ELK ADVISORY COMMITTEE MEETING

3/18/2014 Ho-Chunk Board Room, Black River Falls

Introductions: Kevin Wallenfang, committee chair provided introductions. Membership included: Rocky Mountain Elk Foundation, UW-Stevens Point, Wisconsin Wildlife Federation, Wisconsin Conservation Congress, DNR Area Supervisors for the northern and westcentral district, DNR Ungulate Researcher, DNR Conservation Warden, DNR Elk Biologists, DNR Forester, Ho-Chunk Nation, Great Lakes Indian Fish and Wildlife Commission, DNR Public Affairs Manager, US Forest Service and Jackson County Forestry and Parks. Additional members not in attendance were from the Wisconsin Bow Hunters Association and Hunters Rights Coalition.

- Guests in attendance in the meeting were given time to provide initial comments. RMEF employees and volunteers were those included. They mentioned that RMEF has been matching contributions for some of the donations that are done. When the DNR needs a project completed, funds will hopefully be raised to cover the costs.
- The committee also was asked if they had any other agenda items to include in today's meeting and all responded that they did not.

Elk population estimation and prospects for a 2014 hunt: A subcommittee met previously to assess the current elk population and estimate post-calving numbers. If over 200 animals, a public hunt would be initiated in 2014. For more details regarding estimates, see attached summaries.

- Once the population reaches 200 elk the DNR would initiate a hunt. If the population drops below 200 the hunt there is no requirement in law to stop the hunt in future years.
- ***Laine Stowell DNR Elk Biologist***:
    - Estimates from four subgroups combined to give us a total population of 165 elk as of March 14th 2014. Thirty-nine calves are estimated to be born this year, but based on past history we should expect 1-4 pregnant cows to be lost before calving season and there will be 3-8 elk calves lost during the calving season. Therefore, the total elk population at the end of June is estimated to be within a range of 185 to 196 elk.
- ***University of Wisconsin – Stevens Point (UW-SP) represented by Dr. Tim Ginnett***: From the radio-telemetry data, a survival model has been updated. This modeling suggests that survival rates between males and females are virtually identical. It also supports that the population will not equal or exceed 200 elk by the end of the 2014 calving season.
    - As the elk population grows, new methods must be identified to accurately estimate the current population and projected growth. When determining these new methods, the question was raised, "can we get good demographic data from having cameras out there?" UW-SP began working with a newly published model that deals with camera based counts without identifying unique individuals (which is the opposite of what was used to provide Laine's estimates). The resulting model is telling us there are about 3-4 times as many elk as we know are out there, so it's is clearly not accurate. Based on this it is clear that there are some inherent difficulties in this technique although it is still worth further investigation.
    - Could expanding the current camera sampling grid provide any benefits to methods? It might in areas where we know we have animals moving in and out.

  - Along with expanding the grid, could it be feasible to include a larger number of animals in the survey area? The 9X9 km grid that is now used overlaps the vast majority of the Clam Lake subgroup area which would already capture most of the bulls.
  - GLIFWC**:** Has there been any thought to using genetics to come up with population estimates rather than using trail cameras?
- ***DNR Bureau of Science Services represented by Ungulate Researcher Dan Storm***: With the assistance of Dr. Tim Van Deelen from the UW – Madison they used multiple modeling approaches:
  - Took Laine's population counts and fit a growth curve to them to project the population forward. Modeling also estimated a carrying capacity which is important when understanding population growth and how many individuals could reside in a given area.
  - First model: estimated an average of 197 elk (accounting for model error produced a range from 180-213 elk). Second model: estimated an average of 182 elk (accounting for model error produced a range from 166-197 elk).
  - Confidence intervals (i.e. ranges from each model estimate listed above) gave higher estimates, but played in conservatively.
  - Based on results it is clear that growth has slowed a bit; however whether this population is exhibiting density dependence is not supported. There is more we need to learn about what has been going on before we suggest density dependence.
  - All models suggest that adult survival is what affects population growth rate the most. However, as the population gets closer and closer to carrying capacity it gets more difficult to detect smaller changes in survival.

Recommendation: Taking each population estimate into consideration, the committee recommends that the elk population will not reach 200 animals by the end of the calving season, and recommends that a hunt not take place in 2014. (Post-meeting note: this recommendation was advanced to the Wildlife Policy Team and Secretary's office, and accepted by both).

<u>Reintroduction Prospects:</u>

- **Kevin Wallenfang provided an update**:
  - We are in the process of finalizing several agreements with the USFS and GLIFWC, as well as with RMEF and Ho-Chunk Nation. We are also negotiating with Kentucky to receive elk in exchange for ruffed grouse. There was a recent meeting with Kentucky staff. Kentucky currently doesn't have a Commissioner which is important in the process. That person is expected to be hired by the end of April or early-May.
  - Kentucky is in the process of putting together a grouse management plan and doing grouse habitat work. They remain fairly optimistic.
  - The Wildlife Health team went to Kentucky to help process elk that are going to Virginia. Also, our state wildlife veterinarian is (or soon will be) licensed to practice in Kentucky.
  - Until things become more finalized, we won't be putting a significant amount of effort into the logistics of the reintroduction.

- From an administrative standpoint the Administration is fully behind us. We have continued to have success getting approvals to keep moving forward with the elk project. We appear to be on track and if things come together we remain optimistic for a 2015 import.

- If we receive supplemental elk in Clam Lake, 10 would go to the existing original elk range and 10 would go to the expanded elk range.
- DNR Upland Bird Specialist has helped develop the plans for grouse capture and transport. We have promised over 2000 grouse during a three year period, likely starting in about 2018. The plan is to have multiple department teams spread across the north trapping grouse as we go into the peak of the 10-year cycle. Due to grouse not doing well in captivity, individuals will ideally be trapped one day and released the next day. While the number seems high, it is really a very small fraction of the annual harvest.
- ***RMEF***:
    - Apathy and skepticism from their membership is a concern. This is a good year to fund projects so should there be an entertainment of projects within Jackson County right now. RMEF has $60,000 for projects this year, and projects can now be submitted for May PAC consideration.
    - A subcommittee has formed within the Central Forest area to discuss things such as funding and site selection for holding pens. They will report back to the greater Elk Advisory Committee with their recommendations this summer.

