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Population trends of wolves in Quebec Wildlife reserves: is the harvest really sustainable?

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Abstract:

Lariviere et al.'s () article describes population trends in 9 wildlife reserves in Quebec from 1983 to 1997 as relatively stable and suggests harvest rates of 35% as sustainable based on information provided through hunter surveys. Conclusions made by the authors will most likely influence future wolf management in the province and the likelihood of their recolonization potential into the northeastern US (Harrison and Chapin 1997). We reanalyzed population trends over time using meta-analysis and contest the exponential relationship between wolf and moose density suggested by the authors. Additionally, because a three year wolf study in Laurentide Wildlife reserve supplies actual field observations (Jolicoeur 1999), we compared estimated harvest rates from the Larivière et al. () report to those obtained in the field for accuracy. We found wolf populations in all 9 reserves to be declining at a rate of XX and calculated discrepancies of up to 60% between actual and estimated harvest values. In light of the long-term decline and the inaccuracies we demonstrate in deducing sustainable harvest rates from estimated wolf densities and pelt sales, we suggest that the authors review their harvest and long-term management objectives. The difficulties of wolf management are discussed and alternative management strategies are suggested.

Introduction:

In the ?? issue of Biological Conservation, the article “Status and conservation of the gray wolf (Canis lupus) in wildlife reserves of Quebec” describes population trends of wolves from XX to XX (Larivière et al., 19??). The province of Quebec manages a system of 17 wildlife reserves totaling 68 000 km^2 throughout the province to promote the conservation and sustainable harvesting of wildlife (Crête et al. 1981, Les reserves fauniques http.). The Larivière (19??) paper describes population trends in 9 of these reserves situated in the southern part of the province. The conclusions and recommendations in this paper will have an influence on future wolf management strategies in Quebec and consequently the potential for these populations to be possible sources for reintroduction into the Northeastern US (Harrison and Chapin 1997).

In their paper, Larivière et al. (1998) used estimated wolf densities obtained by using 3 of Crête and Messier’s (1987) indices: tracks seen, scatts seen and wolves heard. By estimating harvest rates using the number of pelts sold by trappers leasing territories, the authors concluded that 1) wolf populations have remained stable in 7 of the 9 reserves in the past 15 years 2) The relationship between wolf and moose density is exponential 3) wolf populations have sustained high levels of exploitation (>50%) without declining 4) stability within the reserves was maintained through immigration by wolves from outside the reserves and high reproduction 5) exploitation rate should not exceed 35% annually.

In the following paper, we reanalyze the trend data presented in the Larivière (19??) paper using meta-analysis and review the suggested relationship between moose and wolf density. Due in part to concern over the possibility of high exploitation rates, the MEF ran a wolf ecology study in the Laurentide reserve from the summer of 1995 to March of 1998 (Jolicoeur, 1999). The data collected during this research project are the only direct field observations available in any Quebec reserve since trapping began and we use them to compare actual harvest rates to those estimated in the Larivière (19??) paper. Based on our analyses, we question the conclusions and recommendations proposed for future wolf management in the province of Quebec (Larivière et al. 19??).

Results:

1) Long-term trends in Quebec reserves:

To describe long term trends in wolf densities for 9 reserves in Quebec, Larivière et al. () performed simple linear regressions using the average of 3 of the 4 indices developed by Crete and Messier (1987) (xwolves heard, tracks seen, scatt seen) versus time. Based on their simple analysis, the authors concluded that in general, wolf populations have remained relatively stable over the past 15 years, because only 2 of the 9 reserves were found to have significantly negative slopes (Rouge-Mattawin and Saint-Maurice) (Larivière et al. XXXX).

The difficulty with using the proportion of significant results to infer the biological importance of a phenomena is well known, and is known as the vote counting paradox in meta-analysis (Hedges and Olkin 1985). The proportion of significance results is more often related to the average power of the analysis rather than the size of the effect studied. Here we suggest a simple approach to estimate the underlying dynamics of the wolf populations.

Meta-analysis, usually used to synthesize data from several experiments, can be extended to assess what is happening in a wide geographical area from limited sampling in certain sub-areas. If the reserves are subject to the same management regime, and similar large-scale environmental variability, then it is most reasonable to consider the hypothesis that they represent different "realizations" from a common distribution. Therefore, we consider these data together, to draw conclusions about wolf population change over time.

