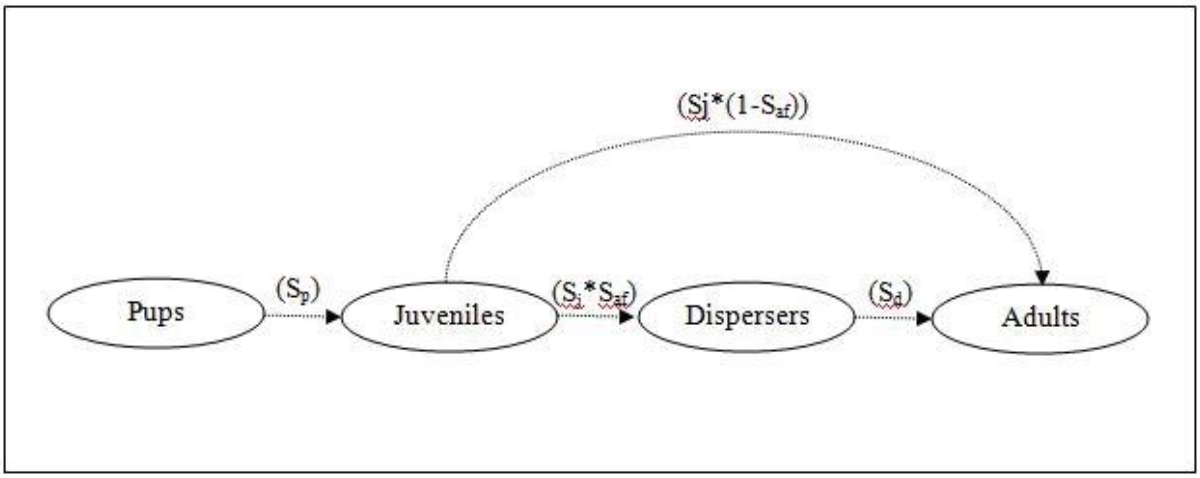
Population Viability Analysis for Conservation and Management

The Wolf Conservation and Management Plan for Washington (Wiles et al. 2011) was approved in January 2012. The plan was not informed by a population viability analysis (PVA). A set of independent scientific reviewers of the draft plan (WDFW 2009) urged WDFW to conduct a PVA because (1) the plan contained low delisting thresholds that raised conservation concern, and (2) PVA is an essential tool to evaluate any population recovery plan (Perez et al. 2012). WDFW then contracted researchers at Washington State University to develop a wolf population model and to evaluate nine wolf population and management scenarios using model simulations (Maletzke and Wielgus 2011). These simulations resemble PVA in many respects, but differ from PVA in several important ways. The simulation results did not appear to inform the final wolf plan substantively, which does not differ from the draft plan in its wolf downlisting and delisting criteria.

We will conduct a simplified PVA, using population parameter estimates from other wolf populations as recommended by the reviewers and used by (Maletzke and Wielgus 2011). We will use PVA to evaluate sensitivity of wolf population abundance and persistence on anthropogenic mortality, including hunting, poaching, and lethal control. Several caveats and simplifying assumptions limit practical application of analyses outlined below, including the following. (1) Wolf population processes will be affected by changes in human population size and distribution and changes in land use, which are not considered here. (2) Effects of climate change, wolf prey population changes, and other factors that may affect wolves are not included. (3) Habitat distribution and other spatial processes may constrain wolf population growth; these constraints are largely ignored here. (4) Dispersal of wolves to Washington from other regions may increase probability of wolf persistence, which we will not consider but could with simple code modifications.

The wolf life cycle can be summarized in four developmental stages: pups, juveniles, dispersing adults, and breeding adults. These stages and transitions among them are depicted in the figure below, from Maletzke and Wielgus (2011). The model is expressed as a set of inter-stage transition probabilities, *S*, which are estimated from wolf population data.



Wolf life cycle diagram, from Maletzke and Wielgus (2011). S_p, S_j, S_d, S_{af} are annual survival rates of pups, juveniles, dispersers, and adult females, respectively.

Wolf populations in the northern Rocky Mountains of the U.S. are most similar to what can be expected to expand into Washington. Maletzke and Wielgus (2011) provided demographic parameter estimates for wolf populations in central Idaho and northwest Montana. Human access and land designation in Washington are most similar to conditions in northwest Montana. These estimates and

their uncertainties are summarized below as transition probabilities in a stage-structured population matrix developed from the wolf life cycle diagram above.

Stage matrix transition probabilities (and standard deviations) for the northwest Montana wolf population. Parameter estimates and standard deviations are from tables 1 and 2 in Maletzke and Wielgus (WDFW 2011), except as noted.

	Pups	Juveniles	Dispersers	Adults
Pups	0.00	0.35(0.13*)	1.04(0.38†)	1.04(0.38†)
Juveniles	0.81(0.16)	0.00	0.00	0.00
Dispersers	0.00	0.52(0.12)	0.00	0.00
Adults	0.00	0.20(0.04)	0.72(0.16)	0.72(0.16)

* Standard deviation in juvenile fecundity is 1/3 the adult value.

† Maletzke and Wielgus(2011) did not report uncertainty in wolf fecundity, and neither did the publications they cited. Instead, above standard deviation in fecundity of adults and dispersers was calculated from Carroll *et al*. 2006, with a binomial adjustment for the 30% probability of each pack not reproducing in a given year.

The 2015 estimate of wolf abundance in Washington is 90 animals in 18 packs (WDFW 2015), with an additional pack located in 2016 (WDFW 2016). Wolf "carrying capacity" in Washington is estimated to be 76 packs, which, assuming a mean of 6 wolves/pack, would correspond to 456 wolves (Wiles et al. 2011).

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