Wolf Harvest Model Simulations for Future Quota Discussions

— Informational Supplement, 2008 —

Introduction

FWP is recommending that wolf hunting and trapping seasons be established in two steps. First, the basic components, such as season dates, management units, means of take etc. would be determined through the regular biennial season setting timeline and process. These are the rules and regulations that outline what's legal and what is not with respect to licensed public harvest. FWP is proposing a tentative wolf season structure for FWP Commission consideration and public comment in December 2007 to begin the process of determining a wolf season structure that would be implemented upon delisting.

The second step is to determine the actual number of wolves that could be harvested. This would be addressed in a separate decision process. FWP is recommending that total wolf harvest be finite and regulated through a quota and special permit system. The actual quota and number of special permits available would be determined through the regular annual quota-setting process at future FWP Commission meetings. FWP would recommend tentative quotas in June and the FWP Commission would adopt final quotas in August of each calendar year. FWP is not proposing actual quotas for a 2008-2009 season at this time.

However, in order to formulate the basic wolf season components, FWP needed to explore a wide variety of alternatives and potential outcomes. By analyzing existing data sets and making some assumptions, FWP developed an initial wolf harvest model simulation to consider a range of harvest rates and the potential effects on the wolf population and the number of Breeding Pairs (BP) in the state in the first year after implementation only. This effort is intended to help determine sideboards around what could be appropriate harvest levels that would not jeopardize the population or cause it to drop below 15 BPs. Montana is required to maintain at least 10 BPs and 100 wolves as its contribution to a recovered northern Rockies wolf population. At least 15 BPs statewide is required to offer public hunting and trapping opportunities. Harvest would be implemented in such a way as to not jeopardize population viability and species recovery.

FWP monitors the wolf population on an ongoing basis throughout the year through a combination of radio telemetry, public wolf reports, track surveys, etc. At the end of the calendar year, FWP estimates and reports the minimum number of BPs, individual named packs, and total wolves. December 31 of each calendar is considered the snapshot population estimate for purposes of demonstrating maintenance of a recovered population and establishing future adaptive management direction.

This document provides additional information and details about the modeling effort. It is meant to supplement the FWP Wolf Hunting / Trapping Season Supporting Information and provide the preliminary basis for future discussions about wolf quota / permit levels.

Harvest Model

FWP explored the potential outcomes of a quota-based wolf hunting and trapping season by simulating various harvest rates in each of three wolf management units as described in the proposed wolf season framework (2007). The simulations were intended to gauge the response of Montana wolves to harvest in the year immediately following implementation and do not reflect an approach to long-term sustainability of wolf harvest. A four -step process was used.

The primary goals were to:

- Examine various combinations of harvest rates to determine population sensitivity by adding harvest mortality to existing causes of death for each of the three management units and statewide, given the 2006 – 2007 population data.
- Gauge the risk of the statewide number of BPs (the federal recovery definition) dropping below 15 in the year following the first year of implementation.
- Consider various combinations of harvest rates that result in a predicted wolf population increase, population stability, or a population decrease one year later.
- Predict the number and size of wolf packs, the number of BPs, and the total number of wolves statewide in the first year following harvest.

1. Determine Population Baselines

The Montana wolf population has increased from a minimum of 66 wolves (6 BPs) in 1995 to approximately 394 wolves (37 BPs) in September 2007. But in order to simulate the effects of harvest, a general baseline understanding of wolf population dynamics is the required first step. Therefore, a population model was created and was largely based on the biological features of wolves in each of the three management units (Mitchell et al. *in press*). The model incorporated birth, death, immigration, and emigration for each unit using actual data from 2006 and 2007. Several assumptions were necessary, however. They were:

- Rates of birth, death, immigration, and emigration are known with certainty, constant and equal to those observed in each area in the previous year.
- Mortality rates are constant for individual wolves.
- Immigration results in the formation of new packs of a consistent age structure and at a constant rate within each area.
- Reproduction results in a consistent number of pups and only in packs that existed in the previous year in each area.
- About 10% of the wolf population is comprised of single wolves not associated with a pack – thus the minimum known population was increased by 10% in each area.