- ***Research proposals from the DNR Bureau of Science Services:***
    - A proposal is currently being written to obtain funding to do elk research. Objectives would be toward survival, resource selection and focusing on population estimation. The hope is to integrate this proposal with the statewide trail camera project, using cameras to look at not only elk numbers, but other animals that elk interact with and their distribution. What has been done in the past could be modified or added upon from this new study. The proposal includes graduate students and technicians conduct intensive monitoring.
    - The RMEF could be a strong financial partner in this endeavor and volunteers are very enthusiastic to help with this type of work.
    - Is there any interest in an herbivory project done within the elk range? As of now, this proposal doesn't have that included although maybe it should or there could be a separate proposal. From the Ho-Chunk Nation perspective there would be interest in a study like this in terms of the gathering of plants etc.
    - Would it be useful to have RMEF foundation money to help with that effort? If the committee thought that was a worthwhile objective it could be integrated.
    - Browse studies are done on the county forest every winter and that data could be used.

Inhibitors to Elk Population Growth: Kevin Wallenfang initiated a discussion to address why the elk population not reached its population objectives sooner, and potential remedies. Habitat, and predation management through better habitat, were both addressed in the elk plan amendment, but are there additional actions that we should be taking beyond zone modifications, etc.

When the plan was approved the Natural Resources Board, an amendment was added that stated: "If future elk restorations or herd growth is compromised by high levels of predation by wolves, bears or other predators, the department will work with the board to reduce predator populations in the elk restoration zones." Considering that the wolf advisory committee will not address predation unless

recommended by the elk committee, now seems to be the time to discuss whether specific wolf management actions or hunting seasons/zones should be proposed.

As a whole, the elk herd is growing at a rate of about 5% annually which is not a negligible number. Especially if it is consistent, it is very sustainable.

- Percentage attributed to various mortality factors.
    - Known mortalities total 222.
    - Wolves: 94 verified wolf predation cases. 42 percent total.
      (90 percent of the elk that have been killed were killed by one of two total packs).
    - Car accidents: 32 mortalities or 14 percent total.
    - Bears: 25 mortalities or 11 percent total.
    - Other factors: 71 mortalities or 32 percent total. None of combined factors in this category account for more than 5 percent of mortalities individually.

  Habitat in some cases has been an underlying factor in all of these situations.

- ***Wolves***
    - This has been monitored since elk release in 1995. The first wolf predations did not occur until 1999 (three calves). The first radio-collared adult elk was killed by a wolf in 2003.
    - Up to 2003, the major mortality factor was vehicle collisions.
    - In 1995 only three known packs were within the elk territory (6-8 wolves in those three packs). In 2003, there were around 111 wolves when the first adult elk was killed. Pack sizes have most likely increased since then, but not necessarily the number of packs. Pack territory densities are probably maxed out and the number of wolves has probably plateaued.
    - Is there any insight as to what age elk are being taken? The highest frequency of wolf kills occurs in February and March. During that time most of the elk that they're killing are calves (around 200 pounds in size).
    - Do we need a specific zone for wolves around elk?
    - Wolves should be within elk zones and there isn't a need for wolf hunting sub-zones. If we're going to have elk on the landscape they're going to have to co-exist with wolves.
    - In terms of facilitating wolf trapping, would there be benefits to attempting to open areas of the pine marten closed area to dry land trapping? There is an unoccupied portion of the martin closed area that contains elk. One potential solution may be a modification of current trapping rules to require minimum pan tension to allow wolf trapping while protecting pine marten. This was not general supported as a solution to the problem.
    - Zone One this year was actually closed before the Dec. 1 start of when the use of dogs or cable restraints is allowed.
    - GLIFWC:
        - Research on martins is currently focused on reproductive performance and habitat associations. We're not currently trying to look at specific marten range.
        - The marten closed area is mostly confined within existing marten range. The main elk range is almost entirely within existing marten range. If there's an opportunity to change the marten closed area it should not be reduced.

- The marten committee looks at information every year and decides if they need to change the current range and so far they have not done it. There may be certain areas that could possibly be discussed to include wolf trapping.
- The department marten advisory committee is going to be mainly interested in protecting martens from foot-hold traps. The furbearer committee needs to be involved in this discussion.

Recommendation: The committee agreed that it is not advisable to make a recommendation to reduce the wolf population to benefit another species. Predator management through better and more quality habitat is what we've emphasized and still believe to be the best route. Were still seeing herd growth and it's not compromised.

Recommendation: The wolf advisory committee should seek ways to change the season structure for wolves in a way that will allow the zones to remain open longer, giving hunters and trappers the opportunity to utilize the marten closed. It may help facilitate hunting of wolves by means other than foot-hold traps within the marten closed area.

- ***Bears***
  - The past 4-5 years have had aggressive bear quotas in Zone A. Because of the large amount of public land within the National Forest there is a lot of bear hunting activity in that vicinity.
  - In 2010 and also in 2012-13, we saw zero bear predation of radio-collared calves. In 2011 three radio-collared calves were lost to bears. Prior to these last 4 years 20-25 percent of collared calves were lost to bears each year. This change is mostly likely attributed to more liberal bear harvest opportunities.
  - Bear densities may not have really changed within the Clam Lake area, although the age structure may have changed.
  - Did calf survival go up or did they just get killed by other means? Calf survival has gone up, although in 2011 we had only 9 percent survivorship of female calves and 55 percent of male calves. In a late spring scenario, bears short on food do more wandering and are going to be more likely to run into calves and kill them.

Recommendation: No modification to bear management zones is needed to protect elk

- ***Habitat Considerations***
  - The biggest impact we can have is providing elk with optimal forage and escape cover.
  - Prior to the year 2000, about 73 percent of the logging that was occurring in the Clam Lake area was occurring on the National Forest. After 2000 and until 2011, the majority was then occurring on private inholdings. Clearcuts that are more attractive to elk on private inholdings and are smaller in size are making it easier for wolves to find elk. This may be contributing to an increase in wolf predation.
  - If the elk range had a broader distribution of clearcuts and more clearcut areas, there would probably be a reduction in wolf predation.
  - Areas that have undergone aggressive tree harvest and aspen management that encompass the Ghost Creek wolf pack have not experienced any elk predations.

- Forest Service update on cutting operations:
  - Black Torch is a project area that goes north and south through Clam Lake. The area to be logged looks like its increasing. There is also an associated cost-share project with RMEF that includes plans to help mark trees to increase suitable elk habitat. Over mature aspen has also been considered as important for harvest.
  - A project completion report is needed by RMEF and a briefing would be beneficial for how the initiative is being implemented and future plans.

Recommendation: An agenda item should be added at the next committee meeting to include a briefing from the Forest Service as to how they are doing with the implementation of cutting.

