OVERHARVEST AND RECOVERY OF MOOSE IN A RECENTLY LOGGED AREA

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Abstract: In Ontario, overharvesting of moose (Alces alces) is often associated with extensive access for hunters and lack of cover for moose in recently logged areas. Our 154 km^2 study area, northeast of Lake Superior, was cutover for conifer from 1975 to 1979. The area was closed to hunting during logging, and the population is estimated to have been 0.40 to 0.45 moose/km^2. Hunting was reopened in 1979, and the harvest was extremely high at 0.30 to 0.35 moose/km^2, leaving a population of about 0.10 moose/km^2. The area was closed to hunting again beginning in 1980 to protect the remaining moose. The population recovered steadily to 0.37 moose/km^2 in 1984-85. Bulls were drastically reduced by the 1979 hunt, but recovered rapidly beginning in the second year after the hunt. Cows were less vulnerable to hunting than bulls, and have increased at a slower rate. Calf numbers have remained remarkably stable during most of the study, but there is evidence of a breeding failure in 1980. Calves seem to be responsible for most of the increase in the population. Immigration appears to be less important in rebuilding the herd. Predation, unsuitable habitat in the cutovers, and hunting in adjacent areas may be limiting the moose population increase. Optimum management of recently logged areas is discussed.

Moose vulnerability to hunting is directly related to the amount of access for hunters and seems to be inversely related to the amount of cover for moose (Coady 1982, Timmerman and Gollat 1982). These two factors often result in overharvesting of moose in recently logged areas, where road networks are extensive and cover for moose has been greatly reduced. This problem is common in the boreal forest region of Ontario, because vulnerable cutovers are not protected by regulations designed for large Wildlife Management Units (WMU's) with lower overall vulnerability (Timmerman and Gollat 1982). Although individual cutovers would usually be less than 5% of a WMU, several cutovers may occur in each WMU. Under normal sustained yield cutting, about 20% of a WMU would be associated with vulnerable cutovers (0 to 15 years old). Overharvesting of this much area could substantially reduce the total moose yield from the WMU.

We have been studying and trying to manage one of these vulnerable cutover areas--the Camp 1 area. This area was cutover between 1975 and 1979, and closed to hunting during this period for the safety of the loggers. The area was reopened to hunting in 1979, with an October 11 to December 15 season and each hunter allowed 1 moose of any age or sex. This resulted in a very heavy harvest. In 1980, the area was closed again to protect the remaining moose and allow the herd to rebuild (Eason et al 1981). Since then, an annual aerial survey has been conducted on the area to follow population changes. Our original intention was to keep the area closed to hunting until cover had regenerated sufficiently and access had deteriorated enough to prevent overharvesting. However, we are now trying to develop an optimum harvest strategy aimed at maximizing long-term yield from the area.

The purposes of this paper are to: 1) estimate the extent of the initial overharvest of the Camp 1 area; 2) describe the population characteristics of the Camp 1 herd as it recovers; and 3) discuss optimum management of recently logged areas.

STUDY AREA

The Camp 1 area lies 20 km south of White River, in the boreal forest region of north-central Ontario (Figure 1). Climate is continental with little local effect from Lake Superior. Topography varies from flat and gently rolling to hilly, with elevations from 390 to 610 m. Stands of black spruce (Picea mariana) dominate low lying areas, with large stands of jack pine (Pinus banksiana) on well drained flats. Upland slopes are dominated by white birch (Betula papyrifera) and trembling aspen (Populus tremuloides), often mixed with white spruce (Picea glauca) and some balsam fir (Abies balsamea).

The Camp 1 area itself is 154 km^2 and is part of WMU 33 which is 5825 km^2. The area was cutover by Abitibi-Price between 1975 and 1979 using a clear cut system in which most of the conifer was removed. A small amount of aspen was removed from 1981 to 1984. This has resulted in contiguous clear cuts ranging from approximtely 0.1 to 22.7 km^2 and totalling about 50 km^2. Most cutovers were over 0.5 km wide with some exceeding 1.5 km. The cut was broken up by hardwood and immature conifer stands, as well as a variety of stands on steep slopes. These residual blocks were generally small (5 to 60 ha) with the exception of a large (10.5 km^2) hilly area called the Camp 1 Island. The cut pattern for the Camp 1 area is shown in Eason et al (1981). The cut was also