2. Simulate Effects of Harvest

Once the basic wolf population dynamics are determined and predicted, FWP then simulated how harvest might affect the number of wolves, number of packs, and the number of BPs in the first year following harvest.

Quotas were set as percentages of the previous year's minimum known wolf population in each area. Thus, reproduction, immigration / emigration, and mortality in the year of harvest are not considered in the simulation exercise itself but will be at the time quotas/ permit levels are set. This allows FWP to be more conservative when recommending tentative quotas in June of the year of harvest. Final quotas would be established in August immediately prior to a season. This allows current year's data to be incorporated in case there are significant, unexpected developments such poor pup survival due to disease or increased mortality due to conflicts with livestock. See Figure 1.

Harvest quotas ranging from 0% to 75% of the population in each area were simulated. The simulation included all possible combinations of these rates at 5% increments for a total of 4096 combinations. Each

combination of harvest rates was simulated 1000 times. The number of wolves, wolf packs, and BPs after one harvest season were estimated after each simulation run.

The harvest simulations made the simplifying assumptions that:

- Wolf mortality due to public harvest is random and is additive to wolf dispersal and all other forms of mortality, including natural mortality, illegal wolf harvest, and mortality due to depredation in each area.
- Managers do not know the statewide number of BPs with 100% certainty; therefore the BP probability estimator was used to estimate the number of BPs for those packs lacking field observations to confirm BP status (Mitchell et al. *in press*, Gude et al. *in review*). This approach generates an estimate of the number of BPs in Montana, as well as lower and upper confidence limits that reflect the uncertainty involved in estimation (i.e., we are 95% certain that the true number of BPs falls between the upper and lower confidence limits (Figure 2).

