Impact of wolf hunting policy on moose populations in northern Minnesota

Thomas J Mackey† and Thomas Bryce Kelly*

*Boston College, Chestnut Hill, MA. Email: kellyyh@bc.edu

† Boston College, Chestnut Hill, MA. Email: mackeyt@bc.edu

Abstract

An ongoing and politically sensitive aspect of proper ecological stewardship revolves around improving the conditions and health of all of the species in the area of concern including both predator and prey species. Human industrial activities have dramatically reduced the land area available to the native species which has placed stresses and fragility into the ecological web. Maintaining proper ecological dynamics has become a critical aspect of policy initiatives designed to safeguard our natural reserves including the establishment of ecological forests and sanctuaries. Herein we outline our proposal to tackle a central issue in wildlife management: improving our knowledge of predator-prey dynamics that vary both temporally and specially in non-linear ways. By leveraging techniques pioneered in other disciplines in addition to the traditional methods, we aim to drastically improve our understanding of the Moose-Grey Wolf interaction and to develop a system with applicability in other regions and other species.

PeerJ PrePrints | http://dx.doi.org/10.7287/peerj.preprints.769v2 | CC-BY 4.0 Open Access | rec: 31 Dec 2014, publ: 31 Dec 2014

Introduction

Northern Minnesota exists at the southern boundary of Moose (*Alces alces*) distributions in central North America. The Minnesota Department of Natural Resources (Minnesota DNR) conducts annual aerial plot surveys to estimate Moose populations. Their estimates indicate that, despite the existence of a number of sub-populations that are either increasing or stabilized, the state moose population has been declining rapidly over the last decade. This trend of decline is common for this species in several other locations around North America (Murray, 2012). In Minnesota (Minnesota), the estimated population has fallen from 8,160 in 2005 to 2,760 in 2013 with a decrease every consecutive year after 2006 (Minnesota DNR, DelGiudice, 2013). Recently, this decline has been increasingly dramatic, with populations down by 52% from 2012 to 2013 (Minnesota DNR, DelGiudice, 2013). Lenarz et al. (2010) collected survivability and fecundity data and found that between 2002 and 2008 the estimated long term growth rate of moose populations in northern Minnesota to be declining (0.85 individuals/year). The Minnesota DNR has been approaching this trend as a conservation and resource management problem and has closed all moose hunting this year (2013). Reasons for this decline are currently being investigated, but speculative explanations include primarily climate change, and secondarily increases in winter tick (*Dermacentor albipictus*) and brainworm (*Parelaphostrongylus tenuis*) infestations (Lenarz, 2010). These latter two changes may be confounding impacts of climate change.

Gray wolves (*Canis lupus*) have historically predated upon moose in northern Minnesota as part of a multi-prey ecosystem where white tailed deer are currently the primary predation targets (Minnesota DNR 2013, Erb and Sampson, 2013). Wolves have been the only significant non-anthropomorphic predator of Moose in the northern Midwest for the past century (Minnesota DNR, DelGiudice, 2013). Since protection of gray wolves by the Endangered Species Act (1973), states and hunting organizations have expressed concern over the impact of wolf predation on game species populations, including moose (Minnesota DNR, 2001). It is not uncommon for countries, provinces and states to justify predator control programs as a management tool for game species populations. Recently, Alberta, Ontario, Montana, Michigan, Wisconsin, Minnesota, and Alaska have all cited decreases in game species populations including those of deer, elk, moose, and caribou, as a reason for either predator hunting seasons or government culling of large predators (Ballard, 2001). With declining growth rates and naturally sparse populations, moose are likely to be more negatively effected by individual predation events in terms of survivability than for a species with a different ecology and life-history. Current research on the ecological interactions between wolves and moose is not necessarily limited, but is more likely to have applicability to the larger theoretics of predator-prey dynamics than on addressing the impacts of wolves on North American Moose decline.

