

WRST Hares: Krebs Plot Data 1991-2008 (DRAFT)

INTRODUCTION

This report describes an analysis by JHS of the Krebs's plot data collected for snowshoe hares in WRST between 1991-2008. Data for 2009 were not yet available, but will be collected in late July (J. Putera pers. comm.). The time period included appears to cover 1 full population cycle and portions of additional decrease at the start and an increase at the end of the data series. Options for methodological improvements are also discussed.

METHODS

Study Area:

Four study areas were selected to represent snowshoe hare trends within WRST north of the Chugach mountains: the McCarthy Road, May Creek, the Nabesna Road, and Chisana. Study area selections were based on access (logistics and cost of obtaining samples), land ownership, and the availability of representative snowshoe hare habitat. Both May Creek and Chisana require aircraft access, while the McCarthy Road and Nabesna Road sites are short walks from the roads.

Field techniques follow the procedures described in Route (1995) and following the work of Krebs et al. (1987, 2001), whereby fecal pellets are counted along permanent transects. Ten (eleven originally: Nabesna-C dropped in 2000), 1.5km permanent transects were installed in WRST near Chisana (2), the Nabesna Road (2), the McCarthy Road (3) and May Creek (3). Each transect contains 50 quadrats, each 0.155m^2 ($5.08 \times 305 \text{ cm}$, or $2 \times 120 \text{ in.}$) in size separated by 30m and aligned perpendicular to the transect. Transects and quadrats are marked with permanent $2 \times 5 \text{ cm}$ wood stakes or with metal rod. Transects are visited in late June to July annually. At each quadrat, an elastic band is placed around 5cm wooden spacers placed on markers at each end of the plot. All hare pellets within the plot (pellets half-in and half-out are tallied as "in") are counted, and totals recorded on standardized data forms. All pellets counted are removed from the plot, and therefore only pellets from the previous year are tallied.

Analysis:

We used zero-inflated conditional autoregressive (CAR) models to describe variation in pellet counts. Counts were assumed to vary among site-years ($11 \text{ sites} \times 18 \text{ years}$) and were therefore modeled as a random effect. We chose zero-inflated models to help account for the large number of plots with no pellets counted, especially during low parts of the cycle. These models tend to fit better than standard count models when excess 0's are present. The CAR portion of the model helped account for lack-of-independence between individual plots on each transect. Because the plots are only 30m apart, it is likely that the home-ranges of individual hares overlap multiple plots. This correlation between plots would tend to overestimate hare density and precision because each plot is not an independent replicate. In the future it may be reasonable to combine data from individual locations within each site to provide estimates at the site level, but we suspected that replicate locations were not acting as true replicates for some sites, so we estimated them separately here.

RESULTS

The hare cycle appears to be synchronous at the May Creek and McCarthy Road sites, with a peak during 1999-2001, and the beginning of another increase in 2007-2008 at all locations (Fig. 1). The population peaks at these sites appeared to occur at 8-9 year intervals, although

additional data through the current peak will be necessary to identify the midpoint and duration of the cycle. At all 3 locations within each of these 2 sites, there was a substantial unexplained dip in pellet numbers during 2000, with a rebound to near or above 1999 levels during 2001. This pattern also occurred at the Nabesna-A and Chisana-A locations, although during different years. Counts tended to increase rapidly in the first year of an increase, drop the second, then increase again in the third year before decreasing dramatically to low levels.

Patterns at the Nabesna road and Chisana sites and replicate locations within sites differed from one another (Fig. 2). The hare peak appeared to occur from 1998-2000 at the Nabesna-A site, and the high part of the cycle appeared to begin in 2008. No discernable patterns were evident at the other 2 replicate locations, one of which (site C) was only surveyed through 1999. The hare peak appeared even earlier (1997-1999) at Chisana-A, while only a small increase was observed in 1999 at Chisana-B. There was a substantial increase in counts at location A during 2007, and the peak of the cycle may have occurred in 2008. Counts were higher in 2008 than at the highest point during the last cycle. It appears that the population peaks at the Nabesna and Chisana sites occur approximately every 10 years, but additional years of data will be necessary to identify this more conclusively. Locations within each of these sites appear to be sampling different populations based on their pattern of counts through time.