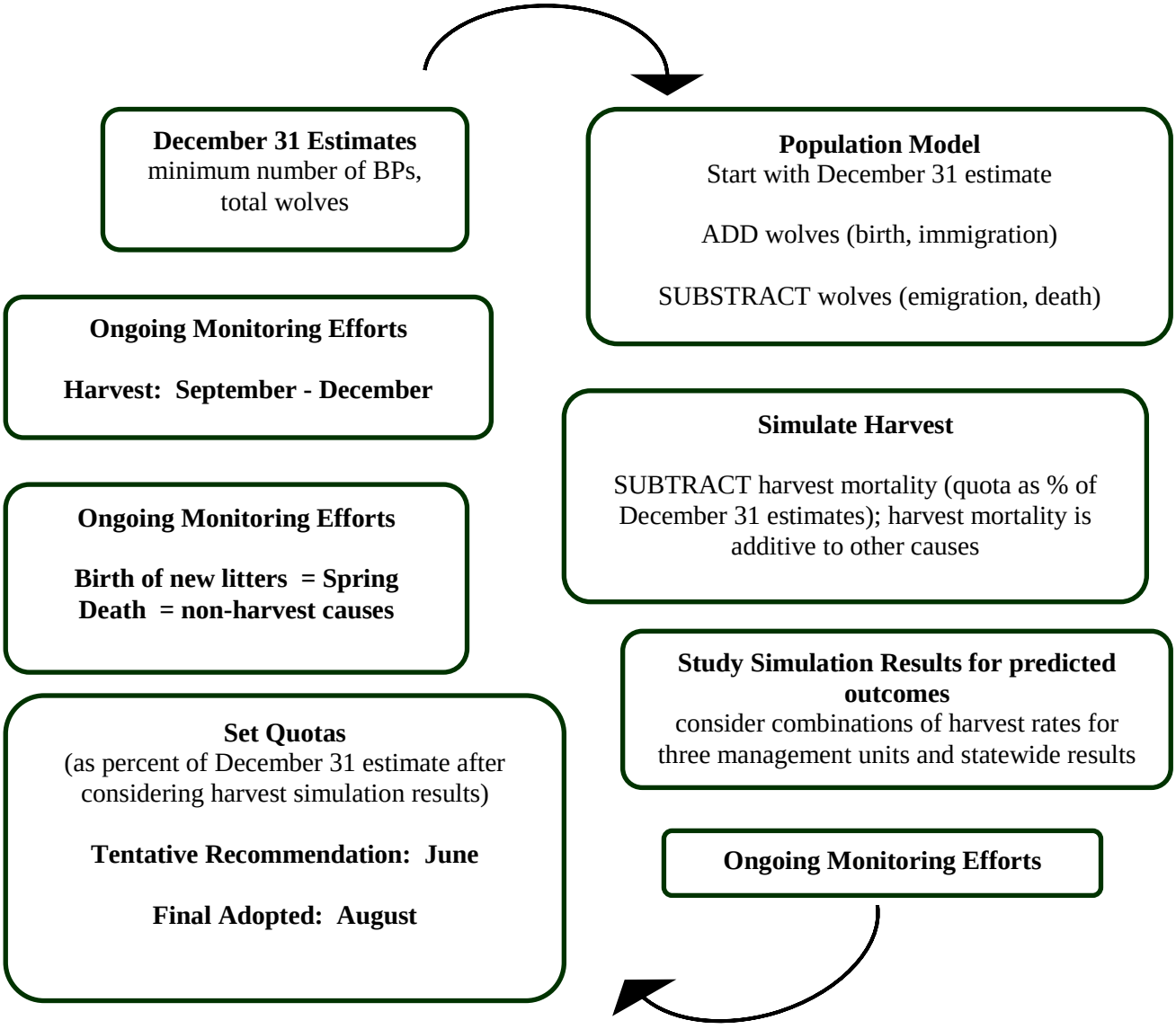

Figure 1. A flow chart of wolf harvest simulation model and quota setting process.

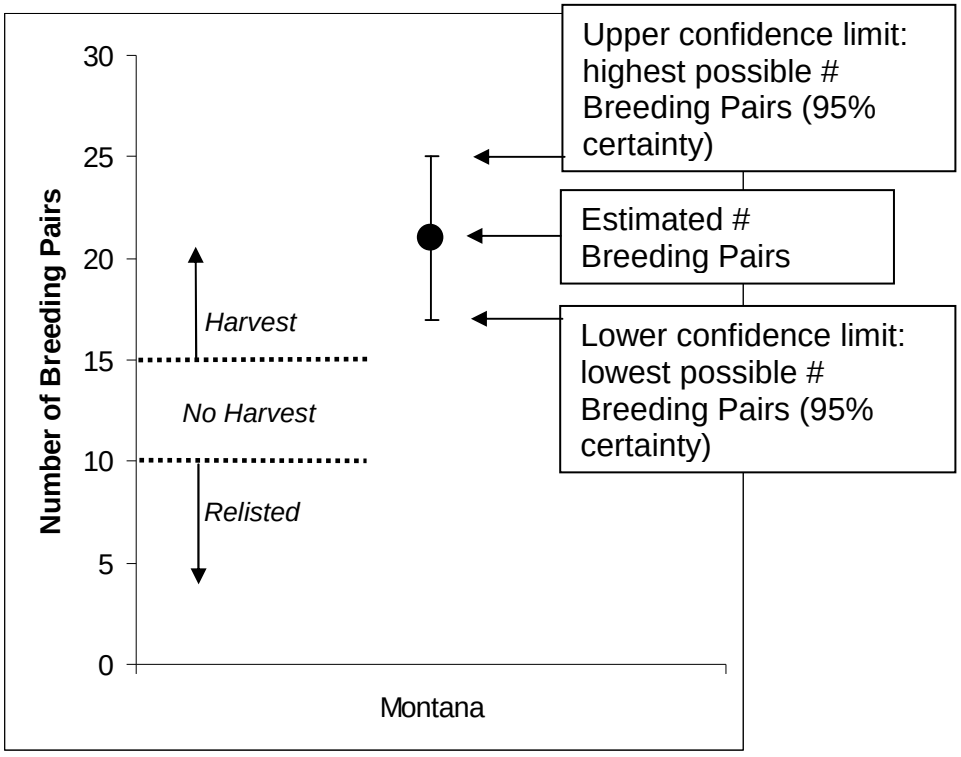

Figure 2. Example of hypothetical estimate of the number of Breeding Pairs for Montana, with upper and lower confidence limits.