- Are there any RMEF Conservation Easements and Acquisitions in the works? A: No.
- Are there any other habitat projects in the works? There is two or three pending.
- Laine has been approached by a number of groups to initiate forest opening projects. The request to the Wildlife Policy Team to do those projects has been approved.
- The National Wild Turkey Federation has also pledged money for habitat projects.
- In terms of our decision making process, there should be emphasis on the fact that where we have good habitat right now is in the expanding range.

- ***Vehicle collisions***

  Recommendation: The current elk warning system should be updated. There has been some vandalism and repairs are needed. There should also be research and a review done on this topic in anticipation of the future Black River elk herd.

  Recommendation: Blaze orange reflective radio-collars should continue to be used. They appear to be working, making elk more visible at night and reducing highway accidents and accidental shootings.

  - Winter trapping efforts have been moved further away from the highway
  - In recent years, the combination of the above measures has resulted in vehicle collisions being reduced to 1.4 per year.
  - Within the past three years we have had six elk mortalities. Perhaps this should be considered an acceptable level?

  Recommendation: No changes necessary regarding elk/vehicle collisions. Current measures are the extent of what can be done at this time.

Modify elk rule in administrative code: Administrative Code establishes rules that elk population must reach 200 animals to initiate a hunt and the tag allocation is set at 5% of the population. When the population reaches 600 elk, the state will have a "bugle season" and once 100 elk tags are available, non-residents of Wisconsin could apply. Having hard population numbers and percentages to rely on is going to cause individuals or groups to want to argue the population size in order to manipulate permit numbers in the future. No other hunted species in Wisconsin sets permit levels in this way.

Recommendation: The committee will form a subcommittee to develop new language to eliminate the 200 animal requirements to hold a hunt, and to develop language to make permit allocation similar to other species with no set percentage based on population size.

Partner Matters:

- ***HO-CHUNK***:
    - The MOU between DNR and Ho-Chunk Nation is still in draft, but must be completed by summer.
    - In January, the Ho-Chunk nation committed $50,000 to elk restoration independent of the original $100,000 grant.

- ***Jackson County Forestry and Parks***: Recently submitted a grant for the application of herbicide and other habitat improvement projects. It will be important to have a meeting at some point with their staff involved in any data collection to ensure that is being properly collected.
- ***USFS***: Appreciates the committees concern for timber harvest needs and habitat requirements of elk. They are currently doing some clearcuts in an area which is on the edge of elk range (eastern part). This area mostly red pine and they would like to get other species of interest growing there.
- ***UW-SP***: They have a long-term initiative in elk management so whatever Science Services comes up with they would like to be a part of it.
- ***RMEF***: Thanks to the department for their leadership in this initiative.

12 March 2014 Elk Population Review

Last year the Elk Advisory Committee determined that the Clam Lake elk herd had not reached the 200 elk threshold. We are again conducting such a review. Elk Project staff are providing information for that review and providing a separate population descriptive effort using staff and cooperator observations, radio telemetry monitoring of survivorship and distribution, and trail camera observations. This effort is part direct count and part extrapolation of observed population characteristics. These characteristics are described for the 4 main groupings of elk, the Clam Lake subgroup, the Butternut subgroup, the Shannagolden subgroup and the Moose Lake subgroup, as follows:

The Clam Lake Subgroup

Bulls: From March through October 2013 Elk Project staff and UWSP graduate student Beth Blicharz placed trail cameras at likely elk "capture" sites closest to a square kilometer center on a 9 Kilometer by 9 Kilometer grid, overlaying the elk activity range near Clam Lake, Wisconsin. During late August through October bulls move into cow/calf group home ranges for the fall mating season. This period provides a prime opportunity to census the elk population. From these 81 cameras, between 20 August 2013 and 29 October 2013 297 elk "events" were recorded. These show 24 bulls with radio collars to 97 without radio collars. A careful review of antler configurations and collared status in these photos by a panel of Elk Project Staff, determined that there were 13 unique collared individuals and 42 unique uncollared individuals. We know that there were 16 collared bulls in the Clam Lake area during this time, but only 13 of these showed up on camera. We assume a proportional number of uncollared bulls would also be in the area. Proportionally 13 observed collared:42 observed uncollared::16 known collared :X extrapolated uncollared, with X equaling the extrapolated number of uncollared bulls, and X equaling 52 uncollared bulls. Total number of Bulls for this area would be 16 collared bulls plus 52 uncollared bulls or 68 total bulls. Radio telemetry monitoring found 1 collared spike was killed by wolves in September and an adult bull died in a vehicle collision in December. Virtually all spike bulls were collared and elk mortalities from vehicle collision are reported so no need to extrapolate these 2 losses. These mortalities leaves 66 total bulls in the Clam Lake Subgroup area.

Cows: We believe all cows in this area (and all 4 sub-areas) are radio collared. Several years of staff field observations and 2 seasons of trail camera surveys have not revealed any uncollared cows (except the remaining cows of the Butternut group that were captured and collared in February of 2013). No images (from 104 camera sites, both Clam and Moose Lake areas) of uncollared cows have occurred during the 2013 camera survey. Nor have we seen or heard reports of uncollared cows from the public. We assume all cows now living within the Clam Lake Elk Range (1,612 square miles) are collared. If any exception exists it would be very rare. Between 103 and 92 elk had been radio collared between 1 January 2013 and 24 February 2014. There are currently 43 radioed cows in the Clam Lake elk activity area sampled by the 81 square Kilometer area.

Calves: We captured 23 calves in 2013. Projected production, winter pregnancy tests, and cow and calf observations indicated another 14 calves were born. Thus far 15 of the sampled and marked 23 calves have survived (0.65 survivorship). Using that rate 9 of those 14 estimated unmarked calves would still survive. However, 3 of these reside in Butternut and 1 in the Moose Lake area leaving 5 unmarked calves in the Clam Lake subgroup area. Of the surviving 15 calves, 2 reside in the Moose Lake subgroup area, leaving 13 collared calves in the Clam Lake subgroup area. Those 13 collared calves plus the 5 unmarked calves equals 18 total calves in the Clam Lake subgroup area.

66 Bulls + 43 Cows + 18 calves = 127 elk estimated in the Clam Lake Elk Activity area

Butternut Subgroup

During February and March 2013 we captured and collared 6 cows, 3 calves (2 males and 1 female) and 1 mature bull (estimated 7+ years) in the Butternut area. We believe all the cows have been captured in the Butternut area and all the calves from 2012. During 2013 we observed 3 uncollared spikes prior to spring antler drop, 1 raghorn (2-3 year old), and 2 mature bulls. Dan Michaels, WDNR Conservation Warden, resides in the center of the Butternut cow/calf home range, and reported he observed 4 mature bulls during the Fall and Winter of 2012/2013. This was collaborated by Mike Emmers and Rick Kilge, landowners in the area.

