ± 614	

Alaska's Game Management Units



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MOOSE

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