CAN DE-DENSIFICATION BE USED AS A STRATEGY TO CONSERVE MOOSE (*Alces alces*) POPULATIONS IN NORTHERN NEW HAMPSHIRE?

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Background

- Moose (*Alces alces*), the largest herbivore in North America, have been experiencing a population decline since the late 1990s when there were approximately 7500 moose in northern New Hampshire compared to approximately 4000 in 2015 (Ellingwood 2020).
- There are a variety of drivers impacting the moose population in northern New Hampshire including moose density, weather, habitat, species assemblages and human influence (Ellingwood 2020; Jones 2019).
- Climate change is causing winters to be shorter and warmer which allows winter ticks (*Dermacentor albipictus*) to thrive and ravage moose (*Alces alces*) populations in northern New Hampshire and throughout New England (Park 2020; Ellingwood et. al., 2020). Studies indicate that the winter tick is the leading cause of the recent population decline (Jones 2019)
- Calves are particularly vulnerable to epizootics caused by ticks, which are disease outbreaks similar to epidemics in humans. A 2014-2016 study found that a 70% calf mortality rate was reflected by 3 consecutive epizootics (Jones 2019).

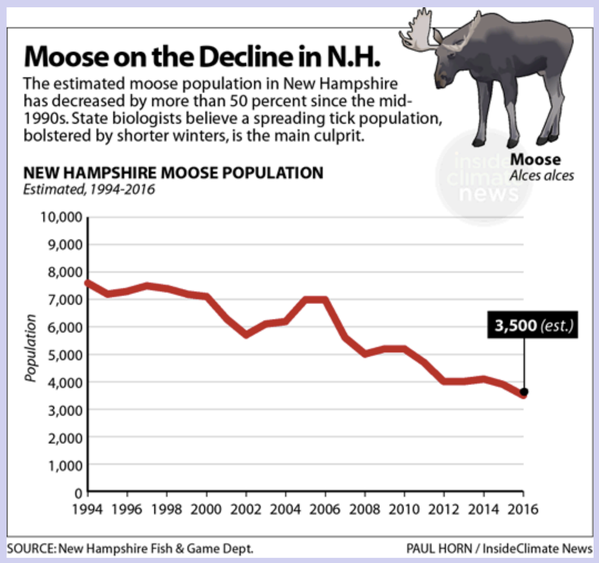
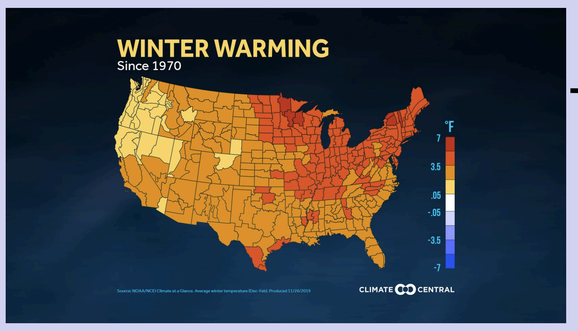


Figure 1: Chart depicting the decline in New Hampshire's moose population since the mid 1990s
Source: NH Fish & Game Department

Motivations

- Previous research has emphasized the importance of understanding the threshold values and role of carrying capacity (K) associated with moose dying off in order to better understand how to manage them (Bergeron et. al. 2014; Ellingwood 2020).
- Researchers suggest that de-densifying moose populations by increasing the number of hunting permits issued each year could help conserve the moose populations by limiting the frequency and impacts of epizootics (Ellingwood 2020; Kusnetz et. al., 2018; Figure 2).
- **We propose to evaluate how increasing the number of permits issued for moose hunting in certain regions in New Hampshire impacts the health of moose populations (measured by calf mortality).**

Warming winters



Greater abundance of winter ticks

Epizootic

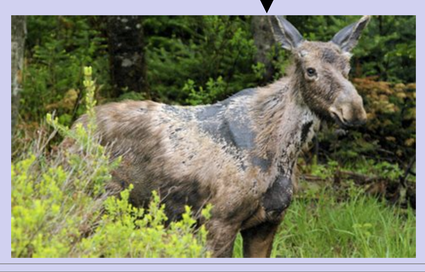


Figure 2: In New Hampshire, average winter temperatures have warmed by 7 degrees since 1970. Warmer winters allow winter ticks to flourish leading to increased incidences of epizootics in moose populations. Photos from the Land Trust Alliance, NH Fish & Game, & Winter Park Times

Hypothesis

- We hypothesize that there is a relationship between density of moose population and occurrence of epizootics, resulting in high calf mortality in moose populations in northern New Hampshire.