In the U.S. midwestern population segment, wolves were delisted as an endangered species in 2011. In 2012, Minnesota implemented wolf hunting and trapping seasons with zone restrictions and these have proven to be highly successful in bringing the wolf population down to DNR established goals (Minnesota DNR, 2013). The study proposed here targets this latter concern by investigating the relationship between declining Moose and a managed wolf population. This has potential pertinence to the question of whether predator control is one effective way to manage declining moose populations in the state of Minnesota.

Literature Review

The ecological consequences of wolves on prey species have been examined in several different contexts in North America In terms of population ecology, there is much evidence of predator control over prey populations. A survey of research on black tail, mule and white tail deer in North America shows that when prey populations are high and near an estimated carrying capacity, then changes in wolf populations are not likely to be correlated with changes in prey populations. However, when prey populations are low and the predation rate is high, then removing the predators is likely to increase prey populations (Ballard, 2001). Furthermore, Evans et al. (2006) and Barbara-Meyer et al. (2008) found that declines in elk population, fecundity, and survivability can be correlated with the reintroduction of wolves to the Greater Yellowstone Ecosystem. Ballard et al. (1997) found that wolf predation did not significantly limit migratory caribou populations but did regulate low-level resident moose populations in northwestern Alaska. However, other research suggest that that low levels of wolf predation can allow low level caribou populations to persist (Ferguson et al., 1988; Haskell et al., 2007). Peterson et al. (1984) found evidence of predator controlled cycling among wolves and moose in Lake Superior's Isle Royale, with significantly correlated prey responses to predator crashes. Finally, Gasaway (1992) found that predation by wolves limited moose populations only at low densities in the Yukon and in Alaska.

The conditionality of wolf regulation of prey species populations found in this research suggests that predation impacts are prey density-dependent. However, other research suggest that wolf regulation follows a ratio-dependent model where the ratio of predator populations to prey populations is the most important predictor of prey response to predators. Vucetich et al. (2011) analyzed long term data of predation rates (percentage of prey population predated), kill rates (average number of prey killed by each individual predator), and predator-prey ratios in Isle Royale (41 years of data), Banff (19 years of data), and Yellowstone (12 years of data). Their assessment indicates that predation rate is much more successfully predicted by predator-prey ratios, and that predator-prey ratios most successfully explained variation in prey populations for two of the three locations. Hebblewhite (2013) also found that predator-prey ratios were successful at predicting declines in elk populations in Banff. Furthermore, Sand et al. (2012) compared data between two locations (Isle Royale and south-central Scandinavia) with similar prey densities but very different kill rates. This difference could not be explained by prey density but was correlated to differences in predator-prey ratios.

It is also important to note that in a multi-prey environment, the ratio of different prey species populations are likely to influence wolf predation The presence of alternative prey may reduce the potential for predator regulation of a prey species (Dale et al., 1994). A threshold model has been proposed to describe when a prey species is common enough to become the main prey of individual packs (Smith et al., 2000).

Wolf management has been documented as a potential means of regulating game species populations in North America (Steenweg, 2012)

Hypothesis

As moose populations continue to decline and wolf hunting quotas are ratified in the northern Minnesota region, the predator-prey ratio is expected to decline, the predation rate to increase logarithmically, and the kill rate to decrease.

Method

Since the vast majority of the forested area in Minnesota is located in the far north of the state, this study will be restricted to national and federal lands, especially in the Superior National Forest, which contain the primary ecosystems effected by change in wolf-hunting laws (Figure 1). In this northeast region of the state, the wolf harvests for the 2013 season included 30% of harvest targets (Minnesota DNR, *Wolf Season*, 2013). Moose populations are also higher in the state's northeast(Minnesota DNR, DelGiudice, 2013). We speculate that the most obvious signs of the impact of new wolf hunting laws on kill rate, predation rate and population ratios will likely take place in this region of Minnesota. Our study will use an array of techniques over the course of the next 5+ years to take predation data in the larger state forests of northeastern Minnesota.