Pregnancy tests on the captured cows showed 4 of the 6 cows were pregnant. Because of the agricultural nature of the Butternut group's home range, the resident human density, and lower densities of wolf and bear in the immediate area, the Butternut elk group experiences above average nutrition and survivorship. We had no observed moratlities for the bulls or cows in this area. However, we did lose the cow calf due to capture myopathy and 1 bull calf was observed with a lame hind leg probably due to an earlier injury jumping a fence (well healed and atrophied at the time of capture). The remains of this lame bull calf was found post 2013 calving season, after continuing telemetry following the post calving season suspension of elk telemetry in the Butternut.

Because of the above average nutrition and survivorship (normally, without invasive experience), we assume high survivorship of calves born in 2013, probably 3 of the 4 born.

Therefore we believe there are: 4 mature bulls (1 radioed); 6 mature cows (5 between 3 and 14 years old; cow 13 is 19 years old…all radioed); 1 bull 3-4 years old (not radioed); 3 bulls 2 years old (0 radioed); 1 yearling bull (radioed); and 3 surviving 2013 calves (estimated) for a total of 18 elk.

Shannagolden Group

Cow 203 (radioed) has left the Clam Lake area each Memorial Day weekend for the past 5 years. She gives birth to her calf near the East Fork of the Chippewa River between Shannagolden and Glidden. Again, this year she was observed by local residents accompanied by an uncollared calf, and this fall by a sizeable bull. In past years she's

returned in the fall to Clam Lake, apparently to find a bull, but this year apparently a bull found her before she left, ergo, apparently a new cow/calf group is created, with 3 elk comprising it.

Moose Lake Group

From 23 cameras on a 6 Km by 5 Km grid (Moose Lake eliminates several square Kms) from 20 August 2013 to 29 October 2013 44 elk "events" were recorded (different elk, or same elk at different times at least ½ hour apart). Using antler shape and marked status the Elk Project staff panel identified 7 different bulls (1 collared and 6 uncollared) present within the Moose Lake cow/calf home range. All of these 7 Moose Lake bulls were independent of the 58 identified unique on the Clam Lake 81 camera grid.

From calf searching, radio telemetry and camera grid photos we determined 1 radioed female calf, 1 radioed male calf and 1 unmarked calf survived to 29 October 2013 (the 2 radioed calves and Cow 228's uncollared calf were observed 10 March 2014).

We had 8 radioed cows in the Moose Lake group during the camera survey period. However, cow 287 was killed by wolves on 28 January 2014, leaving 7 surviving radioed cows as of 10 March. Camera "events" show no other cows in this area.

Camera images, radio telemetry, and adult survivorship indicate 17 elk in the Moose Lake area (7 bulls, 3 calves, 7 cows).

Elk Population Number Estimate as of 10 March 2014

127 Clam Lake Subgroup Area + 18 Butternut Subgroup Area + 3 Shannagolden Subgroup Area + 17 for the Moose Lake Subgroup Area equals 165 elk as of 10 March 2014

However during the past 5 years we lose between 4 to 7 elk between now and the start of calving season:

165 elk minus 4 = 161 elk to the beginning of Calving season (high estimate)

165 elk minus 7= 158 elk to the beginning of Calving season (low estimate)

Based upon past observed birth rates of September 2 year olds (33 percent); September 3 to 14 year olds (90 percent); and 15-17 year olds (46 percent), and notwithstanding any pregnant cow losses from now until calving season, we estimate that 39 elk calves will be born in 2014. Subtracting off range of observed pregnant cow loses leaves between 38 elk calves (1 pregnant cow lost prior to calving season in 2012) to 34 elk calves (4 observed pregnant cow losses in 2008). However, from 2009 through 2013 we have lost between 3 to 8 total elk during the calving season. We could lose as few as 4 due to elk mortality during the calving season and calves lost because of death of mother), or as many as 12 due to

pregnant cow mortality and elk deaths during calving season (range of loses based upon observed loses these past 5 years).

(161 elk plus 39 calves) minus 3 total elk loses during the Calving season (to end of June) minus 1 (loss of a pregnant cow's calf) equals 196 elk at the end of June [High Estimate]

(158 elk plus 39 calves) minus 8 total elk loses during the Calving Season (observed in 2009) (to end of June)Minus 4 (loss of 4 pregnant cow's calves—2008) equals 185 elk at the end of June [Low Estimate]

[Laine Stowell 12 March 2014].