3. Simulation Results

The results of each combination of harvest rates were scrutinized to determine whether it resulted in a "risky" outcome in which the lowest possible number of BPs within the 95% confidence limit went below 15. This threshold represents a boundary below which a harvest season in the following year would be cancelled, as dictated by the state management plan. By accounting for uncertainty through confidence intervals, assuming that harvest would be additive to all other forms of mortality, and only considering "no risk" harvest scenarios, FWP is taking a conservative approach.

The simulations indicated that the Montana wolf population can support a harvest season and remain stable to increasing for one year, given the population vital rates observed in 2006 and 2007. Generally speaking, progressively higher harvest rates resulted in progressively steeper population declines, although the relationship was not linear. This is because of baseline population differences between each of the three units (Mitchell et al. *in press*) and other types and levels of wolf mortality. The Northern Montana Wolf Management Unit (#1) is the most sensitive area for the random harvest of wolves if the goal is to maintain at least 15 BPs in the state.

4. Consider Combinations of Harvest Rates

Based on the 2006-2007 population model, nearly all combinations of harvest rates resulted in a "no risk" outcome where the 95% lower confidence limit for the BP estimate did not drop below 15. Wolf population dynamics and current levels of human-caused mortality are different in each of the three management units (Mitchell et al. *in press*). Therefore, various combinations of harvest rates yielded similar predicted statewide outcomes. However, these results suggested that harvest rates could vary within each of the proposed management units to reflect local social and biological factors such as the status of wolf and/or prey populations, livestock damage, social tolerance, etc. while still maintaining a secure population statewide and assuring connectivity within Montana and the northern Rockies wolf populations, respectively.

Quota percentages were based on the minimum number of wolves that FWP knew were present on December 31 of the previous year. There will likely be more wolves present at the start of the current year's hunting/trapping season due to the current year's reproduction and immigration adding to the population. Current year's mortality could be accounted for at the time final quotas are set. Increasing population trends to date demonstrate that reproduction and immigration have exceeded emigration and total mortality. In this way, the model and quota-setting process is conservative -- it is based on known wolves plus an estimated 10% lone wolves not affiliated with a pack and accounts for wolf mortality up until final quotas are set.

There is considerable variation in the level of human-caused mortality that a wolf population can withstand and remain relatively stable. Important factors include overall wolf density and population size, immigration / emigration rates, other types and levels of mortality (e.g. livestock-related), prey base, and birth rates (Fuller et al. 2003).

Depending on the desired goal or outcome one year later, various combinations of harvest rates could be selected to facilitate a population increase, population stability, or population decrease. The following bar graphs illustrate the predicted outcomes of various combinations of harvest rates in each of the three areas one year immediately following harvest. They are based on current levels of monitoring effort.

References

Fritts, S.H., and L. N. Carbyn. 1995. Population viability, nature reserves, and the outlook for gray wolf conservation in North America. Restoration Ecology 3(1):26-38.

Fuller, T. K., L.D. Mech, and J.F. Cochrane. 2003. Wolf Population Dynamics. Pages 161-191 *in* L. D. Mech and L. Boitani, editors. Wolves: behavior, ecology, and conservation. The University of Chicago Press, Chicago, Illinois, USA.

Gude, J.A., M. S. Mitchell, D. E. Ausband, C. A. Sime, and E. E. Bangs. *In review*. Internal validation of predictive logistic models for decision making in wildlife management.

Mitchell, M. S., D. E. Ausband, C. A. Sime, E. E. Bangs, J. A. Gude, M. D. Jiminez, C. M. Mack, T. J. Meier, M. S. Nadeau, and D. W. Smith. *In Press*. Estimation of successful breeding pairs for wolves in the U.S. northern Rocky Mountains. Journal of Wildlife Management.

Montana Fish, Wildlife & Parks Wolf Hunting / Trapping Season Supporting Information. 12pp.

Graphical Results

The following bar graphs illustrate a variety of scenarios of various harvest rates in each of the three proposed wolf management units (Figure 3). The graphs illustrate the expected statewide number of BPs, the percent of the simulations that resulted in a "risky" outcome (defined as the 95% lower confidence limit dropping below 15 BP), the number of wolves living in packs, and the expected number of packs one year after implementation.

Of the 4,096 combinations of harvest rates simulated, most did not result in risky outcomes. FWP selected a few representative combinations that predicted a population increase, population stability, or a population decrease. Not all simulations predicting a population decrease resulted in an unacceptable or risky decline below 15 BP, but a few did. These are also presented.