We begin with the simplest of models. Let x_{it} be the estimate of abundance in reserve i in year t. We consider the initial model that each population is changing at a constant rate of the period of time of the censuses, we have

$$x_{it} = x_{i0} e^{r_i + \varepsilon_{it}}$$

where r_i is the rate of population change, x_{i0} is the initial population size of the ith population, and ϵ_{it} is the error is the estimate of abundance and deviations from the assumed model (sometimes called ``process error").
It is unlikely that all the reserves will have exactly the same rate of change, so we will investigate the a simple mixed effect model where we assume that $r_i \sim N(\mu,\sigma_r)$. We estimated the parameters of this model under two different assumptions for ϵ_{it}. First, we assumed that the variance of ϵ_{it} is proportional to the inverse of the sample size, which we approximately know.
That is , we assume that $\epsilon_{it} \sim \sigma /n_i$, where σ is estimated from the data. An alternative approach is to assume that the variances are primarily due to factors that are not proportional to sample size, and estimate a separate variance, σ_i for each reserves.

For the meta-analysis, we are interested in the trends produced by the present management regime in Quebec reserves, which is similar, but stricter, than the management regime used where wolves can be harvested. We eliminated one point, the 1997 data point the Laurentide reserve, because trappers were asked not to trap that year because of a research project. (If this year is removed from the data series used in Larivière et al. (19??) regression, the wolf population in the Laurentide reserve to have declined and was not stable as stated by these authors (m= -0.03, r^2=0.37, p=0.04).)

The meta-analysis is discussed in detail in (OTHER PAPER). When fit individually, there are 2 positive slopes estimated, and the rest negative, with statistically significant slopes; these results are similar to the MEF's analysis without the log transform. However, the meta-analytic results are very different. Both versions of the mixed model analysis showed a statistically significant negative population growth rate, of around -0.02 (roughly -2\% a year), and estimate very little variability among reserves in the rate of population change.

This suggests that the 8 reserves are behaving a similar fashion, and are probably representative of much of southern Quebec where trapping of wolves occur. We repeated the analysis using a robustified mixed model and a mixed model with autocorrelated errors; each gave similar results.

2) Influence of moose on wolf density

Larivière et al. () claim that wolf density is an exponential function of moose density. This conclusion is questionable for several reasons. First, the difference in fit of the exponetial model (r=0.42) is only marginally better than the linear fit (r=0.40). Second, Larivière et al. () did not use the same time period to estimte average wolf abundance (1990-1997) as they used for moose densities estimated for some year between 1993-1996 (moose density was only estimated sporatically). Third, it is crucial to use a biomass index when comparing wolf populations utilizing different prey bases (INSERT FROM BELOW).

Using their averaged data, Larivière et al.(19??) found the relationship between wolf and moose density to fit an exponential model with wolf density remaining stable at low moose densities and increasing when moose density reaches 3 moose/10 km^2. We find several flaws with both this statistical analysis and the conclusions drawn from it. Firstly, we compared the fit of a linear model to the exponential one proposed in the report and found the fit to be almost identical (r^2 for the linear model = 0.40 compared to r^2 for the exponential model = 0.42). Secondly, the authors identify a relationship between wolves and moose but clump single and multiple prey systems together as the independent variable. Changes in wolf density due to changes in prey density have been documented in long-term studies for both deer (Mech, 1977) and moose (Messier, 1985). However, when comparing wolf populations having different prey bases, a biomass index should be used and not the density of one particular prey. Accordingly, Keith (1983) found a highly significant correlation between wolf densities and total ungulate biomass in 7 different study areas. Similarly, Fuller (1989) compiled data from 25 studies throughout North America and found a positive linear relationship between wolf density and prey biomass regardless of prey type or stability of wolf populations. We recommend that the authors reproduce their model but regress estimated wolf densities of the individual years on which there is information on biomass (moose and deer densities) available.

3) Effect of trapping on wolf populations

Although we agree that indices are useful and inexpensive tools to help monitor population trends over large areas, we are skeptical of their use in establishing sustainable harvest rates. An index allows us to aggregate information into a single measure to allow for comparison and identify trends over time (Harnett and Murphy, 1986). However, these values do not necessarily accurately reflect absolute or actual values. To illustrate this point, we use direct field observations available for the Laurentide reserve from 1995 to 1998 (Jolicoeur, 1999) and compare them to the estimated values presented in Larivière et al. (19??) (tables 1. and 2.).

a) Harvest rates based on data from Jolicoeur (1999)