The preliminary and primary technique to gauge the changing population levels of the moose and wolf populations will be through passive areal transect surveys similar to those described in Hebblewhite et al. (2013) or in Minnesota DNR's *Areal Moose Survey* (2013). Researchers will conduct 1 mile by 0.5 mile transects on a bi-monthly basis, record wolf/moose sightings, and identify kill sites. Researchers will use sampling analysis of the sightings data to estimate the changes in population ratio of wolves to moose in northeast Minnesota over time. Researchers will use the kill site data in conjunction with population estimates to estimate changes in both kill rate and predation rate in NE Minnesota over time.

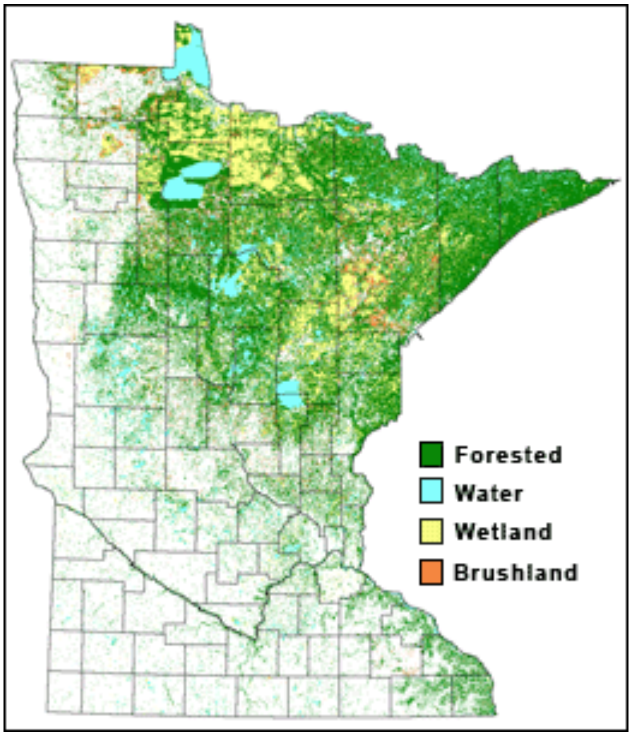

Figure 1. Geography of Minnesota (Minnesota DNR, *Forest Health Highlights* 2012)

With consideration of scat analysis techniques identified by Klare et al. (2011), researchers will also perform bi-monthly scat surveys in transects by foot, ski or snowshoe. Scat analysis can yield statistics on wolf diet (Floyd 1978). Researchers will use this analysis in conjunction with population estimates to provide a second estimate of kill rate and predation rate. This redundancy will not only increase the likelihood that our study will be able to identify any trends in wolf-moose population dynamics, but may also provide insight into the effectiveness of these different techniques.

Researchers will also perform a capture-mark survey of wolves. Leg-hold traps will be placed in consistent locations three times a year for five days throughout the study. These traps will be checked everyday that they are out. Captured wolves will be tranquilized, tagged and guard hair samples will be taken. Each sample will then be analyzed with stable isotope fractionation, which has found wide spread application in recent years (Tieszen et al., 1983; Peterson and Fry, 1987). Derbridge et al. (2012) offers a statistical approach to quantifying the diet of wolves based on the δ^{13}C content of guard hairs. This data will be used to estimate the availability of moose meat in the pack's diet. Data from the hair of recaptured wolves will be used to evaluate the consistency of moose meat in the diet of wolves over time. In conjunction with population ratio, kill rate and predation rate estimates, researchers will assess the impact that wolf predation is having on moose populations.

Finally, researchers will collect data on harvested wolf stomach contents. All hunters are currently required to bring the pelt and carcass of wolves to a DNR office at a specified time in the season. Researchers will perform necropsies for stomach contents of as many carcasses as hunters will individually permit them to. This is a technique employed by researchers in Minnesota during the era of predator bounties (Stenlund, 1955) but that has been recently under-utilized. This data will be analyzed to determine the likelihood that any harvested wolf was predating on moose. In conjunction with population ratio, kill rate and predation rate estimates, researchers will assess the impact that wolf hunting is likely to have on moose predation as the populations change.