Discussion items on population growth in Wisconsin Elk

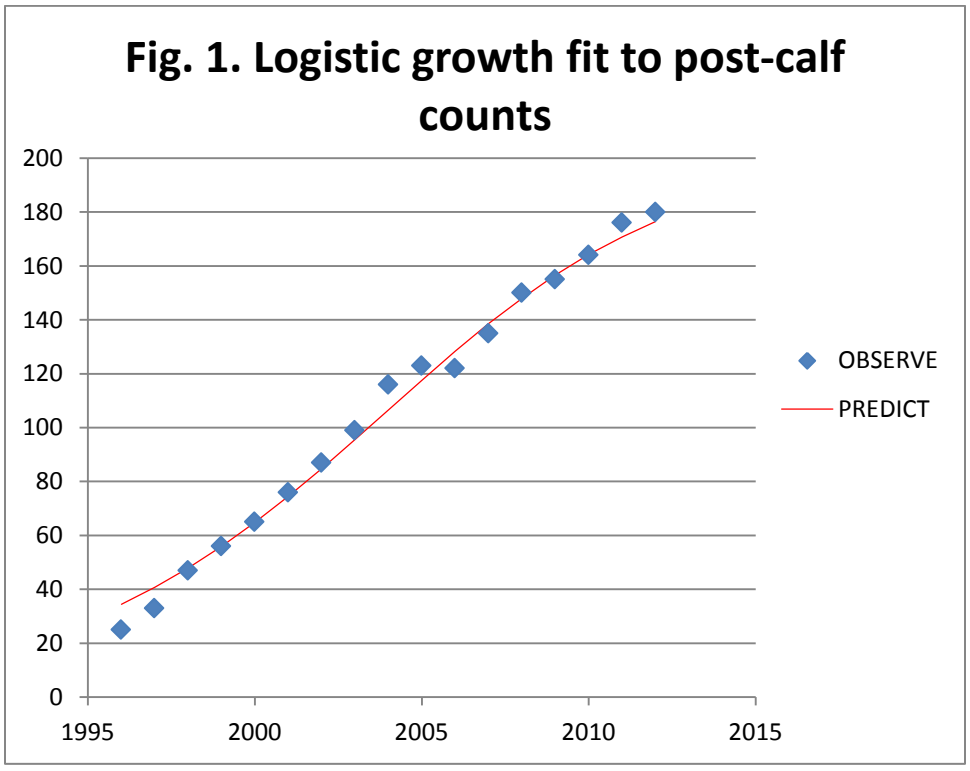
Tim Van Deelen and Dan Storm 2-26-14

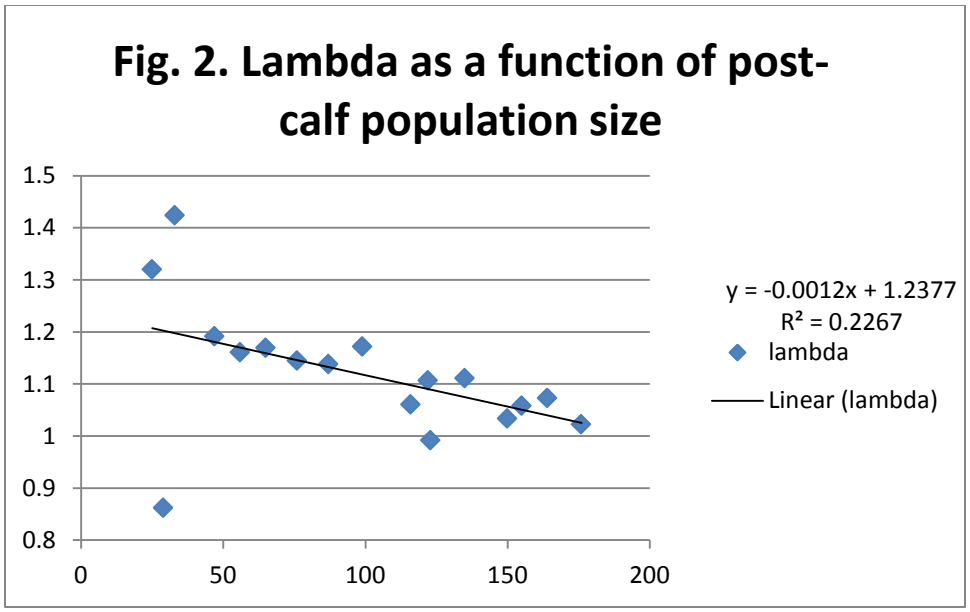
Disclaimer: These results represent a preliminary analysis based on summary data from the DNR monitoring of Wisconsin's elk herd and are offered for the sake of discussion and for consideration of future, more sophisticated analysis.

Summary data suggest that there are likely 3 approaches to estimating population growth available to us: 1) phenomenological modeling based on simple growth equations fit to annual counts, 2) matrix-based demographic modeling based on elk telemetry; and 3) matrix based demographic modeling based on age structure/cohort strength.

1. The Growth Model Approach

We fit a discrete logistic growth curve to 18 years (1995-1996 to 2012 – 1013) of post-calving counts using proc nlin in SAS (v.9). Results suggested a maximum discrete growth rate (λ_{max}) of 1.23 (95% CI: 1.12 – 1.33) and an estimated carrying capacity (K) of 201 (153 – 249, figure 1). The logistic growth model is clearly appropriate as compared to a non-density dependent model because the population is showing the classic negative relationship between growth and density – especially at higher relative density (Figure 2).





It's important to note that the realized growth is not the derived λ_{max}. Realized growth is constrained by K and averaged $\lambda = 1.06$ during the past 5 years. We used the derived parameters and a Monte Carlo simulation (10,000 iterations) to estimate a 2014 for post-calving from a starting point of 180 (2013). That estimate is 184 (182 – 187) –ish.

The caveat here is that we assume nothing about the precision or accuracy of the underlying count data although we acknowledge that the counts are undoubtedly biased low.

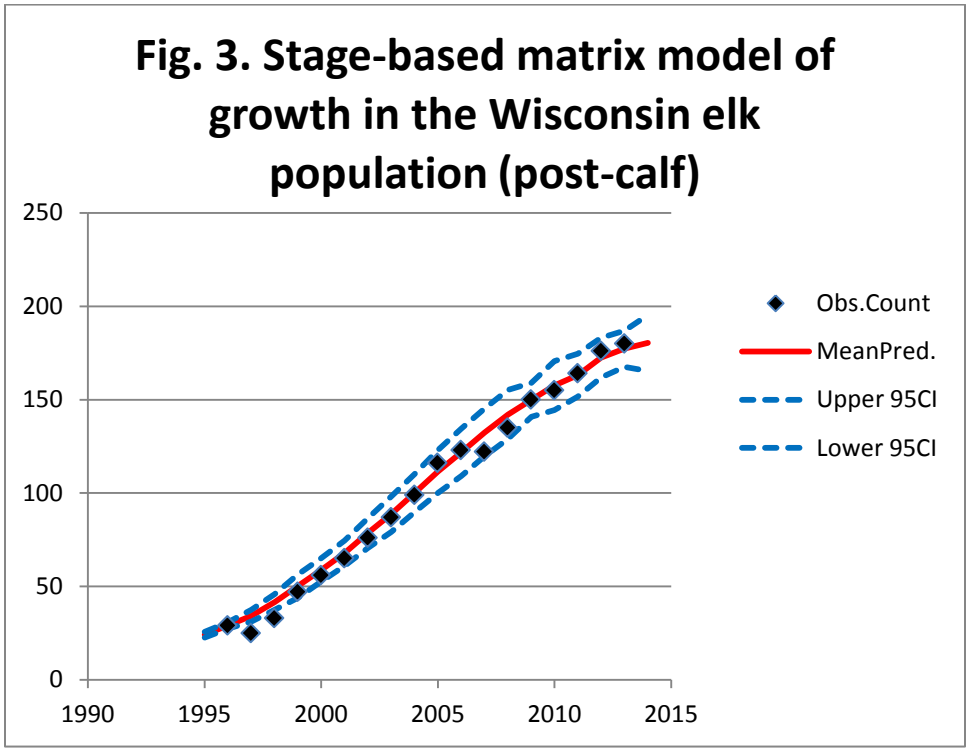
2. **Matrix modeling using telemetry-derived survival rates to quantify stage based transition rates**.