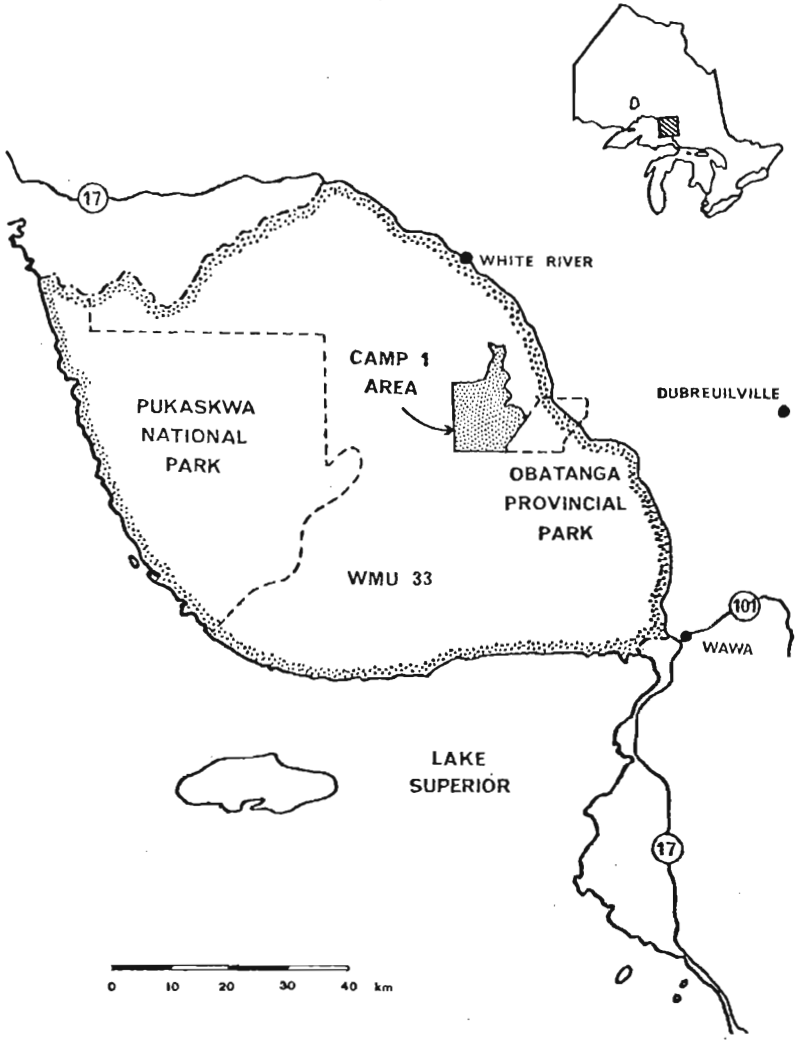

FIGURE 1. . Location of study area in north-central Ontario.

accompanied by an extensive network of roads totalling 168 km. The cutover was closed to hunting during logging, reopened to hunting in 1979, and then closed again beginning in 1980.

A 118 km^2 portion of the Camp 1 area is defined as being associated with the cutover--that is, within 0.5 km of the periphery of the cut. This excludes an uncut area on the west side of the Camp 1 closure. Based on aerial survey data, this uncut area appears to be part of the range of a population of moose centered on a chain of lakes to the west of the Camp 1 area. Changes in this population appear to be unrelated to the cutover or the closure to hunting.

The areas surrounding the Camp 1 area have a wide variety of cut histories and hunting pressures. The area to the northeast of the Camp 1 area was cutover during the 1960's in a manner similar to the Camp 1 area. This area was not closed to hunting during logging, and has remained open since then with moderate to heavy hunting pressure. Obatanga Provincial Park lies to the southeast of the Camp 1 area. The Park had only a small amount of logging in the 1960's, and has been hunted continuously with light to moderate pressure. The area to the north of the Camp 1 area was cut over from 1979 to 1983 in a manner similar to the Camp 1 area. This area was closed to hunting beginning in 1980 and has not been reopened. The remainder of the area west and south of the Camp 1 area is uncut forest. This area has not been closed to hunting, but hunting pressure is light.