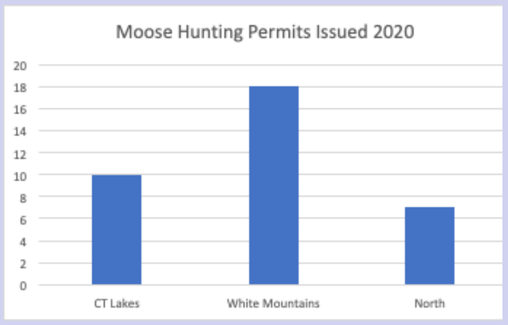


Figure 3: Each year New Hampshire Fish & Game issues a set number of moose hunting permits via a lottery. In 2020, NHFG issued 10 for CT Lakes, 18 for White Mountains & 7 for the North. This study will look at the impact of increasing the number of permits issued.

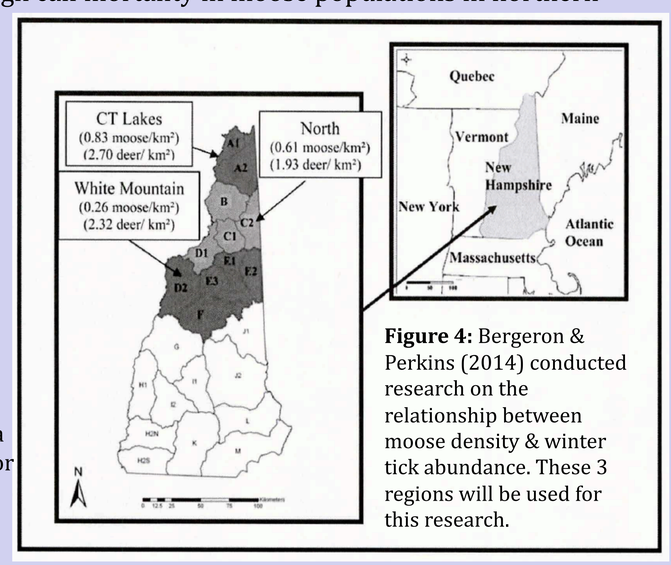


Figure 4: Bergeron & Perkins (2014) conducted research on the relationship between moose density & winter tick abundance. These 3 regions will be used for this research.

Predictions

- We predict that as hunting permits increase there will be a decrease in the number of adult moose which leaves fewer moose for ticks to prey upon thus lowering the abundance of ticks. As a result, there will be fewer ticks to prey on the calves thus decreasing calf thereby increasing population health.
- We predict that the greater number of adult moose that are hunted, the lower the calf mortality rate will be.
- We predict that as the number of hunting permits increases, moose density will decrease thus reducing the abundance of winter ticks and decreasing calf mortality rate.
- We predict health of moose population measured by calf mortality rate will be highest in the North region (Figure 4) where hunting permits will be increased the most (7-14) (Figure 5). Conversely, we predict health of moose population will be the lowest in the White Mountains (Figure 4) where number of permit issued will not change from 2020 (Figure 3).

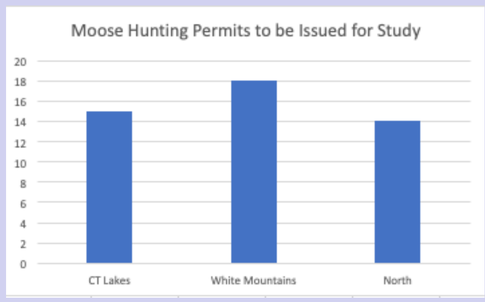


Figure 5: For this study, moose hunting permits will be increased by 1/2 in the CT Lakes region, remain the same in the White Mountains, and will be doubled in the North region.

