CHARACTERISTICS OF COUGAR HARVEST WITH AND WITHOUT THE USE OF DOGS

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Abstract: Prior to 1996, dogs were used to harvest the majority (99%) of cougar during recreational hunting seasons in Washington State. However, in 1996 Voter Initiative 655 banned the use of dogs to aid in the harvest of cougar. As a result, harvest methods shifted to spot and stalk, predator calling, and incidental encounters between deer and elk hunters and cougar. We examined the sex and age structure of harvested cougar and compared these data between seasons with (selective harvest) and without the use of dogs (non-selective harvest). We detected a significant increase in percent female cougars in the total harvest, from 42% to 59% during selective versus non-selective seasons ($T = -7.85$, $P < 0.0001$). We also found that non-selective harvest seasons had significantly more juvenile male ($\chi^2 = 98.1790$, d.f. = 10, $P < 0.0001$) and female ($\chi^2 = 66.5116$, d.f. = 10, $P < 0.0001$) cougars compared to selective seasons. We then used program RISKMAN to evaluate the potential impacts to population growth (finite rate of increase) from changes we observed in harvest vulnerability of specific sex and age classes. Our sensitivity analysis suggests that changes in female adult and cub survival are the most influential parameters to population growth and the increased harvest of female cougars in non-selective harvest methods decreased the finite rate of increase by about 0.01–0.02. Harvest methods that increase the relative harvest vulnerability of these cohorts have a greater potential for impacting population growth. In Washington State, the current level of cougar harvest and increased vulnerability of females and juvenile cougar have likely increased the risk of impacting population growth.

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INTRODUCTION

In Washington State, cougar (*Puma concolor*) hunting regulations and harvest levels have changed dramatically during the last decade (Table 1). Pivotal to these changes was Voter Initiative 655 (I-655), which banned the use of dogs for hunting cougar in Washington in 1996. Prior to I-655, hunters used dogs to take about 99% of the harvested cougar. Recognizing that using dogs was more effective than spot-and-stalk or predator calling methods to harvest cougar, Washington Department of Fish and Wildlife (WDFW) instituted several changes in an effort to maintain harvest levels similar to pre-initiative seasons; including lengthening the season from about 86 to 227 days, increasing the annual bag limit from 1 to 2 cougars/hunter, and decreasing the cost of a cougar transport tag from $24 to $10.

Both prior to and since I-655, wildlife managers in Washington used harvest characteristics to assess the status of the living cougar population. Managers monitored trends in total harvest, harvest success, percent females in the harvest, and median ages of harvested males and females. Using harvest information alone to assess a living population is fraught with problems. The value of harvest information becomes even more suspect when the harvest methods change, because the relationship between trend data and the

Table 1. Recreational cougar hunting seasons in Washington, 1990-2001.

Year	Season Dates	Days	Harvest	Restrictions	Selectivity
1990-1991	Nov. 21 – Jan. 15	57	102	Permit only season	Dogs allowed
1991-1992	Nov. 27 – Jan. 15	50	120	Permit only season	Dogs allowed
1992-1993	Oct. 17 – Jan. 31	107	140	Permit only season	Dogs allowed
1993-1994	Oct. 16 – Jan. 31	108	121	Permit only season	Dogs allowed
1994-1995	Oct. 15 – Jan. 31	109	177	Permit only season	Dogs allowed
1995-1996	Oct. 14 – Jan. 31	110	283	Permit only season	Dogs allowed
1996-1997	Oct. 12 – Mar. 15	155	178	General season	No dogs allowed
1997-1998	Aug. 1 – Mar. 15	227	132	General season	No dogs allowed
1998-1999	Aug. 1 – Mar. 15	227	184	General season	No dogs allowed
1999-2000	Aug. 1 – Mar. 15	227	273	General season	No dogs allowed
2000-2001	Aug. 1 – Mar. 15	227	208	General season	No dogs allowed

living population also may have changed. As a result, trend information based on harvest data may be of limited value in Washington because of the restriction on using dogs to hunt cougar.

Little information is known about how restrictions on using dogs to hunt cougar impacts harvest, trends based on harvest data, or cougar populations. To that end, our objectives are to: 1) determine if there are differences in cougar harvest characteristics (i.e., total harvest, percent female cougar in the harvest, and age structure of harvest cougar) during seasons with and without the use of dogs, and 2) identify potential impacts to the cougar population given changes in season structure and harvest levels in Washington between 1990-2001.