Predators are common on the study area. Aerial surveys indicate that the ranges of 2 or 3 wolf (Canis lupus) packs overlap the Camp 1 area, but the exact number of wolves is unknown. Black bears (Ursus americanus) are also common, but the population size is unknown.

METHODS

The Camp 1 study began with the extremely high harvest in 1979--first indicated by hunter complaints. A minimum harvest for the area was obtained from the provincial voluntary jaw collection program, in which reported kills are recorded by 100 km^2 mercator blocks. An estimate of the total harvest on the area was then derived using the average jaw return rate for WMU 33 from 1979 to 1984. Jaw return rates were determined by dividing the total jaw returns for WMU 33 by the total harvest predicted for the Unit from mail surveys of moose hunters.

Aerial surveys were not conducted on the Camp 1 area in 1978-79 or 1979-80. Therefore, to estimate the extent of the population decline, the moose densities on the Camp 1 area before and after the 1979 hunt were reconstructed. The reconstructed densities were based on known densities from aerial surveys in areas representative of the Camp 1 area before and after hunting. The density on the Camp 1 area after logging but prior to hunting was assumed to be similar to the recent densities in the area to the north of the Camp 1 area, because both areas had similar cutover habitat and both were closed to hunting. The density on the Camp 1 area immediately after the 1979 hunt was assumed to be similar to the density on the area to the northeast of the Camp 1 area, again because habitat and hunting pressure were similar.

The decision to close the Camp 1 area to hunting in 1980 was based on MNR and public concern over the heavy harvest in 1979. The details of the closure implementation are described by Eason et al (1981).

To follow the response of the population to the hunting closure, aerial surveys of the Camp 1 and adjacent areas have been conducted

annually from 1980-81 to 1984-85. A total count survey was conducted using the standard provincial format. The entire Camp 1 area and portions of the surrounding areas were flown using transects 0.5 km apart. All moose and tracks seen were circled until we were confident that all moose were accounted for. All surveys were carried out from December 10 to January 22 during early winter conditions when the moose are most visible. Most flights were conducted under good tracking conditions--distinct shadows, mid-day flights, 1 to 3 days after fresh snow, and snow depths of 24 to 59 cm. Observation time averaged about 1.5 minutes/km^2. A Turbo-Beaver airplane with 4 people was used in 1980-81, 1982-83, and 1984-85; a Twin Otter airplane with 6 people was used in 1981-82; and a Robinson 22 helicopter with 2 people was used in 1983-84. All personnel had considerable previous experience on aerial moose surveys. Despite differences in aircraft and tracking conditions during the study, observation conditions have been good in all years because of the open nature of the forest and the cutover.

An attempt was made to identify the age and sex of all moose seen. Unfortunately, a few moose (9% to 18%) could not be sexed by the vulva patch method during the airplane surveys. However, because of the early dates of the survey, 60% to 90% of the bulls should still have their antlers (Oswald 1984), and the unantlered bulls should all be mature and readily identified by muzzle colour, bell, size, shape, and behavior (Oswald 1982). Immature bulls, which are more likely to be confused with cows, should still have had their antlers. Consequently, most of the unsexed animals were probably females. This is supported by the bull:cow ratio of 0.74:1 in the 1983-84 helicopter survey in which all adults were sexed, which is very similar to the bull:cow+unknown adult

ratios of 0.77:1 and 0.81:1 for the 1982-83 and 1984-85 airplane surveys. Therefore, the sum of the identified cows plus unsexed adults is assumed to be close to the actual number of cows present.

The aerial survey data is described only for the area associated with the Camp 1 cutover (within 0.5 km of the periphery of the cut). This excludes population changes on the uncut portion of the Camp 1 area, which appear to be unrelated to the cutover or the closure to hunting.

Net immigration of adults to the Camp 1 cutover was calculated by taking the population minus calves and subtracting the total population from the year before--or simply the diffence in successive surveys not explained by new calves. This represents the combined effect of immigration, emigration, and mortality since the preceding year's survey--that is, all the changes in the population except natality.