Study Design

- We will, in collaboration with the New Hampshire Fish and Game, conduct a field study at three locations in northern New Hampshire to investigate the relationship between moose population health as measured by calf mortality rate.
- Each of the three regions in which we will be conducting the study (CT Lakes, White Mountains, and the North) will be divided into 4 separate study sites, assuming there is no variation in the study sites
- At the three regions the moose to be included in the study will be fitted with ear tags color-coded by year and a VHF or GPS radio collar (Jones, 2019).
- This study will take place over three years with the first year as a baseline metric with no change in number of hunting permits issued.
- In 2020, 10, 18, and 7 moose hunting permits were issued to the CT Lakes Region, White Mountains Region, and North Region respectively (Figure 3).
- In the first year of the study, the same number of hunting permits will be issued. The calf mortality rate will be assessed via field necropsies (Jones, 2019).
- In the second year of the study, the number of hunting permits will be increased to 15 and 14 in the CT Lakes Region and the North Region respectively and will remain at 18 in the White Mountains Region (control). The calf mortality rate will be assessed via field necropsies.
- In the third year of the study, the same number of hunting permits will be issued and the field necropsies will be repeated to assess calf mortality rate at the three locations.

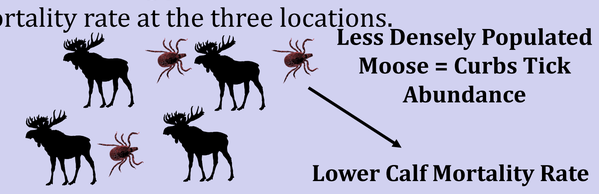


Figure 6: Ellingwood et al (2020) suggest that hunting can proactively limit the frequency and impacts of epizootics. This theoretically shows the impact of de-densification through hunting.

Intended Analysis

- Given that our response variable (calf survival rate) is continuous and our independent (treatment) variable (number of moose hunting permits issued) is also continuous, we will analyze the data using a regression analysis.
- The output of the regression analysis will tell us whether there is a difference in survival rate among the different study sites and different number of hunting permits issued and, therefore, whether or not increasing the number of hunting permits issued as a means of de-densification is related to calf survival.
- As we are limited to study sites in northern New Hampshire for this particular study, our inferences will be limited to the study area.

Expected Benefits

- As aforementioned, moose populations in New Hampshire are in decline and as climate change worsens, increasingly warm winters are likely to exacerbate the frequency of epizootics (Ellingwood 2020).
- Further, increasing the number of moose hunted each year would likely reduce the impact of winter ticks because of the decreased moose density (Ellingwood 2020).
- Moose are an integral part of the ecosystem in New Hampshire and their conservation is a worthy endeavor.

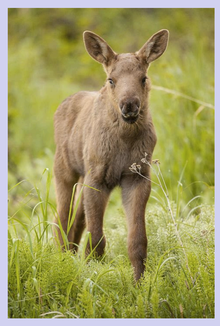


Figure 7: Calves are particularly susceptible to epizootics and stand to benefit from decreasing tick abundance. Photo from Fine Art America

Literature cited: Bergeron, D. H., & Pekins, P. J. (2014). Evaluating the Usefulness of Three Indices for Assessing Winter Tick Abundance in Northern New Hampshire. *Alces*, *50*, 1–15.; Ellingwood, D. D., Pekins, P. J., Jones, H., & Musante, A. R. (2020). Evaluating moose Alces alces population response to infestation level of winter ticks Dermacentor albipictus. *Wildlife Biology*, *2020*, 1–7. https://doi-org.ezproxy.uvm.edu/10.2981/wlb.00619; Healy, C., Pekins, P. J., Kantar, L., Congalton, R. G., & Atallah, S. (2018). Selective Habitat Use by Moose during Critical Periods in the Winter Tick Life Cycle. *Alces*, *54*, 85–100; Jones, H., Pekins, P., Kantar, L., Sidor, I., Ellingwood, D., Lichtenwalner, A., & O'Neal, M. (2019). Mortality assessment of moose (Alces alces) calves during successive years of winter tick (Dermacentor albipictus) epizootics in New Hampshire and Maine (USA). *Canadian Journal of Zoology* , *97* (1), 22–30. https://doi-org.ezproxy.uvm.edu/10.1139/cjz-2018-0140; Kusnetz, N., Berwyn, B., Bruggers, J., Lavelle, M., Tigue, K., Gustin, G., . . .Hasemyer, D. (2018, November 02). Climate Change Is Killing New England's Moose. Are Hunters the Answer? Retrieved November 25, 2020, from https://insideclimatenews.org/news/24052017/climate-change-ticks-killing-new-england-moose-hunter; Park, K. B., Jo, Y. H., Kim, N., Lee, W., Lee, H., Cho, S., Patnaik, B. B., & Han, Y. S. (2020). Tick-borne viruses: Current trends in large-scale viral surveillance. *Entomological Research*, *50*(8), 379–392. https://doi-org.ezproxy.uvm.edu/10.1111/1748-5967.12435