Figure 3. Proposed Wolf Management Units.

Population Increase Scenarios – No and Low Harvest – NO RISK -- Figures 4 and 5

- No harvest or low harvest rates in each of the three management units
- Increase defined as outcomes greater than 40 BPs
- No risk of the lower confidence limit dropping below 15 BP
- Monitoring at current level of effort

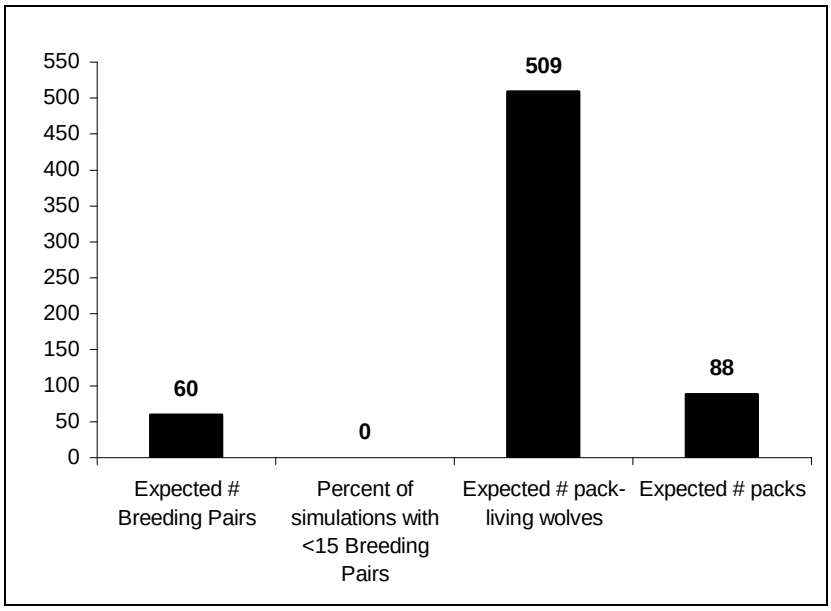

Figure 4	Harvest Rate	Number
Northern Montana Unit 1	0	0
Western Montana Unit 2	0	0
Southwestern Montana Unit 3	0	0

Figure 4. Model simulation statewide results if harvest quotas were set to zero for all three proposed wolf management units.

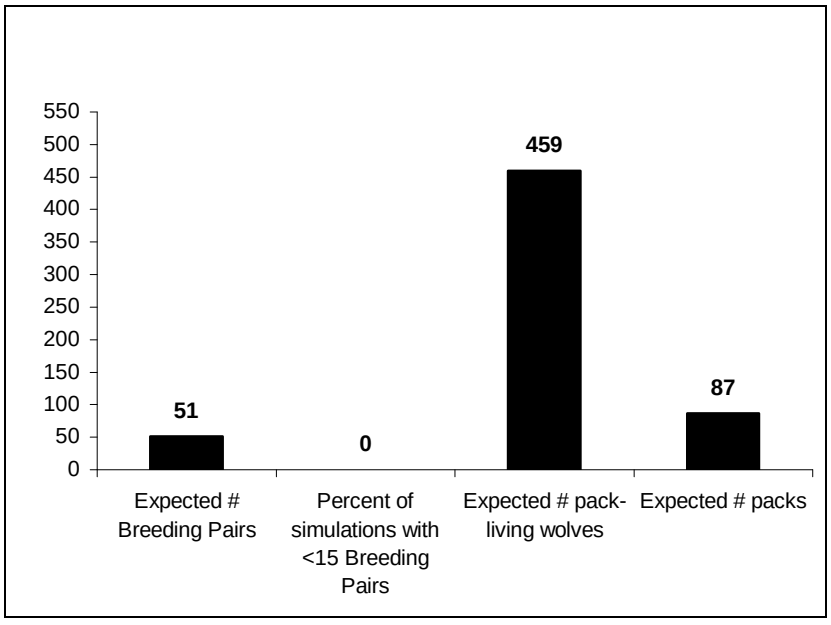

Figure 5	Harvest Rate	Number
Northern Montana Unit 1	15%	30
Western Montana Unit 2	15%	14
Southwestern Montana Unit 3	15%	11

Figure 5. Model simulation statewide results if harvest quotas were set at 15% in each of the three proposed management units.