RESULTS

Extent of the 1979 Harvest

The population on the Camp 1 area before the 1979 hunt was reconstructed from the density on the similar unhunted cutover to the north. This 70 km^2 area was flown in 1983-84 and had a density of 0.43 moose/km^2. Therefore, the 1979 pre-hunt population on the Camp 1 area is estimated at 0.40 to 0.45 moose/km^2 or 62 to 69 moose (Figure 2).

The population on the Camp 1 area after the 1979 hunt was reconstructed from the density on the heavily hunted cutover to the northeast. This 91 km^2 area had an average density of 0.10 moose/km^2

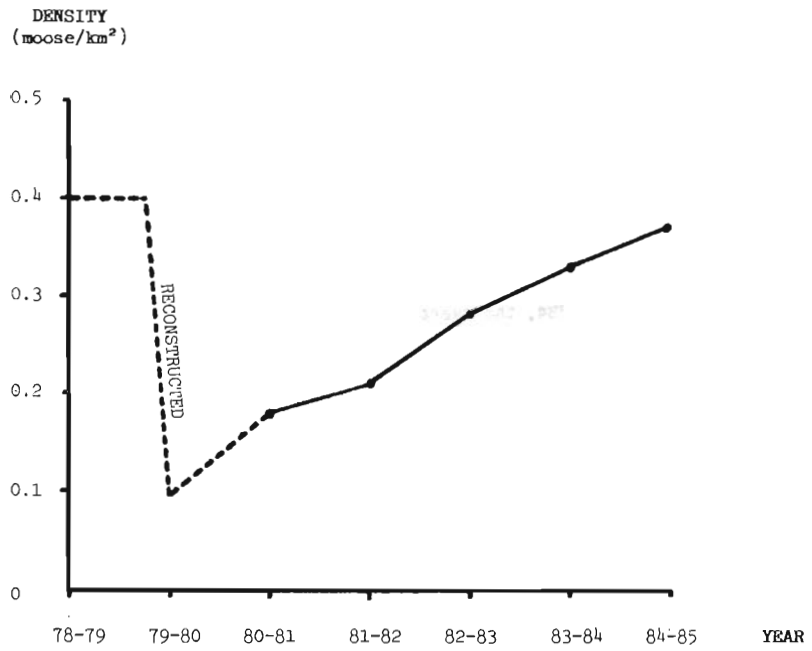

Figure 2. Density of moose on the Camp 1 cutover.

(range 0.08 to 0.12 moose/km^2) during the period from 1980-81 to 1982-83. Therefore, the 1979 post-hunt population on the Camp 1 area is estimated at about 0.10 moose/km^2 or 15 moose (Figure 2).

In 1979, 39 jaws were turned in from the four 100 km^2 mercator blocks enclosing the Camp 1 area--but not all of these jaws came from the Camp 1 area. During the 3 years prior to 1979, most of the present Camp 1 area was closed to hunting, and an average of 8 jaws per year (range 5 to 12) was recorded on the 4 mercator blocks exclusive of the Camp 1 area. Assuming that about 8 jaws came from outside the Camp 1 area again in 1979, then about 31 jaws came from the Camp 1 area itself. Based on the total harvest estimates from the provincial mail surveys from 1979 to 1984, the average jaw return rate for WMU 33 was 57% (range 45% to 87%). Applying the average return rate to the 1979 jaw returns gives an estimated harvest of about 54 moose or 0.35 moose/km^2 from the Camp 1 area.

Effects of the Hunting Closure since 1980

Since the closure to hunting in 1980, aerial surveys indicate that the number of moose associated with the Camp 1 cutover has increased almost linearly ($r = .994$) from 21 moose or 0.18 moose/km^2 in 1980-81 to 44 moose or 0.37 moose/km^2 in 1984-85 (Figure 2).

The moose associated with the Camp 1 cutover were also strongly associated with the uncut edges or residual forest. Of the 162 moose observed during 5 years of surveys, only 1 group of 4 moose in 1982-83 and 1 group of 5 moose in 1984-85 were found in clearcuts more than 200m from uncut timber.

The number of bulls associated with the cutover has increased substantially from 1 in 1980-81 to 17 in 1984-85 (Table 1). The bull component of the population has risen from 5% to 39% in the same period.

