Bienn. Symp. North. Wild Sheep and Goat Counc. 7:282-289.

PERSPECTIVES ON MANAGEMENT OF ISOLATED MOUNTAIN GOAT POPULATIONS WITH HIGH NONCONSUMPTIVE VALUES: THE PEND OREILLE LAKE, IDAHO, CASE STUDY

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Abstract: A population of mountain goats (*Oreamnos americanus*) occupies cliffs along the south shore of Pend Oreille Lake in northern Idaho. This population was established from 16 animals transplanted in 1960, 1962, and 1965. Population estimates using mark-recapture techniques indicate 54 goats were present in 1985. This population should be managed as a closed, isolated herd. A Leslie matrix analysis based on data from trapping approximately 65% of the population was used to estimate potential offtake given several scenarios of survival and fecundity. A plan to remove 3 to 5 goats, including 2-3 adult nannies, from this population annually should be implemented. If survival or fecundity rates are unchanged, the population is predicted to stabilize at about 75% of its current level, or about 38 goats. If survival rates or fecundity rates increase, as is likely, the higher level of 5 goats will be an appropriate offtake. In addition new stockings should be considered at 10-20 year intervals. This population is below minimum viable levels and will not survive over the long term without management.

Mountain goats are occasionally transplanted to areas where their primary values are nonconsumptive. In other cases, natural populations have high nonconsumptive values and harvest is a secondary consideration. The histories of several introduced mountain goat populations (Houston and Stevens 1988, Swenson 1985) suggest that the sequence of population growth described by Caughley (1970) may be an appropriate model of how this species responds following transplanting. This model suggests that the population will interact with forage resources, altering the vegetation and ultimately limiting the population. The model predicts that introduced mountain goat populations which are not managed appropriately will achieve an initial population high, followed by a decline and eventual levelling off with the population fluctuating according to a weather-forage interaction.

A management strategy to disrupt this irruptive sequence with the goal of retaining a larger population than would occur if the sequence were allowed to occur would be useful for managing mountain goats where nonconsumptive values are emphasized. The assumption is that if the forage is not allowed to deteriorate to some equilibrium which controls goat numbers, then a greater abundance, or quality, of forage would support more goats over the long run. This would provide greater nonconsumptive values from the population, assuming more goats in better nutritional status is a measure of value. It may also maintain the habitat in a more acceptable condition, depending upon the nature of vegetation change that would occur if the irruptive sequence was permitted.

The purpose of this study was to estimate offtake for an introduced mountain goat population which would stabilize it below a probable irruptive high. The population occupies a 5.3 km^2 cliffy area on the south side of Pend Oreille Lake, Idaho. Naylor (1988) reported that by 1985, this population appeared to be approaching the asymptotic high that precedes a decline, based on kid production/survival and available population trend data.

This population originated from transplants of 16 goats in 1960, 1962 and 1965. Six billies, 7 nannies, and 3 adults of unidentified sex were transplanted. Winter aerial surveys in 1973, 1976, 1981 and 1984, counted 14, 19, 37, and 38 goats, respectively, in the area.

This project was supported by Idaho Dep. Fish & Game, Idaho Panhandle National Forest, and University of Idaho McIntire-Stennis Project MS-22. We thank P. Hanna and P. Harrington for their support during the study. L. J. Nelson developed the computer model we used for this work. This is University of Idaho Forest, Wildlife, and Range Experiment Station Journal Series Publication No. 528.

METHODS

During summer 1984 and 1985, 29 mountain goats were captured at a salt lick in 2 Clover style deer traps (Clover 1956). Sex and age of each animal were determined following Brandborg (1955), and animals were individually marked. Reproductive status was assessed by presence of absence of kids at the trap site. From October 1984-August 1985, 112 censuses were conducted using a multiple capture-recapture method (Schnabel 1938) with 95% confidence limits calculated from Ricker (1975). Visual sightings of 7 radio-marked animals were used as recaptures to reduce bias associated with using trap recaptures (Flyger 1959). Censuses were conducted from a boat travelling slowly about 150 m from shoreline. Slopes were searched with binoculars by 2 observers who verified their sightings with each other to avoid double counting.

A Leslie matrix model (Leslie and Ransom 1940) was used to determine rate of increase. Survival and fecundity rates were based on the age composition of the trapped sample, augmented with a literature search. The model was run on a computer for 20 iterations which sufficed to smooth the age structure obtained from the sampled population and to stabilize trends in age-sex composition.

Different levels of offtake were then explored to determine their effects on finite rate of increase and population size. Survival and fecundity rates were then altered to simulate potential compensatory responses to levels of offtake.