DISCUSSION

Over the 18 years included in this dataset (1991-2008) only 1 full cycle was observed, however, it appears that the end of a cycle occurred around the initial year of sampling and another was beginning near the end of the current dataset. A few more years of data should capture a complete second cycle and help to identify differences in timing and duration of cycles at different sites. There were 2 interesting apparent differences between the southern sites (May Creek and McCarthy Road) and northern sites (Nabesna and Chisana). First was the timing of hare population peaks. From the data available, it appears that the peaks at the northern sites occurred 1-2 years earlier. Second, the peaks appear to be approximately 1-2 years further apart than in the southern sites. These differences could be related to the dramatic separation of the 2 areas by a mountain range. Populations in these areas are generally isolated from one another, and habitats may differ. This could allow cycles to occur independently of one another, and monitoring through another complete cycle will help to clarify these differences. These results suggest that snowshoe hare population cycles are not uniform on a large scale. Additional monitoring in DENA and YUCH will help to identify these potential differences on a much larger scale.

One potentially confusing result was the decrease in counts in the second year of a peak at most locations. This occurred at both northern and southern sites, and it is unlikely to be an observer effect in one particular year because the peaks occurred during different years at different sites. There are several possible explanations for this result. First, a sudden increase in the hare population may affect habitat, resulting in lower use during the second year of a high. Another possibility is that decomposition rates may differ between years depending on weather, and fewer pellets may have been available for sampling during some years. This may also explain some of the variability in pellet counts between years. A third explanation could be the timing of the counts. Changing the timing of the surveys would alter the amount of time for pellet deposition. Additional years of sampling and analysis should consider these possibilities and may help to explain some of the observed annual variation in the data.

One of the main criticisms of this approach to monitoring snowshoe hares is that there are no direct estimates of population density or abundance. Because decomposition rates vary depending on annual weather patterns and site-level characteristics, pellet densities cannot be directly compared among sites and limits comparisons among years to a relative index of the population trend. Annual, site-specific assessments of pellet decomposition, as well as average snowshoe hare defecation rates, would be necessary to determine actual hare densities. Defecation rates probably vary depending on time of year and diet, adding additional complexity. If the main goal of the monitoring effort is to identify the stage of the cycle, this monitoring approach may be adequate, but because of annual variation and differences in the amplitude of the cycle, identification of the stage of the cycle may only be evident in retrospect. If more precise information on the stage of the cycle or actual density is needed, other monitoring methods should be considered.

There are some improvements that could be made to the sampling scheme that would likely improve inference. The southern sites and locations within these sites all show similar patterns of increase and decrease in counts. This suggests that they are sampling from the same population that is on the same cycle, which is probable because locations within sites are in close proximity. The replicate locations within the northern sites do not show this similarity. This is likely due to the larger distances between sites in the northern areas, and the possibility that some locations are in low quality habitat or a different habitat type where few pellets are counted even during a population peak. Additional locations would greatly improve the ability to detect cycles at a particular site and could be placed closer together to avoid sampling different populations. Another option would be to add many more sites over a wider spatial scale to look at gradients in the population cycle over a large area. The current design only samples populations at a few distinct points, and with only 1-2 replicates for the northern sites it is difficult to identify trends. At least 3 locations (more if possible) should be sampled at each site (Krebs et al. 2001), and this increase in effort would improve the ability to detect changes in the population. The current design leaves the northern sites with little or no replication with each location appearing to act more as an individual site instead of a replicate within a site. Sampling should also occur at the same time each year to allow the same amount of time for pellets to accumulate between sampling occasions.