This approach follows Van Deelen (2000) and is essentially the model that the elk committee has seen earlier. Earlier versions were not density dependant, thus positive growth over time always assumed an exponentially increasing shape – hence it was very difficult to fit the sigmoid or nearly linear shape seen in figure 1. To fix this, we added a commonly used density dependant term, $(1-N_t/K)$, to each of the stage-specific transition probabilities (this is the density dependant term used in several logistic growth equation formulations, Skalski et al. 2005).

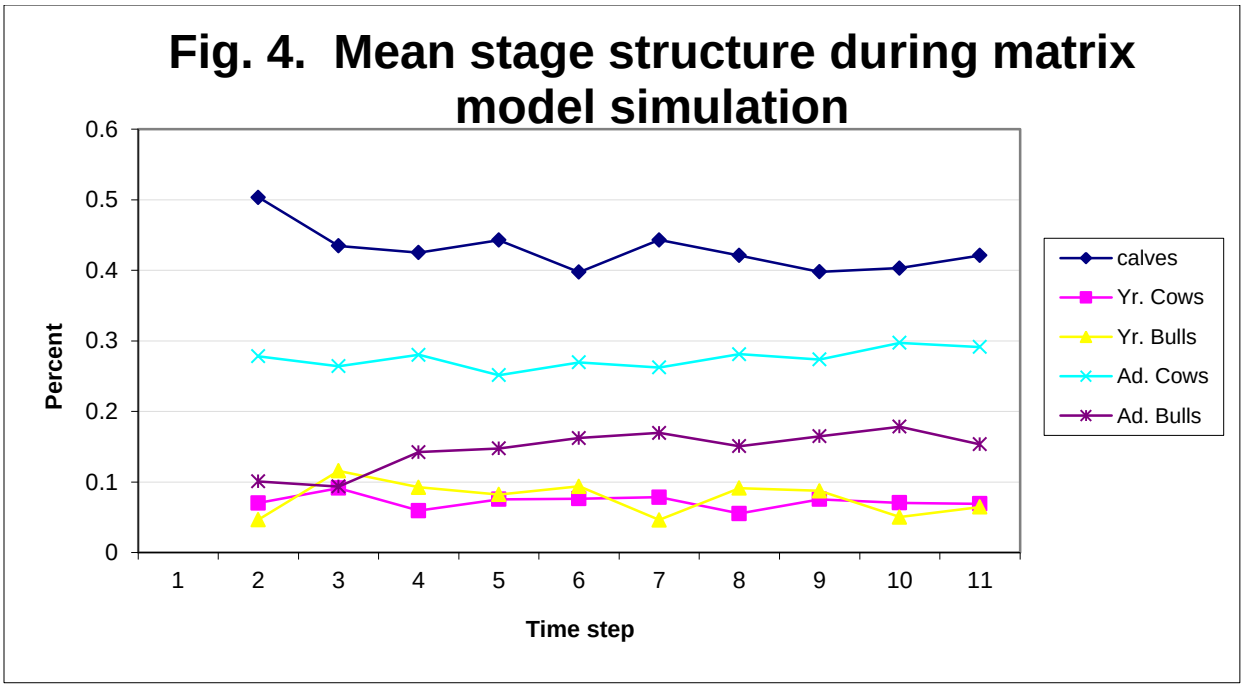
The stage-based matrix model is stochastic because it incorporates a matrix of variance terms for each of the stage transitions. Growth, consequently is the realization of stage structure, stage transitions, stage transition variances and K. Our strategy was to assume that the stage transitions representing survival were accurately characterized by DNR estimates of yearly survival for radioed elk and then manipulate the stage representing recruitment, the stage variances and K to get the modeled growth to match the observed growth. We used the sum of the squared differences (predicted-observed) as our measure of closeness. Adjustments were made *ad hoc*.

This model is essentially a Monte-Carlo simulation and confidence intervals represent propagation of error across all the yearly population estimates. This means that the model-derived confidence intervals

over-estimate the uncertainty in predicting the post-calving population size in 2014 when one assumes that you know the equivalent population size in 2013. To cope with this issue, we tuned the model such that the mean predictions fit the observed data as closely as possible (min(sum of squared differences)) and the confidence intervals comfortably covered the observation – particularly those in later years (since 2001, figure 3).

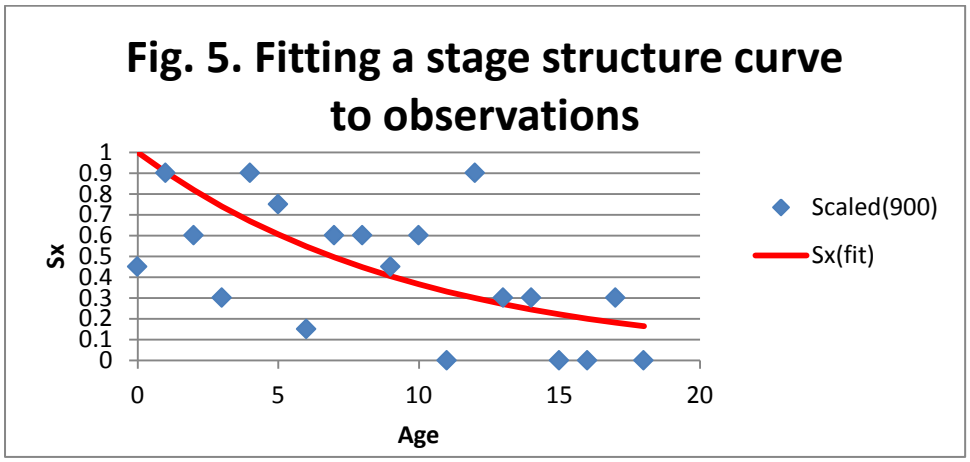


Our best-fit model (K = 350) predicts a mean population size of 182 (166 – 197). The advantage to this kind of modeling is that it also produces stage frequencies (figure 4). Stage frequencies can be used to compare to field-based composition counts to see if the model is realistic under equilibrium assumptions. When demographic rates are constant, stage frequencies stabilize – consequently we used the equilibrium stage-frequency associated with our survival transitions to populate the various life history stages (calf, yearling female, yearling male, adult female, adult male) at the beginning of each simulation.