Because of the pre-existing research on wolf-moose trends, we predict that moose populations will continue to decline while wolf populations remain stable in NE Minnesota, thus increasing the predator-prey ratio. We predict that kill rates will remain stable or decrease but predation rate will increase because of the declining moose population. Furthermore, we predict that the percentage of wolf diet composed by moose will remain stable or decline because of declining moose populations. Because it reduces the predator-prey ratio, hunting is likely to have an overall increase on predation rate but have minimal effect on kill rates.

Conclusion

A significant weight of research has been brought to bear upon the predator-prey dynamics of large animals in North America, including both moose and wolves, but not always in the context of deteriorating populations. This study will provide one of the first glimpses at the state of this upper trophic level as statewide populations of moose decline and as wolves are limited by hunting. This research has implications on whether wolf predation is likely to interfere with moose conservation.

While the wolf-moose dynamic is just one small part of a much larger ecosystem, it's a dynamic where small changes can cascade down the trophic levels and ripple change throughout the temperate ecosystems (Beschta and Ripple, 2010). These temperate regions have been under increasing pressure due to climate change in recent years; and with an uncertain future, the wildlife management experts need access to high-quality, regional level data on predator-prey interactions in order to make informed, productive policy recommendations and actions.

References

Ballard, W. B., Ayres, L. A., Krausman, P. R., Reed, D. J., & Fancy, S. G. (1997). Ecology of wolves in relation to a migratory caribou herd in northwest alaska. *Wildlife Monographs*, (135, *Ecology of Wolves in Relation to a Migratory Caribou Herd in Northwest Alaska*) 3-47.

Ballard, W. B., Lutz, D., Keegan, T. W., Carpenter, L. H., & deVos, J. C.,Jr. (2001). Deer-predator relationships: A review of recent north american studies with emphasis on mule and black-tailed deer. *Wildlife Society Bulletin* 29(1), 99-115.

Barber-Meyer, S. M., Mech, L. D., & White, P. J. (2008). Elk calf survival and mortality following wolf restoration to yellowstone national park. *Wildlife Monographs*, (169, Elk Calf Survival and Mortality Following Wolf Restoration to Yellowstone National Park) 1-30.

Beschta and Ripple, (2010). Mexican wolves, elk, and aspen in Arizona: Is there a trophic cascade? *Forest Ecology and Managemen*t 260.

Dale, B. W., Adams, L. G., & Bowyer, R. T. 1994. Functional response of wolves preying on barren-ground caribou in a multiple-prey ecosystem. Journal of *Animal Ecology* 63(3):644-652.

Derbridge, J. J., P. R. Krausman, and C. T. Darimont. (2012). Using Bayesian Stable Isotope Mixing Models to Estimate Wolf Diet in a Multi-prey Ecosystem. *Journal of Wildlife Management* 76:8

Evans, S. B., Mech, L. D., White, P. J., and Sargeant, G. A. (2006). Survival of adult female elk in yellowstone following wolf restoration. *Journal of Wildlife Management*, 70(5):1372-1378.

Ferguson, S. H., Bergerud, A. T., & Ferguson, R. (1988). Predation risk and habitat selection in the persistence of a remnant caribou population. *Oecologia*, 76(2), 236-245.

Ferguson, S. H., Bergerud, A. T., & Ferguson, R. (1988). Predation risk and habitat selection in the persistence of a remnant caribou population. *Oecologia*, 76(2), 236-245.

Floyd, T. J., Mech, D. L., & Jordan, P. A. (1978). Relating Wolf Scat Content to Prey Consumed. *Journal of Wildlife Management*, 42(3), 528-532.

Gasaway, W. C., Boertje, R. D., Grangaard, D. V., Kelleyhouse, D. G., Stephenson, R. O., & Larsen, D. G. (1992). The role of predation in limiting moose at low densities in alaska and yukon and implications for conservation. *Wildlife*

Monographs, (120, The Role of Predation in Limiting Moose at Low Densities in Alaska and Yukon and Implications for Conservation), 3-59.

Haskell, S. P., & Ballard, W. B. (2007). Modeling the western arctic caribou herd during a positive growth phase: Potential effects of wolves and radiocollars. *The Journal of Wildlife Management*, 71(2), 619-627.