Accessible shrubs on the cliffs were surveyed to obtain a species list and to estimate utilization and degree of hedging. We assumed that current conditions would provide evidence concerning the vegetation-goat interaction.

RESULTS

Minimum breeding age for the 20 females was 4 years (Table 1). Seven of 13 females >4 years of age were pregnant or had kids. Three of 6 radio-collared nannies lost their kids during the 1984-85 seasons. Two nannies lost kids in summer, while a third lost hers in January. Two kids from radio-collared nannies survived their first year and 1 kid's fate was undetermined.

Known adult mortalities consisted of 2 billies, 4.5 years and 9.5 years old, and a 10+ year-old nanny. The younger billy was found in the lake below the cliffs with a crushed skull and other abrasions indicating a fall. The older billy was found in March 1985 alive but emaciated and died the next day. The nanny was killed during an archery hunt (2 permits annually).

Census data reflected goats at least 1 year old (Table 2). The annual kid crop was estimated by counts of 12 kids in 1984 and 10 in 1985. The Schnabel estimate of the mean number of goats 1 year old or more was 42 (20-78, $P<0.05$), for a total mean summer population estimate of 52. Among surveys, 12% and 22% of the observed goats were radiocollared and between 11-33 goats were observed.

The first Leslie matrix model used fecundity rates of 0.5/year, survival rates of 0.55 for kids, 0.75 for billies >1 year, and 0.95 for nannies >1 year (Table 3). Age at first reproduction was 4 years for females. The initial population was set at 52, and the resulting finite rate of increase of 1.027 indicated a slowly increasing population. When an annual harvest of an adult billy and an adult nanny was applied to this population, it stabilized at 54 goats (Table 3). Harvest of 2 adult nannies and 1 adult billy (4% of the adult population) caused this population to decrease slowly from 52 to 38 in 20 iterations representing 20 years (Table 3).

The population stabilized at 54 when kid survival was decreased to 0.45, assuming no harvest (Table 3). When all survival rates were decreased 0.1, the population declined to 20 animals in 10 years, with the finite rate of increase being 0.904. If survival rates were kept at original levels and fecundity rates were decreased 0.1, the population stabilized at 49 individuals. If fecundity rates were decreased 0.15, the population declined to 44 individuals at 10 years and the finite rate of increase was 0.975.

When fecundity rates were increased 10% to simulate a population response to harvest, the population then stabilized at 49 individuals with a 4% harvest consisting of 2 billies and 2 nannies. When fecundity rates were set equal to the initial run and survival was increased by 0.10 for all age classes, the population stabilized after 20 iterations at 51 individuals with a 9% harvest of 4 individuals (2 billies and 2 nannies).

When fecundity rates and survival rates were both increased by 0.10, the population stabilized at 55 after 20 iterations with an offtake of 10% or 2 billies and 3 nannies.

Utilization of shrubs that were able to be sampled safely ranged from 0-30% of leaders browsed (Table 4). Rocky mountain maple, oceanspray and common ninebark were the most heavily used shrubs. Heavily browsed shrubs are found in widely scattered areas, but occasionally two shrubs of the same species were found adjacent to each other with only one showing severe browsing.

DISCUSSION

Of an estimated 44 adults, approximately 65% of the population was trapped over the 2-year period. This suggests that the age structure was as representative of the population as is practical to obtain unless a complete capture is attempted. The fact that this population is readily accessible, readily observed, is habituated to using a salt lick, and occupies a small area contributed to the high proportion that was trapped.

Census information represented visibility biases as well as seasonal fluctuation of the population in the area. Probably December-February has the least immigration or emigration to other areas because snow conditions impede movements. Observations during that period indicate a very clumped distribution. The high estimate in November may be due to rutting activities during which these goats use the more open cliff face and are consequently more visible, or reflects immigration to the study cliffs of goats occupying nearby isolated habitats. Vegetative conditions also influenced goat observations because dense deciduous shrub stands adversely affect observation.

The density estimate of 18.5 goats/km^2 in the core of the habitat is among the highest recorded. Stevens (1983) reported 14 goats/km^2 in Olympic National Park on 1 ridge. Chadwick (1979) reported 1.2 goats/km^2 in Glacier National Park. Rideout (1974) reported 0.6-1.1 goats/km^2 in a western Montana habitat, and Fox (1979) reported 1.3 goats/km^2 in a southeast Alaska study area.

Our population models suggest that relatively small changes in fecundity or survival will affect rate of increase of this small population. Changes in survival rate have a greater effect on trend than does variation in fecundity. A change in mortality of 2-3 animals/year can significantly affect this population. Density-related responses in initial breeding age, litter size, or age ratios were shown for populations in Olympic National Park (Houston and Stevens 1988), the Absaroka Range in Montana (Swenson 1985) and in Colorado (Adams and Bailey 1982).