METHODS

We obtained cougar harvest data from 1990 to 2001 through a mandatory harvest reporting system implemented by WDFW. Successful hunters were required to report their harvested cougar and present the hide and skull to WDFW, where Agency staff collected a tooth sample, and documented sex, kill location, kill date, and kill type (depredation, recreational, public safety cougar removal, or other). We determined ages for 79% of the harvested cougar using cementum annuli analysis.

We classified harvest data from 1990-1995 as "selective" and from 1996-2001 as "non-selective" to compare harvest characteristics between periods when dogs were legal to years when they were not, respectively. We used a T-test to determine if cougar harvest (recreational only) and percent females in the harvest (recreational only) differed between selective versus non-selective periods. To compare harvest age structures between selective and non-selective periods, we generated a mean age structure for each sex and each period by pooling cougar management units (CMUs) (Washington is divided into 9 administrative CMUs) and years. We then used a chi-square test to determine if mean age structures for each sex differed between selective versus non-selective periods. We considered all tests significant at $\alpha \leq 0.05$.

We used program RISKMAN to assess potential impacts to the cougar population from changes in harvest methods and rates (Taylor et al. 2002). We incorporated parameter estimates from Logan and Sweanor (2001) and Spencer et al. (2001) (Table 2). For initial population size we multiplied the amount of suitable cougar habitat in Washington (88,497 km^2) by the

Table 2. Parameter inputs for program RISKMAN simulations in Washington.

Parameter		Value	Source
Recruitment	Probability of 1 cub	0.00	Logan and Sweanor 2001
	Probability of 2 cubs	0.25	Logan and Sweanor 2001
	Probability of 3 cubs	0.49	Logan and Sweanor 2001
	Probability of 4 cubs	0.26	Logan and Sweanor 2001
	Mean litter size	3.01	Logan and Sweanor 2001
	Proportion of females with litters	0.80	Logan and Sweanor 2001
	Proportion of males at birth	0.50	Logan and Sweanor 2001
Survival	Male cubs (age 0)	0.67	Logan and Sweanor 2001
	Female cubs (age 0)	0.67	Logan and Sweanor 2001
	Male yearling (age 1-2)	0.64	Logan and Sweanor 2001
	Female yearlings (age 1-2)	0.88	Spencer et al. 2001
	Male adults (age 3-12)	0.91	Logan and Sweanor 2001
	Female adults (age 3-12)	0.82	Logan and Sweanor 2001
	Litter survival rate	0.93	Logan and Sweanor 2001
Population size		4159	WDFW[a], unpublished data

[a] Washington Department of Fish and Wildlife

highest cougar density reported in the literature (4.7 cougars/100 km^2) (Ross and Jalkotzy 1992). Each of the parameters values, including density, are at the high end in terms of the range reported in the literature. We chose to model a population with high productivity, survival, and density so our analysis would reflect how harvest strategies and rates might impact even the most robust cougar population. Therefore, potential impacts to a more realistic population would be at least as great, if not more, than those to our modeled population. We used the age structure from cougars harvested between 1997-1999 to develop the input age distribution for the model. We selected these years because they probably better reflect the standing population than years when dogs were legal or years when potential impacts may begin to be apparent. From the average age structure we generated a stable age distribution and used this as the age distribution in the model.

To assess the impacts of selective versus non-selective harvest methods, we conducted two simulations; one where the strata specific harvest vulnerabilities were set to levels observed during the selective

Table 3. Vulnerability inputs for selective and non-selective model simulations in Washington.

		Relative vulnerability	
Parameter	Age class	Selective	Non-selective
	Cubs (age 0)	0.000	1.0
Males	Juveniles (age 1-2)	0.118	1.0
	Adults (age 3-12)	0.464	1.0
	Cubs (age 0)	0.001	1.0
Females without offspring	Juveniles (age 1-2)	0.109	1.0
	Adults (age 3-12)	0.277	1.0
Females with offspring	Adults (age 3-12)	0.031	1.0

period (1990-1995) and one where the vulnerabilities were constant across strata, thereby mimicking a non-selective method (1996-2001) (Table 3). We repeated each simulation for harvest rates ranging from 0% (no harvest) to 14% of the censused population. All simulations were deterministic and the realized finite rate of increase with no harvest was 1.062.