Population Stability Scenarios – NO RISK -- Figures 6 and 7

- Harvest rates could vary within each management unit and still maintain population stability
- Stability defined as outcomes between 35 and 40 BPs (the actual September 2007 preliminary estimate)
- No risk of the lower confidence limit dropping below 15 BPs
- Monitoring at current level of effort

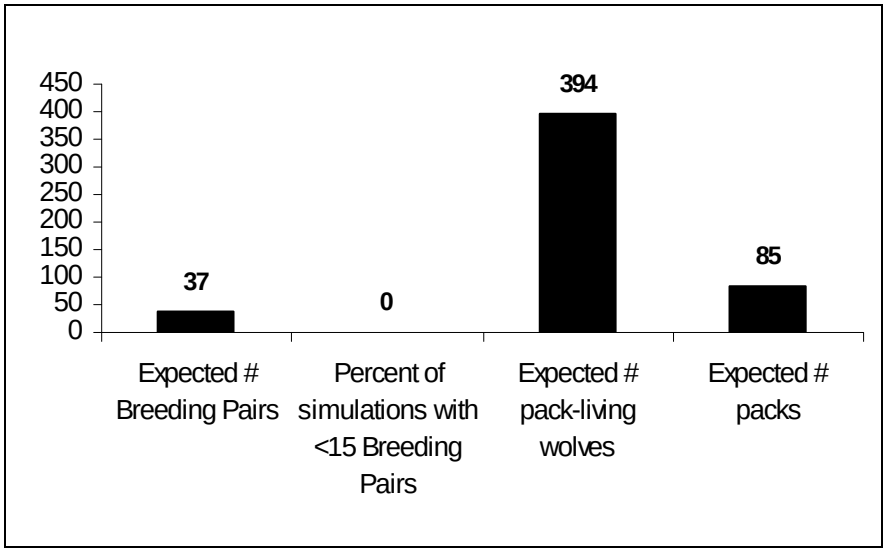

Figure 6	Harvest Rate	Number
Northern Montana Unit 1	30%	60
Western Montana Unit 2	40%	38
Southwestern Montana Unit 3	40%	30

Figure 6. Model simulation statewide results if harvest quotas were set at different rates in each of the three proposed management units.

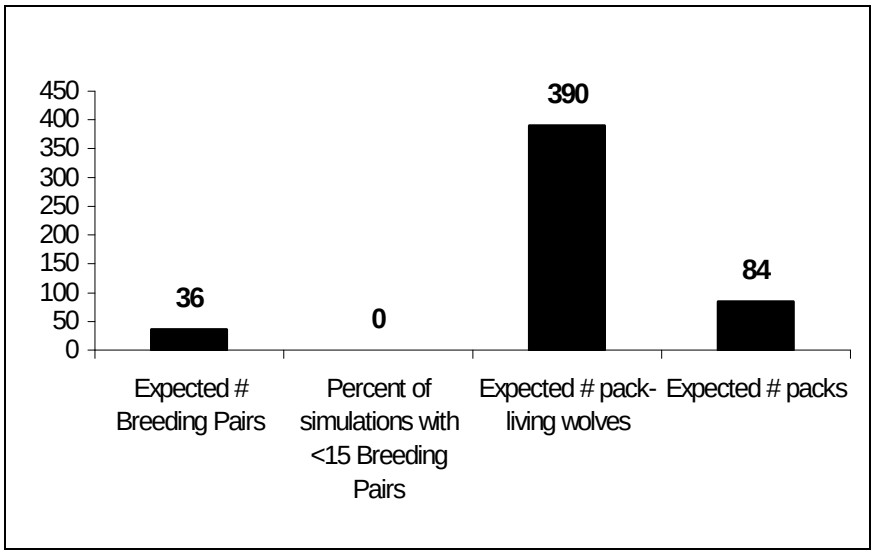

Figure 7	Harvest Rate	Number
Northern Montana Unit 1	30%	60
Western Montana Unit 2	30%	29
Southwestern Montana Unit 3	60%	44

Figure 7. Model simulation statewide results if harvest quotas were set at different rates in each of the three proposed management units.