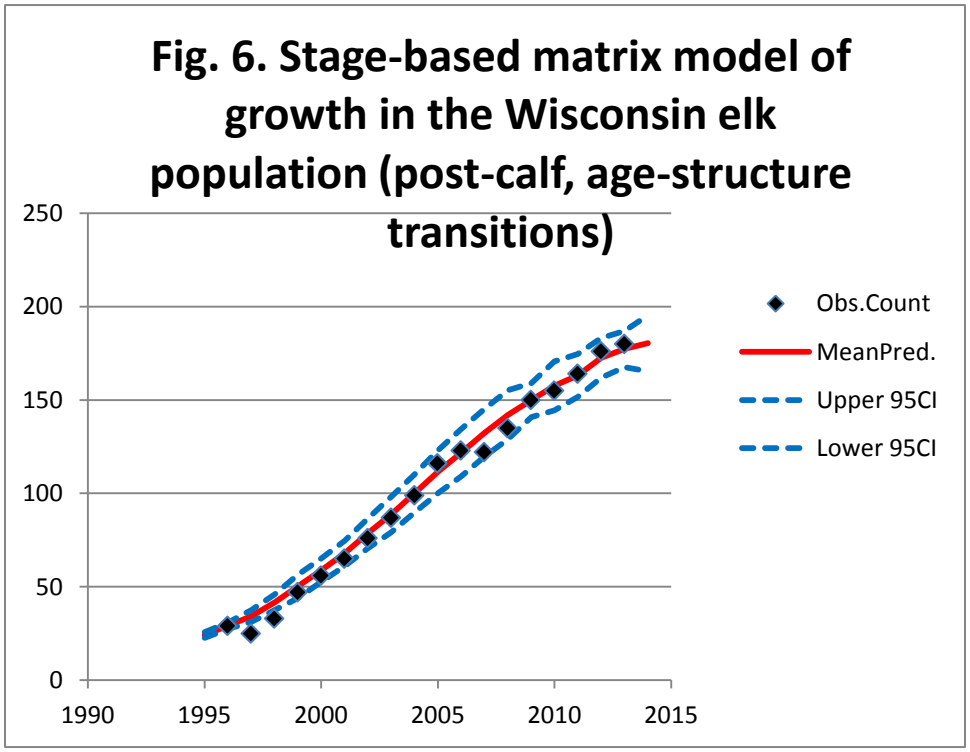
3) Matrix modeling using age structure-derived survival rates to quantify stage based transition rates.

This technique takes advantage of the fact that at stable-age equilibrium, the relationship between the standardized age structure (S_x) and cohort survival (l_x) is a function of age (x) and growth rate (r, Caughley 1977). Consequently, if you have the age structure/cohort strength and an independent estimate of growth, one can calculate the survival ($S_x = l_x e^{(-rx)}$). We used this relationship to estimate a smoothed S_x curve through observations of S_x by choosing a value for survival that best minimized the sum of the squared differences between observed and expected (Figure 5). Using a growth rate of λ = 1.06 (the average realized λ from the past 5 years) we estimated a yearly adult survival for females of 0.97.



We didn't have equivalent cohort information for males but growth in ungulate populations is most sensitive to the variance in demography of adult females (Gailliard et al. CITE.) However, plugging the estimated survival into the Matrix model did not change the predictions measurablly.

The predicted 2014 post-calf population size was 197 (180 – 213) ish (Figure 6).



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Clam Lake Elk Modeling

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The following analyses are based, in part, on bull and cow life histories and other data maintained by Laine Stowell, WDNR

Known-Fate Survival Models

The known-fate survival model is an extension of classical Kaplan-Meier survival analysis that allows examination of covariates that might affect survival probabilities. In this application I define a year as an "elk year," essentially May 1 to May 1. In brief, each animal is assigned a "capture" history that records the animal's status during each elk year. The animal is either known to have lived during all or part of the year, was unaccounted for, or was known to have died during the year. Capture histories consist of a sequence of 1's and 0's with two digits pairs representing each year. The first digit represents whether or not an animal was detected alive during the year. The second digit records whether or not the animal died during that year. A typical capture history over a 5 year period might look like 0010101100. This animal was not present (or not detected) the first year, hence the 00. It was either born or first encountered the second year and it survived the entire year (10). It was known to have survived the third year (10), and was known to be alive during in the 4^{th} year during which it also died (11). The 00 at the end indicates that the animal is no longer present. From the capture histories, the known-fate model allows the assessment of survival probabilities based on attributes of the individuals (i.e. gender, age) and also allows us to assess survival rates over time. The models were implemented in Program MARK and the likelihoods of various models were compared using AIC. The "best" model suggests that survival does not differ between bulls and cows and does not vary over time but does vary with age of the animal. However, there is some support for a model that includes sex and age. Calf survival estimates of the model (49.4%) underestimate Laine's observed survival rate of 54% although the confidence intervals on the model estimate include Laine's figure.

Table 1. Program MARK results for a variety of known-fate models applied to Clam Lake elk life histories.

Model	AICc	Delta AICc	AICc Weights	Model Likelihood	Num. Par	Deviance
{ Age - Quadratic}	1085.394	0	0.66708	1	3	1079.38
{Sex by Age - Quadratic}	1086.784	1.39	0.33292	0.4991	4	1078.761
{Sex by Age - linear}	1175.352	89.9578	0	0	3	1169.338
{Sex + Origin + Time}	1271.733	186.3386	0	0	20	1231.241
{Sex * Origin + Time}	1272.609	187.2151	0	0	21	1230.068
{Origin + Time}	1272.73	187.336	0	0	19	1234.286
{Sex + Origin}	1276.831	191.4369	0	0	3	1270.817
{Origin}	1277.615	192.2208	0	0	2	1273.608
{Sex * Origin}	1277.881	192.4866	0	0	4	1269.858
{Sex + Time}	1278.163	192.7684	0	0	19	1239.718
{Time}	1280.683	195.2886	0	0	18	1244.283
{Sex}	1285.906	200.5113	0	0	2	1281.899
{.}	1288.991	203.5966	0	0	1	1286.989
{Sex*Origin*Time}	1326.449	241.0545	0	0	76	1167.368

Table 2. Survival estimates by age for the best fit model which includes only age as a covariate. Age 0 indicates newly born animals.