Based on fairly precise wolf counts obtained from extensive aerial surveys and ground tracking, the total mortality of this wolf population during a period of voluntarily restricted trapping was estimated at 38% for 1996-97 and 55 % for the 1997-98 season (Jolicoeur 1999). Usually when harvest rates are calculated for a population, the number of animals present at the end of the trapping season are compared to the total population present on the territory prior to the opening of trapping. In the case of a wolf population, this should include not only adult wolves present but also all pups born in the spring as they will be recorded by trappers if caught. Excluding pups in the pre-season count would significantly distort harvest rates due to the high proportion of pups in the population during periods of heavy exploitation by trapping (up to 70% of a population) (Mech 1970 pp.59-62; Keith 1983; Gasaway et al. 1983; Peterson et al. 1984). In the government report describing the Laurentide wolf population (Jolicoeur 1999), pups were omitted in 2 of the 8 packs which were known to have bred (Gite and Montagnais packs) thus deflating the pre season wolf numbers and thereby underestimating actual mortality. Although it is not always possible to determine the exact number of pups born per pack, the average litter size within the Laurentide reserve from 1995 to 1998 was 6.3±0.42 pups (Jolicoeur 1999). To be conservative in correcting in correcting for this error, we will use five standard deviations below this mean (4 pups) to estimate numbers for the 2 packs where an exact pup count is not available. The resulting revised mortality rates suggest that overall mortality in the reserve population was 47% in 1996-97 and 72% in 1997-98, years during which there was a voluntary ban on wolf trapping to reduce overall mortality.

b) Harvest rates based on estimates from Larivière et al. (19??)

In 1996, the wolf density in the Laurentide reserve was estimated at 0.64 wolves/100 km2 (Larivière et al. XXXX) which represents a total of 49 animals in the fall. Only 6 pelts were registered from the trappers giving an estimated harvest rate of 12.2%. Trapping in the Laurentide reserve represents 54% of the total causes of mortality (Jolicoeur, 1999), yet even if the published Larivière et al. (XXXX) harvest rate is doubled to 24.4%, it is far below the mortality rate of 38% based on field observations reported by the MEF (Jolicoeur 1999). The discrepancy with the corrected mortality of 47% we calculated with pups added to the pre-winter count is even greater (see table 2.). The inadequacy of the published estimates is more obvious in 1997 where 4 pelts were sold out of an estimated population of 78 wolves giving a harvest rate of 5.1% (Larivière et al. xxxx) while the mortality we calculated using data from Jolicoeur (1999) is 72.0% (see table 2.).

Larivière et al. (19??) acknowledge that their numbers represent minimum harvest rates, but failed to appreciate the extent to which their estimated harvest rates could be deflated. This could explain why the average estimated harvest rate from 1985 to 1996 for the Laurentide reserve of 18.3±4.8% (Larivière et al. 19??), although well below the accepted maximum exploitation values, actually led to a population decline.

Discussion:

Larivière et al (19??) state that that harvests of up to 35% or overwinter mortalities of 50% are considered sustainable (Mech, 1970; Peterson et al., 1984; Ballard et al., 1987; Fuller, 1989; Smietana and Wajda, 1997). Indeed, Mech (1970, pp.63-64) did find that over 50% of a population had to be removed for a decline to occur. However, Larivière cite Ballard et al. (1987) as having similar results, when in fact his data was reanalyzed by Fuller (1989) who found that populations remained stable with overwinter mortalities of 35%. Similarly, Van Ballenburg (1975) and Gasaway et al. (1983) found that sustained annual harvests of approximately 20% were sufficient to limit wolf numbers. Although in the Peterson et al. (1984) study, a higher harvest was required for the wolf population to decline, it had been under complete protection for the 13 years previous to their study. Keith (1983) summarized 13 studies and concluded that harvest rates exceeding 30% should be of concern. Therefore, the harvest rate suggested by Larivière et al. of 35%

based on deflated estimated harvest rates, to maintain stable populations in reserves where trapping has been uninterrupted for 15 years, is higher than those suggested in the literature from long-term reduction studies based on actual wolf numbers, not on estimations from indirect observations and indexes. Since our reanalysis shows that wolf populations in Quebec to be declining, and not stable as stated in the Larivière (19??) paper, their suggested harvest rate is of concern.

One of the main effects of short-term heavy exploitation is the reduction in pack size (Peterson et al. 1984, Ballard 1987). This consequence is not as serious where packs consist of individuals from several generations before harvesting and there are adults in the population available to breed. In the case of reserves where overwinter mortality has exceeded 50% for many years, packs often consist solely of adult couples and their offspring (Ballard et al. 1987; Jolicoeur 1999), increasing the probability that entire packs could be eliminated during the trapping season, as in the Laurentide population. This extreme destruction of pack structure on a yearly basis could have biological and evolutionary consequences for such a social predator (Haber 1996) and would hardly reflect sound management. Family units, and not only numbers of wolves should be considered when defining management strategies for wolf populations (Haber 1996).