Population Decrease Scenarios – NO RISK – Figures 8 and 9

- Harvest rates could vary within each management unit, yet still maintain minimum of 15 BPs statewide
- Decrease defined as outcomes less than 30 BP
- No risk of the lower confidence limit dropping below 15 BP
- Monitoring at current level of effort

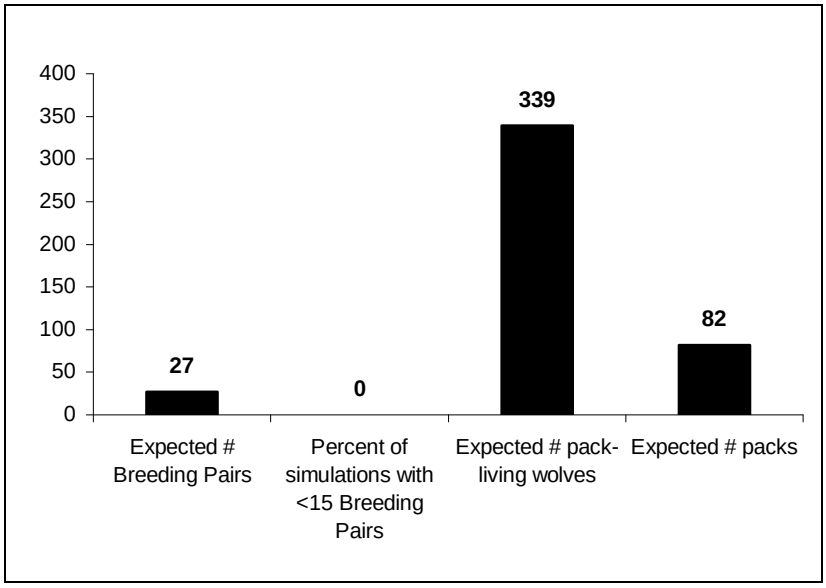

Figure 8	Harvest Rate	Number
Northern Montana Unit 1	55%	109
Western Montana Unit 2	45%	43
Southwestern Montana Unit 3	50%	37

Figure 8. Model simulation statewide results if harvest quotas were set at different rates in each of the three proposed management units.

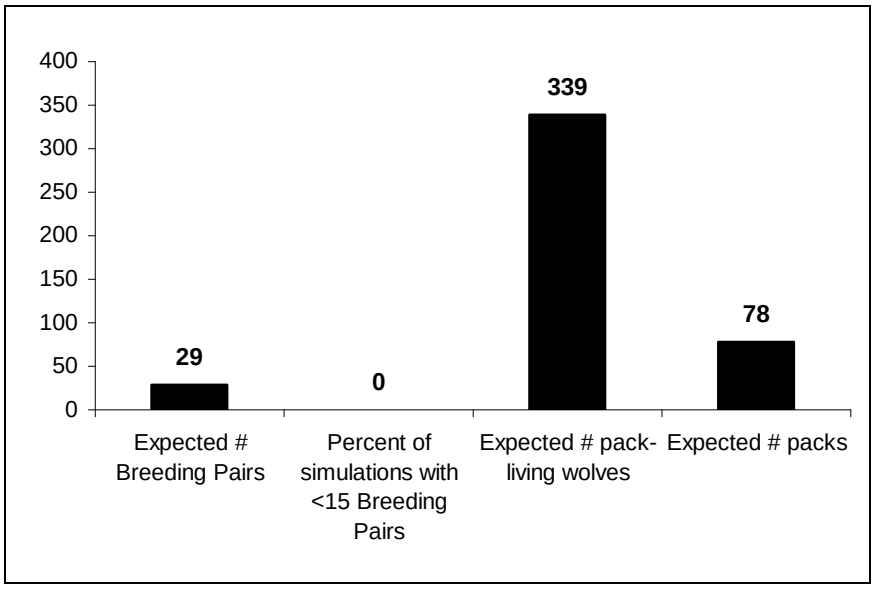

Figure 9	Harvest Rate	Number
Northern Montana Unit 1	35%	70
Western Montana Unit 2	70%	67
Southwestern Montana Unit 3	70%	52

Figure 9. Model simulation statewide results if harvest quotas were set at different rates in each of the three proposed management units.