An additional option for monitoring on a broader spatial scale is to integrate hare pellet counts into the vegetation minigrid sampling scheme. In 2009, hare pellets are being counted in 4 quadrats at each point within each minigrid sampled. Using occupancy modeling, it may be possible to estimate occupancy and abundance of pellets on a much broader scale. One limitation with this method is that the same areas are not resampled annually. This could make it difficult to track the general hare cycle because spatial variability in population size and phase of the cycle may add a large amount of uncertainty to the estimates. A better solution may be to combine fixed annual plots with the rotating schedule of plots sampled on the minigrid. The fixed plots would help identify the phase of the cycle in a particular section of the park, while the minigrid plots would address some of the spatial limitations of the current sampling scheme. Depending on the goals of the monitoring project, it appears that additional sites are warranted because there seems to be broad-scale spatial variation in the timing and length of the cycle in WRST. If the goal is to describe this at a large scale, more sites (with ≥ 3 locations each) should be monitored in the future. At a minimum, additional locations should be added to the northern sites, and the current locations within these sites may need to be treated as unique sites with

additional locations added nearby. These changes would at least provide better estimates of the differences between sites.

Distance sampling is another option that would provide estimates of pellet density at each site, but would likely require additional sampling effort. Preliminary work has suggested that this method is too labor intensive (~1hr/transect) to add to the vegetation sampling effort on the minigrid. Using it to replace the Krebs's-style plots is an option, but both methods would need to be used for several years to provide a comparison between estimates. In general, ≥ 10 transects 100m in length would need to be sampled at each sampling site for which density estimates are desired, although the actual number of transects would depend on detection rates. It would be important to test this method during the low phase of a cycle to determine the number of transects needed to achieve a desired level of precision. This method would have some of the same limitations as the Krebs's plots (variation in annual and site-specific decomposition rates), but may be easier to complete and would provide more direct estimates of pellet density.

Ultimately, the choice of a sampling scheme depends on the desired resolution of estimates of the snowshoe hare cycle stage or abundance. Krebs's plots may be useful for identifying the stage of the cycle retrospectively, but annual variability may obscure important features and produce confusing results (e.g. the dramatic decrease in pellet numbers observed in the middle of the peak of the cycle; Fig. 1). Increasing the number of replicate locations per site and collecting occupancy data on the minigrids will improve accuracy of estimates of cycle stage. If more in-depth information is needed such as actual abundance or density for direct comparisons among sites and across years, more intensive methods (e.g. estimates of decomposition and deposition rates, or mark-recapture methods) would be necessary. Estimates of defecation rate and site and year specific decomposition rates could be used with the current methods or combined with distance sampling to estimate actual abundance. A sampling design could be produced for any of these methods if desired.

LITERATURE CITED

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- Krebs, C.J., R. Boonstra, V. Nams, M. O'Donoghue, K.E. Hodges and S. Boutin. 2001. Estimation of Snowshoe Hare density from pellet plots: a further evaluation. *Can. J. Zool.* 79:1-4.
- Route, B. 1995. Preliminary analysis: baseline inventory and the development of methods for long-term monitoring of Snowshoe Hares in Wrangell-St. Elias National Park and Preserve, Alaska. USDI, National Park Service, Wrangell-St. Elias NP/P, Copper Center, AK. unpublished report.

Figure 1. Predicted counts for the May Creek and McCarthy sites based on the best model incorporating spatial autocorrelation between points at each location. Solid lines indicate mean estimates, dotted lines indicate 95% credible intervals, solid symbols represent observed mean counts.