Caughley (1970) postulated that when a population exhibiting an irruptive sequence entered the final stage, the mean size around which it stabilized would be significantly lower than the size at which it peaked prior to the decline. The Pend Oreille goat population may have approached the asymptotic level and be ready to decline. It is at a very high density relative to other populations. Recruitment to the population appeared low, and no twins were observed. Age at sexual maturity was high.

This population is isolated from other mountain goat herds by extensive forests. While marked goats were observed to disperse to patches of habitat adjacent to the study cliffs, probabilities for interchange with other populations are considered low.

A management strategy for maintaining goats on these cliffs should include a plan to remove between 3-5 goats, including 2-3 adult nannies, each year. Following severe winters, the lower numbers may suffice, while during normal or more mild winters, higher levels may be appropriate. If no changes in survival or fecundity rates occur, the population will stablize at approximately 75% of its currently estimated level, or around 38 goats. This could be an initial goal of the management program. If survival rates or fecundity rates increase, as we predict they will, the higher level of 5 goats including 3 nannies would be an appropriate offtake, and higher levels may be needed. The population should be monitored to determine production and survival of kids.

Inbreeding depression may eventually decrease productivity and survival, and new stock, perhaps consisting of 2 billies and 3 nannies, should be considered for transplanting onto these cliffs. This may have to be accomplished at 10-20 year intervals.

The strategy of not actively managing this goat population will eventually result in a highly reduced density and probably extirpation. The amount of habitat is too small and too isolated to maintain a population without management.

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Table 1. Sexes and ages of mountain goats captured at Pend Oreille Lake study area, June-July 1984, and May 1985.

AGE	MALE	FEMALE	REMARKS
1	0	4	
2	2	2	
3	3	1	
4	1	1	
5	2	2	1 with kid
6	0	5	2 with one kid each
7	1	3	1 pregnant, 1 with yearling
8	0	1	1 with kid
8+	0	1	
TOTAL	9	20	

Table 2. Population estimates from monthly censuses at Pend Oreille Lake study area. Estimates are for goats greater than 1 year old.

Month	No. of Surveys	Total No. of Goats/day	Obs. Marked Goats/day	(%)	N	95% Conf. Limit
Jan	15	29.6	5.06	(17)	41	35-51
Feb	11	22.9	4.09	(18)	39	30-53
Mar	12	23.5	4.30	(18)	38	33-49
Apr	10	32.5	5.20	(16)	43	48-56
May	4	23.8	3.75	(16)	38	26-64
June	6	24.8	3.16	(13)	45	33-72
July	19	11.8	2.63	(22)	27	20-35
Aug	7	15.3	2.00	(13)	43	27-74
Sep	no censuses					
Oct	8	22.5	3.25	(14)	47	33-70
Nov	14	27.4	3.28	(12)	57	44-78
Dec	6	30.5	4.66	(15)	45	37-66

Table 3. Leslie matrix projections of the Pend Oreille Lake mountain goat population using different harvest, survival, and fecundity rates. Initial population size was 52, and minimum breeding age was 4 for females.

FECUNDITY RATES	SURVIVAL RATES			OFFTAKE		FINITE RATE OF INCREASE	POP. SIZE AT 20 ITERATIONS
	Kids	Adults Females	Adults Males	#	%		
0.5	.55	.95	.75	0		1.027	96
0.5	.55	.95	.75	2	3	1.000	54
0.5	.55	.95	.75	3	4	0.987	38
0.55	.55	.95	.75	2	4	1.000	49
0.5	.65	.99	.85	4	9	1.005	51
0.55	.65	.99	.85	5	10	1.014	55
0.5	.45	.95	.75	0		0.997	54
0.5	.45	.85	.65	0		0.904	7
0.4	.55	.95	.75	0		0.994	49
0.35	.55	.95	.75	0		0.975	33

Table 4. Common shrubs and estimated utilization on accessible sites, Pend Oreille Lake study area.

Species	Utilization(%)
Rocky mountain maple *Acer glabrum*	30
Servicebery *Amelanchier alnifolia*	15
Kinnikinnick *Arctostaphylos uva-ursi*	0
Red-osier dogwood *Cornus stolonifera*	5
Oceanspary *Holodiscus discolor*	20
Syringa *Philadelphus lewisii*	15
Ninebark *Physocarpus malvaceous*	25
Chokecherry *Prunus virginiana*	0
Wood's rose *Rosa woodsii*	0
Snowberry *Symphoricarpos albus*	15