The assumed number of cows (cows + unsexed adults) associated with the cutover has had a generally steady increase from about 10 to 21 over the study period (Table 1). The cow component of the population has fluctuated from 44% to 58%. The bull:cow ratio has increased rapidly from 0.10:1 in 1980-81 to 0.81:1 in 1984-85.

The number of calves associated with the cutover has remained quite stable at 6 or 7 each year, except in 1981-82 when only 1 calf was present (Table 1). However, the calf component of the population showed a steady decline from 39% to 14% during the study, again with the exception of a very low value in 1981-82. The number of sets of twins was 3, 0, 1, 2, and 1 over the study period. Using the assumed number of cows, the calf:cow ratio has delined steadily from 0.70:1 to 0.35:1, again with the exception of a very low ratio in 1981-82.

Net immigration of adults to the cutover over the previous year declined steadily from +3 in 1981-82 to -1 in 1984-85 (Table 1). Net immigration accounted for a 13% gain in the population in 1981-82, but dropped steadily to a 2% loss in the population in 1984-85.

Table 1. Moose population characteristics in the Camp 1 cutover.

YEAR	TOTAL MOOSE	BULLS	COWS	CALVES	UNSEXED ADULTS	UNKNOWN	ASSUMED COWS[1].	ASSUMED BULL:COW:CALF RATIO	NET ADULT IMMIGRATION[2].
1980-81	21(0.18)[3].	1(5%)[4].	7	7(39%)[4].	3	3	10(56%)[4].	0.10:1:0.70	
1981-82	25(0.21)	9(39%)	11	1(3%)	2	2	13(58%)	0.69:1:0.08	+3(13%)[4].
1982-83	33(0.28)	10(33%)	8	7(23%)	5	3	13(44%)	0.77:1:0.54	+1(3%)
1983-84	39(0.33)	14(36%)	19	6(15%)	0	0	19(49%)	0.74:1:0.43	0(0%)
1984-85	44(0.37)	17(39%)	13	6(14%)	8	0	21(47%)	0.81:1:0.35	-1(-2%)

1. Assumed cows = cows + unsexed adults.
2. Net adult immigration is the net change in the moose present in the previous year caused by immigration, emigration, and mortality, but excluding new calves.
3. Density in moose/km^2.
4. Percent of known age moose

DISCUSSION

Extent of the Overharvest

The 1979 harvest estimate for the Camp 1 area based on jaw returns is quite similar to the harvest estimate based on reconstructions of the pre-hunt and post-hunt populations. Therefore, the population reconstructions are thought to be representative of the actual 1979 populations, and should reflect the actual extent of the 1979 harvest.

The drop in population from 0.40 to 0.45 moose/km^2 down to about 0.10 moose/km^2 was a reduction of at least 75% in just one hunting season. The maximum sustainable yield (MSY) for the Camp 1 area should be close to the largest annual increase observed during the recovery of the population--which was about 0.07 moose/km^2 from a population of 0.21 moose/km^2 in 1981-82 (Table 1). Crête et al (1981) also estimated that MSY occurred at a density of about 0.2 moose/km^2 in areas of southwestern Quebec similar to the Camp 1 area. The 1979 harvest of about 0.30 to 0.35 moose/km^2 was 4 to 5 times the estimated MSY for the Camp 1 area, and reduced the population to about half the level at which MSY appears to occur. Therefore, the moose population on the Camp 1 area was heavily overharvested in 1979. Other overharvests from newly accessible cutovers have been alluded to (Cumming 1974, Timmerman and Gollat 1982), but the extent of these harvests was not described.

Recovery of the Population

The sightability bias for the aerial surveys on the Camp 1 cutover

is unknown, but is thought to be small because of good visibility in the open cutovers. Therefore, all of the aerial surveys should be close to complete counts and should be directly comparable from year to year.

The population on the Camp 1 cutover has more than tripled from an estimated 0.10 moose/km^2 after the 1979 hunt to 0.37 moose /km^2 in 1984-85. In 1984-85 the density on the Camp 1 cutover was well above the 0.15 moose/km^2 in the adjacent heavily hunted cutover to the northeast. At the current rate of increase, the Camp 1 cutover should be very close to its pre-hunt density and the density of adjacent unhunted areas by 1985-86. The increase has been almost linear ($r = .994$) at an average rate of 0.05 moose/km^2/year. However, there also appears to be a logistic pattern to the recovery--with the population growth rate increasing and then decreasing. The finite rates of increase (λ) (Van Ballenberghe 1983) for the cutover increased from 1.19 to 1.32 and then declined to 1.18 and 1.13 for successive years from 1980-81 to 1984-85.