Most wildlife reserves in Quebec have elaborate road systems due to ongoing logging activities, making these areas highly accessible to trappers and increasing the incidence of mortality factors other than trapping such as collisions with automobiles. In the case of the Laurentide reserve, trapping represented only 54% of the total mortality between

1994 and 1998 (Jolicoeur 1999). If this situation is representative of other reserves then the suggested harvest rate of 35% (Larivière et al. 19??) actually represents an approximate over-winter mortality of 70% which clearly cannot be considered sustainable.

Larivière et al. (19??) use the term “stable populations” for reserves where immigrating individuals are needed to compensate for high exploitation rates. The authors describe reserves as population “sinks” and surrounding areas as “sources”. A “source” is a population that shows no net change in population size over a large period of time but is a net exporter of animals (Poulliam 1988). Areas surrounding reserves have higher trapping pressure due to the lack of exclusive trapping territories (Larivière et al 19??). Therefore, the ability of these areas to provide animals to the reserves indefinitely is unlikely and certainly cannot be assumed. If wolf populations in reserves were managed correctly, they should be supplying animals to areas outside reserves where there are no exclusive trapping territories and harvests are more difficult to monitor and manage. Describing “managed” areas as “sinks” raises questions about what wildlife management is and what we hope to achieve when land is set aside for wildlife. This is of particular concern since two of the authors of the Larivière et al. (XX) paper are biologists for the Ministry of Environment and Fauna of Quebec.

Wolf management

The setting of an overall target harvest rate for a population based on available information is the first step in responding to a wildlife management issue. However, this goal must be followed by clearly defined actions to achieve the desired outcome. Larivière et al. (1998) recommend that wildlife managers set quotas and shorten harvest seasons to maintain wolf harvest at an acceptable level. Although these are the traditional methods used to regulate most harvested wildlife populations, it is important to consider the changes that the trapping industry has undergone in the past ten years before applying them to wolves. In Quebec, individuals must complete a 30-hour course describing modern techniques before being awarded a trapping permit (MEF http). Additionally, trappers can attend more specialized clinics where specific species are targeted. Trapper education has several major advantages including the reduction of suffering inflicted to animals and the decrease in bycatch species. It has also made trappers much more effective and while the number of wolf pelts sold on the Quebec market has increased significantly since 1990 (Larivière et al. 1998), there has been no change in management practices. Wolves are trapped almost exclusively using baits and snares and much less frequently in leg-hold traps. From a trapper's perspective snaring is relatively inexpensive ($2.50 per snare vs. $50 to $200 for individual leg-hold traps) and much less time consuming than leg-hold trapping (daily visitation is not required since snares are lethal). However, from a management perspective, snaring has several major practical and biological disadvantages. Since wolves travel in packs during the winter (Mech 1970 pxx), they are not evenly distributed over the territory as some solitary harvested species are. The vast areas that wolf packs cover, and thus the many trapping territories they traverse as a unit makes them particularly vulnerable to this type of exploitation. Because snaring kills the animals it difficult if not impossible for trappers to abide to any type of quota system as dozens of snares are set around every baiting site and it is impossible to release animals if quotas have been exceeded. Furthermore, in Quebec, baiting is allowed before the season opens and can involve tons of meat being deposited over several weeks, attracting entire packs to these sites. This creation of dependency results in most of the wolves being captured within the first weeks of the trapping season (Rolland Lemieux, pers. comm.). It is therefore unlikely that a shorter season would significantly decrease the number of wolves captured. This type of quota system has been blamed for the overexploitation of many natural resources because of errors in population data (Holt and Talbot 1978; Ludwig et al. 1993).

When leg-hold traps are used, the majority of wolves captured by trappers are pups or sub-adults since adults are more experienced and frequently are able to avoid the traps. In contrast, with snares individual members of a pack are captured indiscriminately. The use of baited snares thus can seriously affect the survival and social structure of a family pack since adults are as likely to be killed as pups. A pertinent example is the GJ pack in the Laurentide reserve where snares killed successive alpha females on 3 separate years during the 4-year study (Jolicoeur 1999). Recommendations regarding the management of harvested wildlife should take into consideration not only the biology and status of the population but also the harvest methods used and their long-term effect on a population.