RESULTS

Mean harvest increased from 157 during the selective period to 199 in the non-selective period; however the increase was not statistically significant (T = -1.26, P = 0.2368). We detected a significant increase in percent females in the harvest (T = -7.85, P < 0.0001). Percent females in the harvest increased from 42 to 59% during selective versus non-selective periods, respectively (Figure 1). We detected a significant difference in male age distributions for selective versus non-selective periods (χ^2 = 98.1790, d.f. = 10, P < 0.0001). On a statewide level, there were a greater proportion of younger males in the harvest during the non-selective period. Although less pronounced, there also were a lower proportion of adult males in the non-selective period (Figure 2). We detected a significant difference in female age distributions for selective versus non-selective periods (χ^2 = 66.5116, d.f. = 10, P < 0.0001). On a statewide level, there also were a greater proportion of younger females in the harvest during the non-selective period (Figure 2).

Using model simulations, we found that changing from a selective harvest to a non-selective harvest (with all other parameters held constant) decreased the population's finite rate of increase by about 0.01–0.02 annually (Figure 3). This is roughly equivalent to about a 1.5% increase in harvest rate (proportion of population harvested).

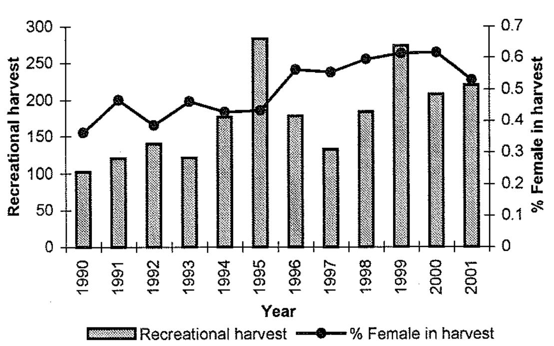

Figure 1. Recreational cougar harvest and percent female in the harvest during selective (1990-1995) and non-selective (1996-2001) years, Washington, 1990-2001.

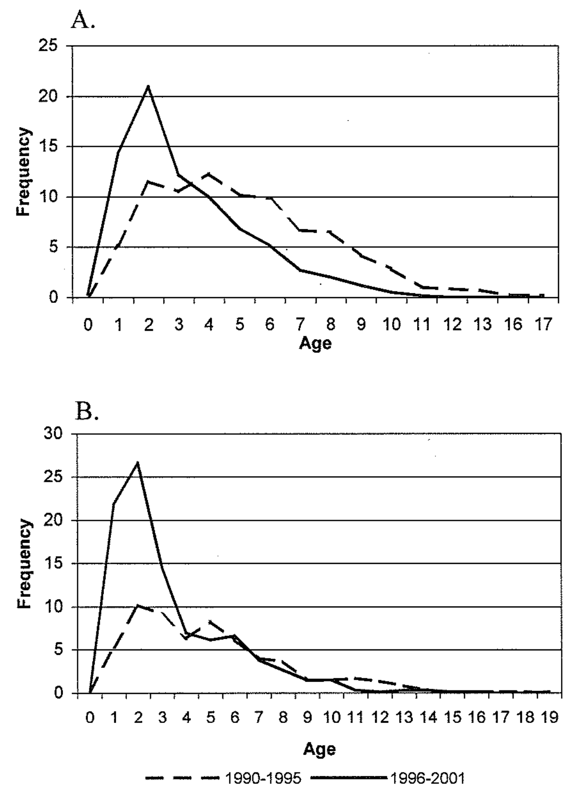

Figure 2. Age structures of harvested male (A) and female (B) cougar during selective (1990-1995) and non-selective (1996-2001) periods, Washington, 1990-2001.

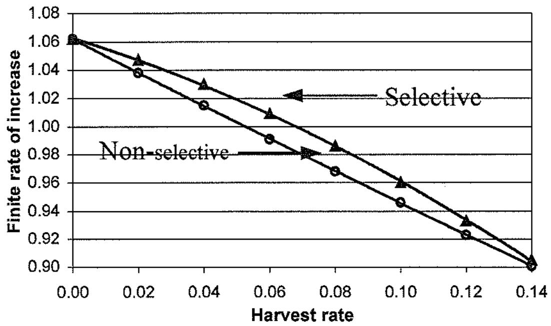

Figure 3. Relationship between harvest rate and finite rate of increase for selective and non-selective harvest strategies.