Population Decrease Scenarios – RISK – Figures 10 and 11

- Harvest rates could vary within each management unit, but outcomes much more variable
- There is a risk that the 95% lower confidence limit drops below 15 BP
- Monitoring at current level of effort

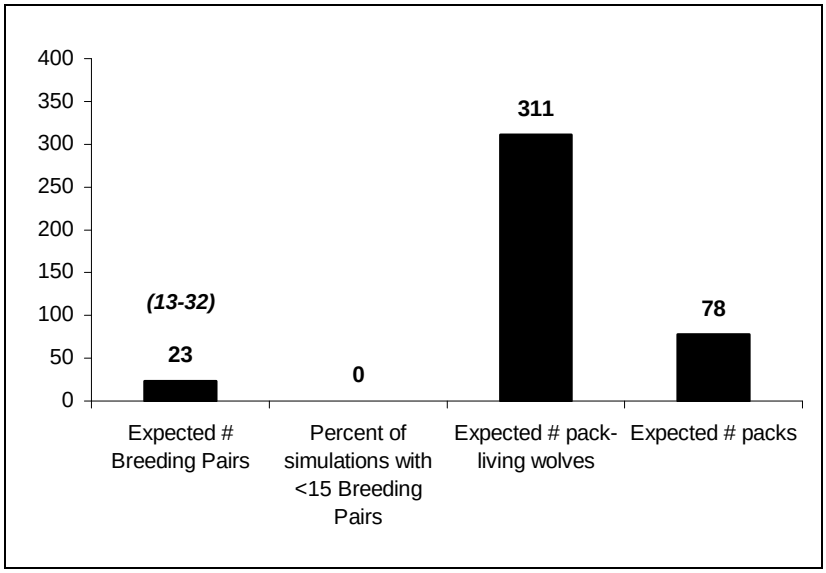

Figure 10	Harvest Rate	Number
Northern Montana Unit 1	60%	119
Western Montana Unit 2	60%	58
Southwestern Montana Unit 3	60%	44

Figure 10. Model simulation statewide results if harvest quotas were set at high enough levels in each of the three proposed management units that would cause the lower confidence limit to drop below 15 BP. In this example the 95% confidence interval spans from 13 BPs to 32 BPs.

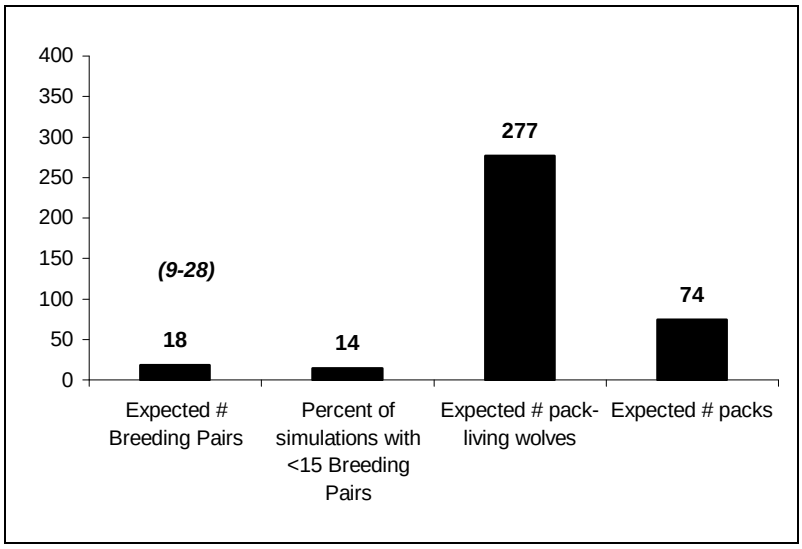

Figure 11	Harvest Rate	Number
Northern Montana Unit 1	70%	139
Western Montana Unit 2	70%	67
Southwestern Montana Unit 3	70%	52

Figure 11. Model simulation statewide results if harvest quotas were set at high enough levels in each of the three proposed management units that would cause the lower confidence limit to drop below 15 BP. In this example the 95% confidence interval spans from 9 BPs to 28 BPs.

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