The closure to hunting has been effective in rebuilding the overharvested population. The population increased to average densities for hunted areas in our District after 2 to 3 years of closure. It also took about 2 years to reach the density where MSY appears to occur. However, it appears to require 6 years of closure for recovery to pre-hunt levels. Moose populations in the Algonquin area of Ontario recovered to normal levels after 2 years of closure following very heavy harvesting, but actual densities are not known (Cumming 1974).

Despite the large population increase in the Camp 1 area, not all of the cutover area is being regularly utilized by moose. Only 2 groups of moose have been seen more than 200 m from uncut timber, indicating

that some of the cutover may be too far from cover to be suitable for moose. Lack of cover in clearcuts may be limiting the population increase by preventing the full utilization of the food in the cutovers (Thompson and Euler 1984) or by reducing the area available for escape from predators (Bergerud 1981). However, the actual effect of the clearcut size and pattern on the recovery rate, yield, or carrying capacity of the Camp 1 area cannot be calculated.

Bulls were apparently heavily overharvested on the Camp 1 area in 1979, because only 1 bull was observed on the cutover in 1980-81. The high susceptibility of bulls to hunting is well known (Cumming 1974), but such drastic reductions from only one hunt have apparently not been recorded. However, the number of bulls increased rapidly in 1981-82 (2 years after the hunt), and has increased steadily since then.

The assumed number of cows (cows + unknown adults) made up most of the Camp 1 population in 1980-81, indicating that cows may be less vulnerable to hunting than bulls. Since 1980-81, there has been a generally steady increase in the assumed number of cows, but this increase has been more gradual than the increase in bulls. Therefore, it appears that cows can support more hunting pressure than bulls because they did not decline as drastically, but it also appears that fewer cows than bulls can be harvested because of their lower recovery rate. This supports the present management approach in Ontario of harvesting fewer cows than bulls (Gollat and Timmerman 1983).

With the exception of 1981-82, the number of calves on the Camp 1 cutover has remained quite stable at 6 or 7 each year--despite a large increase in the total population. In addition, the number of sets of twins is generally low, and the calf:cow ratio has declined steadily

with the exception of the very low value in 1981-82 ($r = -.998$ excluding 1981-82). This suggests that predation may be limiting the number of calves and that the amount of predation is increasing. A similar conclusion was reached in studies of nearby Pukaskwa National Park (Bergerud et al 1984). Reduced productivity of females does not seem to be a feasible explanation because food is abundant. The stable number of calves may also support Bergerud's (1981) theory that moose are limited by the amount of space they have in which to successfully evade predators. It appears that there may be enough space in the Camp 1 area for only 6 or 7 calves to escape predators, regardless of the number of calves born. The additional calves that should be produced as the population increases are probably being removed by density dependant predation (Keith 1983). By limiting the survival of calves, predation will also be reducing the growth rate, potential yield, and density of the Camp 1 population--a common situation in moose populations (Coady 1982).

The unusually low number of calves in 1981-82 is of interest. Increased predation does not seem to explain this decline, because predation should have been even greater on the lower population in 1980-81. However, there seems to be a good correlation between the number of calves and the presence of bulls the previous year. It appears that the cows in the Camp 1 cutover were successfully bred before the 1979 hunt, and raised 7 calves in 1980-81. But, these same cows may not have been bred successfully in 1980, because only 1 bull was observed in 1980-81 and only 1 calf was raised in 1981-82. In 1981, the number of bulls had recovered, and the cows seemed to have bred successfully again--because 7 calves were raised in 1982-83. Therefore,

this may be a case where an extremely heavy harvest of bulls prevented successful breeding and reduced subsequent calf numbers. By allowing bull numbers to recover, the closure may have allowed calf numbers to recover as well. Crête et al (1981) found a positive relationship between bull and calf numbers in Quebec, and they recommended that at least 40% of mid-winter adults should be bulls to maximize productivity.