Leg-hold traps have become synonymous with cruelty to animals over the years, but it is important to weigh the consequences of the alternative before promoting one method over another. Unfortunately, there is presently no commercial restraining trap for wolves meeting the requirements of the Agreement on International Humane Trapping Standards (Fur Institute of Canada http). It is important to note the “new generation” of leg-hold traps used by most biologists having to capture wolves to equip them with radio-collars. Modifications include rubberized jaws as well as multiple swivels and shock absorbers to reduce possible injuries to the animal’s leg (Lemieux unpublished report). During the Laurentide wolf research project, over 60 wolves ranging from 15 to 45 kg were captured and released using leg-hold traps without a single injury (no cuts or swelling) and bycatch species such as lynx can be released without injury as well. Such modifications, which can be made to existing models, should be made mandatory wherever leg-hold are used (including by researchers).

Specific management recommendations and Conclusion:

It is impossible for individual trappers to decide on sustainable quotas on their own because they would need to be aware of the activities of other trappers in the area. It is for this reason that trappers are demanding a science-based management plan to guide them.

Structured reserves with exclusive trapping territories, unlike private and crown land, offer many advantages and management possibilities to government biologists, particularly when dealing with a social species. If we acknowledge the importance of preserving key individuals within well established packs then it becomes obvious that setting an overall harvest rate for an entire reserve is counterproductive. Even a reduced harvest rate could lead to overexploitation in one part of the reserve if several trappers within a pack's territory are using baited enclosures. Traditional management strategies for wolf population need to be rethought and consider family units, their biology and present harvest methods.

One possible scenario could be to divide reserves into "wolf harvest zones" which would encompass a certain number of trapping territories based on average wolf territory size. This could be estimated at least roughly based on prey densities (Messier 1985), that are available for all reserves. If trappers are permitted to use baiting sites then only a few trappers in each zone should be permitted to capture wolves; this could be decided in the form of a lottery or some type of rotation among interested trappers within each "zone". Quotas per trapper should take into consideration the importance of other mortality factors within the different reserves. Other alternatives could be devised if only wildlife managers are ready to abandon traditional management methods for more biologically oriented ones. Such modern management strategies can only succeed with the cooperation between governments, hunters and trappers. A good example is the management of cougar populations surrounding Banff National Park ……get info

The declining trend of wolf populations in southern Quebec should be addressed by wildlife managers without delay to halt the present overexploitation. We suggest a target harvest rate well below 20% (Van Ballenburg 1975, Gasaway et al. 1983) since reserve populations have been exploited for fifteen years without any type of management plan and because of the high rate of collisions with vehicles (Jolicoeur. 1998). Officials should hold discussions with the FTGQ in order to develop a scientifically sound and technically feasible management plan that will ensure the long-term survival of this population.

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Tables and Figures:

Figure 1. **RAM**

Table 1. Estimated wolf numbers and harvest (1990-1997 excluding 1994) and population trends (1983-1997) for Quebec reserves. Values adapted from tables 2. and 3. in Larivière et al (1998).

Table 2. Total mortality calculated for the Laurentide reserve from 1996-1998. Results for the official population numbers were obtained from Jolicoeur (1999). Our revised estimated population numbers were calculated by adding 4 pups to 2 of the 8 packs where the pups were omitted from the pre-season count.

Table 1:

Reserve	Estimated number of wolves	Average harvest rate (%)	Regression analysis		
			Slope	r^2	p
Portneuf	6±1	1.2±0.3	-0.01	0.04	0.49
Saint-Maurice	5±1	22.2±8.3	-0.04	0.40	0.02
Rouge-Mattawin	18±3	15.7±5.5	-0.07	0.38	0.01
Mastigouche	11±1	33.9±8.2	-0.01	0.05	0.47
Papineau-Labelle	34±2	53.3±19.9	0.03	0.26	0.63
Ashuapmushuan	45±4	---[b]	0.04	0.30	0.10
Sept-Iles/Port-Cartier	54±5	2.2±0.9[a]	0.02	0.08	0.50
Laurentides	63±6	18.3±4.8	-0.02	0.16	0.18
La Vérendrye	147±6	1.2±0.3[a]	-0.01	0.22	0.09

[a] These values are underestimated due to trapping by Natives who have exclusive rights on most of the reserve

[b] Harvest statistics are not available. Only Natives trap wolves.

Table 2.

	1996-1997 season			1997-1998 season		
	Count on May 1st	Count on April 30th	Total mortality (%)	Count on May 1st	Count on April 30th	Total mortality (%)
Official population numbers	45	28	37.78	51	23	54.90
Population numbers adding 4 pups to 2 packs known to have pups	53	28	47.17	59	23	61.02