Age	Survival	S.E.	lower 95%	upper 95%
0	0.494	0.037	0.421	0.566
1	0.675	0.022	0.630	0.718
2	0.804	0.013	0.777	0.828
3	0.882	0.010	0.862	0.900
4	0.926	0.008	0.909	0.941
5	0.951	0.007	0.936	0.963
6	0.966	0.006	0.953	0.975
7	0.974	0.005	0.963	0.982
8	0.979	0.004	0.969	0.986
9	0.981	0.004	0.972	0.988
10	0.982	0.004	0.973	0.988
11	0.982	0.004	0.972	0.988
12	0.980	0.004	0.969	0.987
13	0.975	0.005	0.962	0.984
14	0.968	0.007	0.951	0.979
15	0.956	0.010	0.930	0.972
16	0.934	0.017	0.892	0.960
17	0.895	0.029	0.822	0.940
18	0.826	0.052	0.700	0.906
19	0.710	0.087	0.516	0.849

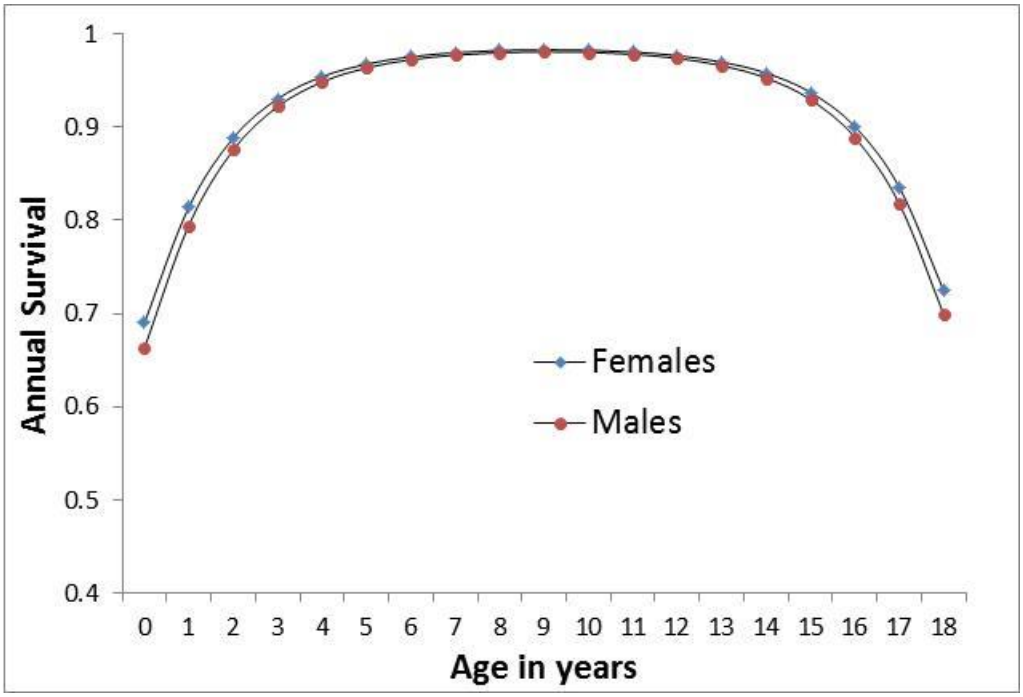

Figure 1. Sex and age-specific survival rates predicted by the second best model from Program MARK.

Population Modeling

I constructed a stage matrix model for elk that incorporates sex, six age classes from neonates to animals 5 years and older, a user-set carrying capacity, as well as a user-controlled additive harvest. Inputs for the model include sex and age-specific survival rates, % males at birth, average age-specific fecundities, starting age-distribution, carrying capacity, and harvest amounts. The model operates on a post-breeding census, which means that it tracks numbers of individuals immediately after all calves are born but **before** any calf mortality. Populations are projected forward on a yearly basis for 30 years. Outputs include age-distributions and total numbers over time as well as the sex-ratio. The model also calculates the finite rate of increase (λ), stable-age distribution, reproductive values by age, and elasticities for any unique combination of inputs. The model is implemented in Microsoft Excel.

The following results are based on using the age-specific survival rates from Table 2 with the exception that I used Laine's observed value of 54% calf survival. I used a value of 0.581 for the proportion of births that are male. This number was calculated by Laine from historical elk records. I used values of 0, 0, 0.33, 0.9, 0.9 and 0.9, for reproductive rates of females age 0 to 5+ respectively. These are based on pregnancy testing and observations made on the Clam Lake herd.

General Results

Using the above values the matrix model predicts an average annual rate of increase (λ) of 1.043, or a 4.3% annual increase. By Laines Stowell's counts, if there are currently 159 elk, then the average annual rate of increase from 1995 until now is (159/25)^(1/19) = 1.102 or 10.2% suggesting that the population is now growing more slowly than in the past. This is also substantiated by VanDeelen and Storm's suggestion that a logistic model fits the Clam Lake's growth well. The sex ratio at the stable-age distribution is 0.72 females per male (1.39 males per female). More on this can be found below. Stable age distributions and reproductive values are below. The first five columns pertain to females and the last five columns are males.

Stable Age Distribution	9.56%	4.95%	3.20%	2.47%	2.09%	19.63%	13.26%	6.86%	4.44%	3.42%	2.89%	27.22%
Reproductive Value	1.00	1.93	2.85	3.32	3.55	3.62	0	0	0	0	0	0

Examination of the elasticities indicates that the model is most sensitive to changes in adult survival which makes sense due to the fact that reproductive value is highest in the 5+ year old age-class.

Population projection

We can use the matrix to project hypothetical populations forward in time to examine likely future abundances. Laine estimated 158 elk prior to last year's calving season. An estimated 37 calves were born last year for a post-calving total of 195 (ignoring calf mortalities). Arranging these 195 animals according to the stable age distribution and using a carrying capacity of 10000 to limit density-dependent feedback the model predicts 204 (46 calves) animals after this year's birthing season not accounting for any calf mortalities. Immediate calf mortalities during calving season will likely result in a number less than 200. Using a carrying capacity of 600 suggests a total of 202 animals (46 calves). With a carrying capacity of 250 the model predicts 198 animals (45 calves). Given historical calving season

losses, in all likelihood there will be fewer than 200 animals at the end of the 2014 calving season. With the carrying capacity set at 10000 (the most optimistic setting) the model predicts 213 animals in 2015 and 222 in 2016 (again ignoring calving season losses). With carrying capacity set at 250 the model predicts 199 and 202 animals for 2015 and 2016 respectively. We will clearly need good calf survival to hit the 200 mark in the next year or two.

Sex Ratios

The model predicts a sex ratio of 1.39 bulls per cow. On the camera grid we know that there were 43 cows using the grid. Based on identifying individual bulls in the camera grid, and knowing that there were 16 radio-collared bulls, Laine estimates 66 bulls for a sex ratio of ca. 1.5:1. A sex ratio calculation simply based on the total number of bull and cow photographs during the rut suggests a sex ratio of 1:1. This suggests that cows have a higher probability of detection than bulls on the grid, possibly due to larger group sizes. Therefore obtaining a reliable sex ratio from cameras without identifying individual animals is likely to be biased.