The main component of the population increase on the Camp 1 cutover has been calf production at 6 or 7 moose/year in all years except 1981-82 when only 1 calf was present. Net adult immigration appears to be less important in building up the herd. Net immigration increased the herd on the cutover by 3 in 1981-82, but then declined steadily to a net loss of 1 adult in 1984-85. This decline fits the expected pattern of net inflow at low densities and net outflow at high densities. The findings also agree with Goddard's (1970) conclusion that immigration from remote to heavily hunted areas is less important than the productivity of resident survivors, but are somewhat contrary to the view that yearling immigration is important in annually rebuilding heavily harvested areas (Cumming 1974).

Net immigration might have been more important (as suggested by Cumming 1974) if the Camp 1 area was totally surrounded by unhunted or lightly hunted areas. As it is, few moose were available to move into the Camp 1 area from the heavily hunted area to the east, and some moose likely moved from the Camp 1 area into the low density area to the east as the Camp 1 population increased. Also, Conservation Officer reports indicate that at least 3 bulls have been called out of the Camp 1 area and shot since the closure began. Therefore, the adjacent hunted area may have reduced the recovery rate on the Camp 1 area.

Optimum Management

Optimum management of cutover areas could be defined as taking the MSY from the area, with minimum restrictions on hunters, and at minimum management cost. MSY needs to be determined for more cutovers, but tentatively appears to occur at a density of 0.2 moose/km^2 (Crête et al 1981, and this study). Therefore, a simple and inexpensive harvest system is needed to keep the population at about this level.

The normal hunting regulations may be sufficient to restrict the harvest to the MSY in small cutovers, where the moose are not much more vulnerable than in uncut areas, or in cutovers receiving a large amount of immigration from adjacent high density areas. However, in many cutovers, additional restrictions would be required. Harvest quotas, limiting hunter numbers, season adjustments, age and sex restrictions, and archery hunts have all been rejected as too confusing or too restrictive for hunters to accept on small areas, or too expensive to implement (Eason et al 1981). However, a system of periodic harvesting appears to be acceptable in terms of simplicity and cost. Using this system the cutover would be opened to hunting under the normal regulations for the WMU; and if more than the MSY was removed, the area would be closed to hunting until the population recovered. Based on the Camp 1 data, heavily overharvested cutovers may require 2 years of closure to recover to the density at which MSY occurs. But as cover regenerates and access deteriorates, overharvests will be less and recovery will be faster--and eventually an annual hunt can be resumed.

Periodic harvesting should provide much higher long term yields than annual hunts without additional restrictions. The Camp 1 data

indicate that yields under annual hunting would be low because of the low immigration and possible reproductive failure. Data from other cutovers with annual hunting also indicate that yields remain low for long periods (Timmerman and Gollat 1982). On a larger scale, yields in the Algonquin area of Ontario declined with heavy annual hunting, but increased with periodic hunting (Cumming 1974). Also, Walters and Bandy (1972) suggested that periodic harvesting at 2 to 4 year intervals may increase big game harvests 10% to 20% above the sum of annual MSY's, but this has not been confirmed. Because of the apparent potential of this system we hope to expand the Camp 1 study to determine the effect of periodic harvesting on long term yields from cutover areas.

Overharvesting of bulls with a failure of calf production the following year may be a potential problem with periodic harvesting. If this occurs, reducing the harvest of bulls with a later and shorter season should speed the recovery of the population and increase yield.

Techniques other than harvest control may also increase yield. In particular, productivity in some cutovers may be limited by predation. Therefore, predator control or increased predator harvest may increase moose yields (Crête and Messier 1984). However, predator reduction may not be feasible because of the high cost and effort required and because of negative public opinion.

Habitat may also affect yields. More and larger residual blocks with smaller clearcuts should provide more access to food and more cover from weather, predators, and hunters--thereby increasing carrying capacity and yield. Because the optimum cut pattern for protecting moose from hunting and predation is unknown, we hope to expand the Camp 1 study to evaluate the yields from different cut patterns.

In summary, to reach the provincial moose harvest objectives, high sustainable yields are required from all areas. Periodic harvesting appears to be a feasible method for increasing moose yields on cutover areas, particularly if predation cannot be reduced or if cutover habitat cannot be managed to increase moose production.

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