Hebblewhite, M. Consequences of ratio-dependent predation by wolves for elk population dynamics. *Population Ecology*, 2013 55(4), 511-522.

Klare, U., Kamler, J. F., and MacDonald D.W., (2011) A comparison and critique of different scat-analysis methods for determining carnivore diet. *Mammal Review.* 41(4): 294-312.

Lenarz, M. S., Fieberg, J., Schrage, M. W., & Edwards, A. J. (2010). Living on the edge: Viability of moose in northeastern Minnesota. *The Journal of Wildlife Management*, 74(5), 1013-1023.

Middleton, A., (2011). The influence of large carnivore recovery and summer conditions on the migratory elk of Wyoming's Absaroka Mountains. University of Wyoming (2012).

Minnesota Department of Natural Resources. (2013). *2013-14 Wolf Seasons Regulations Handbook*. Retrieved from: http://files.dnr.state.mn.us

Minnesota Department of Natural Resources. (2013). *Aerial Moose Survey Final Results*. Retrieved from: http://files.dnr.state.mn.us By Glenn DelGiudice.

Minnesota. Department of Natural Resources. (2013). *Distribution and Abundance of Wolves in Minnesota, 2012-13*. By John Erb and Barry Sampson.

Minnesota Department of Natural Resources. (2013). *Forest Health Highlights*. Retrieved from: http://fhm.fs.fed.us/fhh/fhh-03/mn/mn_03.htm

Minnesota Department of Natural Resources. (2013). *Wolf Management*.

Minnesota Department of Natural Resources. (2001). *Wolf Management Plan*.

Murray, D. L., K. F. Hussey, L. A. Finnegan, S. J. Lowe, and G. N. Price. (2012). Assessment of the Status and Viability of a Population of Moose (Alces Alces) at Its Southern Range Limit in Ontario. *Canadian Journal Of Zoology* 90.3.

Olson, E., (2013). As a wolf: A Wisconsin case-study of wolf-human conflict and predator-prey ecology. (Doctorial dissertation, University of Wisconsin, WI).

Peterson, P. J. and Fry, B. (1987) Stable Isotopes in Ecosystem Studies. *Annual Review of Ecological Systems*, 18, 293-320.

Peterson, R. O., Page, R. E., & Dodge, K. M. (1984). Wolves, moose, and the allometry of population cycles. *Science*, 224(4655), 1350-1352.

Sand, H., Vucetich, J. A., Zimmermann, B., Wabakken, P., Wikenros, C., Pedersen, H. C., et al. (2012). Assessing the influence of prey-predator ratio, prey age structure and packs size on wolf kill rates. *Oikos*, 121(9), 1454-1463.

Smith, D. W., Mech, L. D., Meagher, M., Clark, W. E., Jaffe, R., Phillips, M. K., et al. (2000). Wolf-bison interactions in yellowstone national park. *Journal of Mammalogy*, 81(4), 1128-1135.

Steenweg, Robin. (2012) Interactions of wolves, mountain caribou and an increased moose-hunting quota --- Primary-prey management as an approach to caribou recovery. (Doctoral Dissertation, University of NC, NC).

Stenlund, M. (1955). *A field study of the timber wolf (canis lupus) on the superior national forest, minnesota*. St. Paul, Minnesota: Minnesota DNR.

Tieszen, L. L., Boutton, T. W., Tesdahl, K. G., Slade, N. A. (1983). Fractionation and turnover of stable carbon isotopes in animal tissues: Implications for $\delta^{13}C$ analysis of diet. *Oecologia* 57, (1-2), 32-37.

Vucetich, J. A., Hebblewhite, M., Smith, D. W., & Peterson, R. O. (2011). Predicting prey population dynamics from kill rate, predation rate and predator-prey ratios in three wolf-ungulate systems. *Journal of Animal Ecology*, 80(6), 1236-1245.

Wright, G. J., Peterson, R. O., Smith, D. W., & Lemke, T. O. (2006). Selection of northern yellowstone elk by gray wolves and hunters. *The Journal of Wildlife Management*, 70(4), 1070-1078.