DISCUSSION

In Washington, when dogs were legal for hunting cougar, seasons primarily occurred from October to January. In contrast, when dogs were banned, season length increased and, more importantly, overlapped with deer and elk seasons. The reduced cougar tag and overlapping seasons made purchasing a cougar tag more attractive for deer or elk hunters, and licensed cougar hunters increased from less than 1,000 annually prior to I-655 to about 58,000 post I-655. This in turn created a situation where the majority of the harvest was by deer and elk hunters that took a cougar incidentally during their deer or elk hunt. We believe season timing, tag cost, and the large number of deer and elk hunters resulted in post I-655 harvest levels that were similar to pre I-655 levels.

The proportional increase of females and juveniles in the harvest during years with and without dogs probably was correlated with the proportions of these cohorts in the standing population. That is, individual sex and age classes of cougar were probably taken relative to their availability. Deviations between sex and age specific proportions in the population versus harvest probably were influenced by cougar and hunter distributions, cougar behavioral patterns and home range sizes, and prey distribution.

Our model simulations suggest that population growth is sensitive to female survival. The importance of female survival for population growth has been well documented (Clark 1999). A simple sensitivity analysis done by halving each parameter one-by-one and documented the percent decline in lambda further illustrates that female survival is the most influential parameter on lambda (Table 4). It therefore seems reasonable that changing from selective to non-selective harvest methods can impact a population's growth rate. Our model, although crude, suggests that the

Table 4. Percent decrease in λ when cougar parameter values are divided by two. Realized λ=1.062 with original parameter values (see Table 2 for parameter estimate sources) (adapted from Clark 1999).

Parameter	Actual estimate	Reduced estimate	λ	Percent decrease in λ
Female survival	0.82	0.41	0.73	31.3
Female juvenile survival	0.88	0.44	0.84	20.9
Cub survival	0.67	0.34	0.94	11.5
Litter size	3.01	1.50	0.94	11.5
Litter survival	0.93	0.47	0.96	9.6
Prop. of females with litters	0.80	0.40	0.97	8.7
Male adult survival	0.91	0.46	1.06	0.0
Male juvenile survival	0.64	0.32	1.06	0.0

impact may be in the range of increasing lambda by 0.01–0.02. In more familiar terms, this is analogous to a 1.5% increase in harvest rate. At first glance this appears small, but in our example population a 1.5% increase in harvest rate equals a 38% increase in observed harvest level. So changing to a non-selective harvest method was biologically equivalent to increasing the harvest by about 38%.

Of course, our model and the corresponding impacts to population growth assume that harvest is constant between selective and non-selective harvest methods. This is probably not a reasonable assumption unless season adjustments are made to mitigate the inefficiencies of boot hunting (e.g., spot and stalk, predator calling, and incidental take) for killing cougar. Without season changes, similar to those we discussed earlier, harvest would probably decline significantly without the use of dogs. The population growth rate would likely increase accordingly until density dependence occurred.

We also assumed there was no immigration or emigration occurring. Logan and Sweanor (2001) found that immigration could have as large of an impact to population growth as reproduction. This suggests that immigration could potentially counter decreases in lambda that resulted from increased female harvest. The effect of immigration acting in this manor decreases as the perimeter-to-area ratio of the population boundary decreases.

MANAGEMENT IMPLICATIONS

Several factors probably influence whether changing from a selective to non-selective harvest method will cause a cougar population to decline. In addition to parameter estimates and standard errors, knowing the age structure and growth rate are essential for predicting how an actual population might respond to changes in harvest vulnerability (Caughley 1977). Unfortunately, collecting biological data on cougar population dynamics is difficult and costly because cougars are extremely secretive, difficult to count, have large home ranges, and occur at relatively low densities. As such, wildlife managers often use harvest information as a surrogate to data on the living population. The risk of using harvest information is more acceptable when the majority of the harvest is males, because male survival has a relatively small impact on population growth. In contrast, the risk of using harvest data to guide management decisions is higher when the majority of the harvest is females, because female survival has a greater impact on population growth.

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