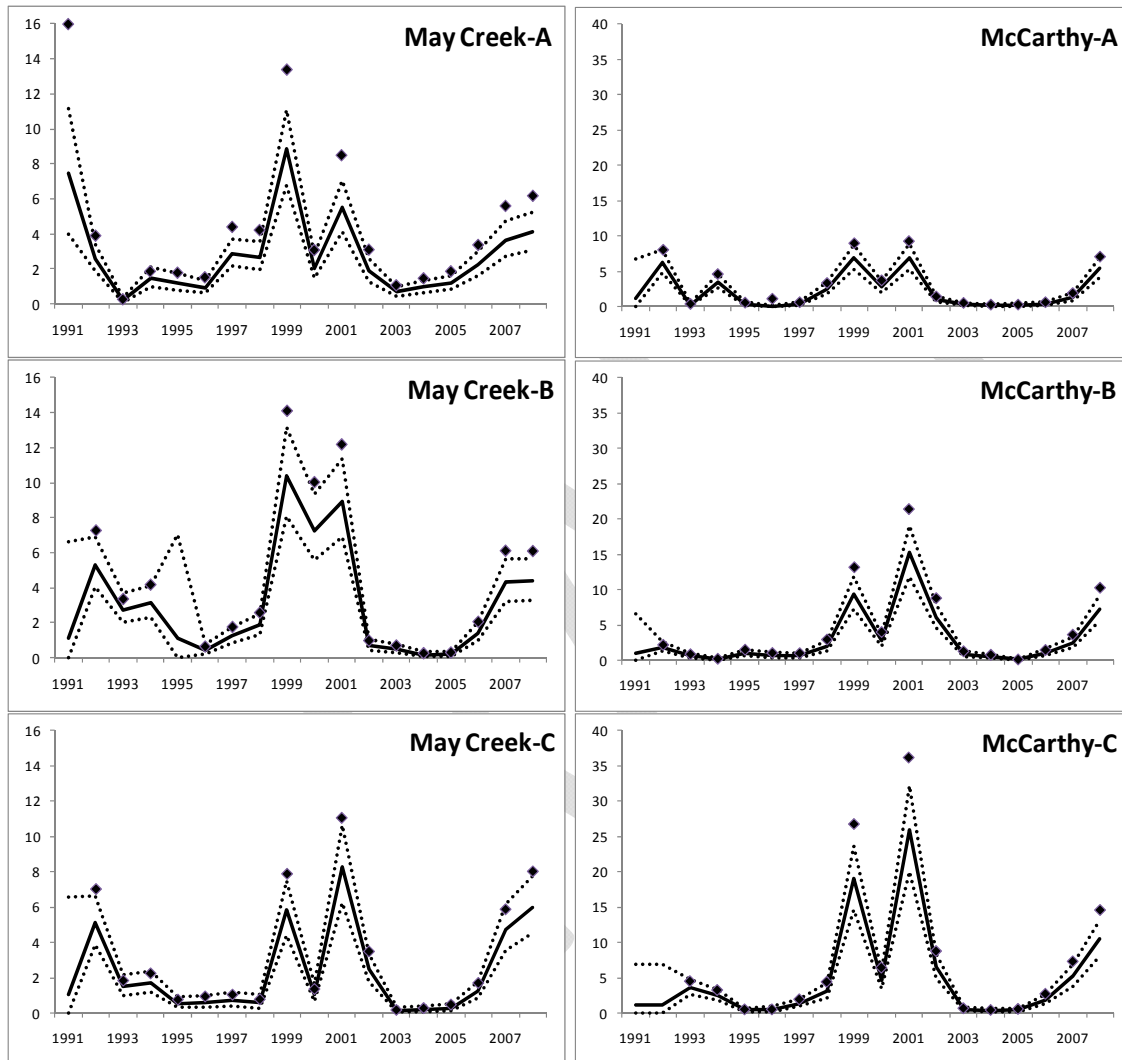


Figure 2. Predicted counts for the Nabesna and Chisana sites based on the best model incorporating spatial autocorrelation between points at each location. Solid lines indicate mean estimates, dotted lines indicate 95% credible intervals, solid symbols represent observed mean counts.

