**Starkey Elk Integrated Population Model**

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**Process Model**

The population is divided into 4 age classes:

Calves: 0.5 – 1.5 years old

Yearlings: 1.5 – 2.5 years

Young adults: 2.5 – 3.5 years

Adults: 3.5+ years

For a total of 8 groups once males/females are divided. Some of those 8 groups share survival probabilities and all non-calf females groups share a recruitment rate. I’ll got into those in more depth below.

The biological year in the model starts on November 1 and ends on October 31. The first step in the model is additions and removals on the feed grounds. We don’t have perfect age data for all of those elk, so I simplified to adding and removing calves and full adults. The yearling and young adult age classes are not affected by removals or additions. I will revisit this if adding the removals from the 2020-2021 winter handling inflates the 1.5 – 3.5 age classes.

The next step in the model is natural survival. Male and female calves share a natural survival rate for the 0.5 to 1.5 years old transition. After the first year, the sexes have separate survival probabilities. For both sexes, the young adults and full adults share a survival probability. There is no “old elk” survival probability at this point.

At the end of the biological year, harvest is included. For harvest, I simply subtracted the number of animals listed as being harvest from main each year. I used the listed birth dates for harvested elk to assign age groups.

Finally, recruitment is added just prior to the feedground stage of the process. The recruitment estimates are based on the cow calf ratios on the feedgrounds. My understanding is that the “cows” are any antlerless elk that are not calves, so I use all females, not just adults, in the recruitment step. Calves entering the population are subjected to the additions and removals on the feedgrounds, and the process repeats.

**Data Used**

Survival: The survival data all comes from the capture and handling database. I used a Cormack-Jolly-Seber model with November through February as the capture session. Elk that were harvested or had handling events in which they were moved out of Main were excluded. I did not include survival estimates from years that had >10 elk listed as removed from Main in handling summary.

Recruitment: As mentioned above, the recruitment estimates are based on cow calf ratios from the feedgrounds. I used the numbers in the handling summaries for the estimates.

Abundance: I used the abundance estimates that Darren provided. They include sightability and capture/recapture abundance estimates from 1989 to 2005, which is why those years are more precise for total abundance. I also incorporated minimum number known alive based on individual capture histories. In each year, the result of natural survival has to be at least as many individuals as we know were alive in that age/sex class based on individual capture histories. I have not included feedground counts yet. They are not broken down into age classes as well, so I need to learn how to include them appropriately.

Removals: For harvest numbers, I used the capture and handling database to find the number of individuals from each age/sex class harvested from Main each year. For animals being moved into and out of Main, I used the capture and handling summaries. Adults moved were assumed to be in the full adult age class.

**Thoughts/Next Steps**

I’ll include a results summary in a csv file. I think the MCMC chains will be too large to email, but I’m happy to get them to anyone that is curious.

The model is estimating adult female survival very close to 1. Is that plausible when harvest and removals are excluded? It might also be an artifact of the normal approximation for the binomial. The model crashes if I use binomial distributions because of the removals. Using normal approximations solves that, but they might behave poorly near p = 0/1. I’ll look into that and chat with Taal.

Adult male survival is fairly unstable and occasionally has a “bathtub” posterior. I’m going to work on diagnosing that. Part of the issue is likely the lack of information about male survival during the breeding bull survey years. Unstable male survival shouldn’t impact female numbers, but it could change total abundance. I’ll update folks if any estimates change.

Including recent abundance estimates will shrink the confidence intervals through the 2010s. I’d like to look into getting camera-based abundance estimates incorporated for the recent years.

The final year of removals is not included yet. When I incorporate more recent data, I will double check all of my workflows and work to make the entire analysis easy to add years to moving forward.