Report to the Minnesota Department of Natural Resources (DNR) by the Moose Advisory Committee

18 August 2009

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*Committee members did not represent the policies or viewpoints of their employers or the organizations they served, but were chosen as individuals who could provide valuable perspectives based on their personal and/or professional expertise.

Executive Summary

Between the late 1980s and the early 2000s the density of moose (*Alces alces*) in northwestern (NW) Minnesota declined precipitously because of high non-hunting mortality and low pregnancy rates. The population decline was correlated with increasing summer temperatures, although year-to-year variation was large. In northeastern (NE) Minnesota, mortality of radiocollared moose is comparable to that seen during the decline of moose in the NW. Population modeling based on mortality and fertility rates indicates a declining population. Recruitment of calves into the population is at low levels, and hunter success has declined over the past decade. These lines of evidence all suggest that the NE population is declining as well. In addition, there is anecdotal evidence of population decline: people are reporting seeing fewer moose than they used to. In response to these developments, the Minnesota State Legislature directed the Department of Natural Resources (DNR) to establish a Moose Advisory Committee (MAC) that would make recommendations to the DNR and form the basis for their development of a Moose Management and Research Plan.

To help guide its discussions and recommendations, the MAC developed the following Vision Statement for moose management in Minnesota:

> *"**Moose have intrinsic value and are recognized for their importance to Minnesota. To the greatest extent possible, moose shall be managed for ecological sustainability, hunting, and viewing opportunities**."*

While climate change is a long-term threat to the persistence of moose in Minnesota, we do not know the rate and extent of change over the next 50 years. Under worst-case scenarios the threat would be serious. However, the MAC believes that moose are likely to persist in MN for the foreseeable future, at least in the NE. The substantial cultural and ecological significance of moose should prompt a major effort to retain the species among Minnesota fauna. Based on our current knowledge of the status of moose in Minnesota, the MAC makes several recommendations to the Minnesota DNR which can be summarized and paraphrased as follows:

- Raise the public profile of moose in Minnesota by building a diverse constituency that will recognize the ecological, cultural, and economic values of this species.
- Inform the public of impacts to moose and mitigation strategies through a vigorous outreach and educational program.
- Continued monitoring of population status is critical, and research is needed to improve habitat, develop best management practices for habitat management, and increase understanding of factors affecting moose populations.
- Moose hunting can be continued in the NE but continue to monitor harvest and population indicators that could initiate closure of hunting seasons.
- Through harvest and a ban on recreational feeding in moose range in NE Minnesota, white-tailed deer should be managed at low densities to reduce potential parasite-mediated impacts to moose.
- Enhance future availability of wetlands and other habitats where moose are most secure from heat stress.
- Increased funding and personnel are needed to enhance moose research and management in Minnesota. This needs to be a collaborative effort (already begun) involving the DNR, other state agencies, federal agencies, tribal governments, academics, and other non-governmental organizations.
- The MAC recommends that moose *not* be listed as either state-designated Threatened or Endangered in Minnesota. A narrow majority of the MAC considers it desirable at this time to designate moose as a Species of Special Concern (vote tally 9Y:8N:1abstain).

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Version 1.01 printed 8/19/2009. Version 1.01 corrects several (10-20) minor typographical errors in the report released on 8/18/2009. .

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Acknowledgements: I'd like to thank each member of the committee for his/her diligence to the tasks of this committee – we were clearly united in a sincere desire to see moose flourish in Minnesota. Ron Moen, in particular, stepped in during my (too frequent) absences to chair meetings or otherwise keep committee business moving forward; with the prerogative of the Chair, I named him Co-Chair of the committee. DNR staffer Grant Wilson patiently and capably served as liaison to the committee, a position with the unspoken responsibility to organize and review everything we did. Also from the DNR, Michael DonCarlos and Steve Merchant served as advisors to the MAC, providing valuable sounding boards for instant feedback regarding DNR policies and practices. Kathy DonCarlos provided valuable organizational skills and recorded minutes of initial meetings. The Center for Urban and Regional Affairs at the University of Minnesota awarded a grant to Ron Moen and Grant Wilson for graduate student Amanda McGraw to serve as recorder for meetings and assist with drafting and review of the final report. Much of the hard work of the committee was accomplished by various subcommittees, ably chaired by the following committee members: Dennis Becker, Lou Cornicelli, Mark Lenarz, Jeff Lightfoot, Mike Schrage, and Dan Ryan.

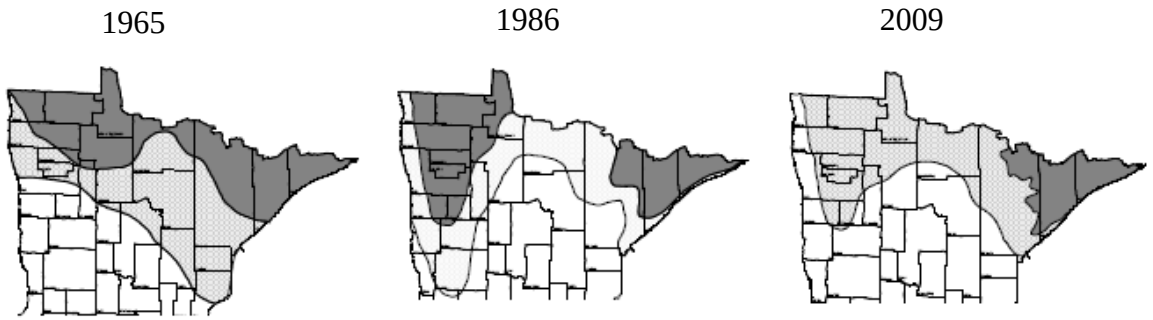
Rolf Peterson, 18 August 2009

Introduction

During the past two decades, moose density declined dramatically in NW Minnesota, from at least 4,000 to fewer than 100 animals. Essentially, Minnesota has lost one of two relatively disjunct populations of moose in the state (Fig. 1). The precipitous decline in the NW continued even after the cessation of hunting in 1996 (Murray et al. 2006). During a period of intensive research in the late 1990s in northwestern Minnesota, annual moose mortality was high, at 21%, and moose pregnancy and recruitment rates were very low. Mortality was attributed to poor nutritional condition and parasitism. These health-related issues were correlated with increased summer and winter temperatures in recent decades, in an area of forest edge where tree cover is relatively sparse.

Beginning in 2002, moose research and monitoring were intensified in NE Minnesota through a cooperative effort by the DNR, tribal authorities, and federal and academic researchers. Annual mortality of moose in the NE was found to be comparable to that of the NW during the moose decline there, and there was also evidence of declining recruitment of moose calves in the NE. Annual aerial surveys in the NE do not indicate significant population decline, but high mortality from health-related stressors and a positive correlation between annual mortality and wintertime temperature (Lenarz et al. 2009) suggest that a climate-related population decline may be underway or imminent. Concerns voiced by members of the Minnesota State Legislature led to passage of legislation in 2008 directing the DNR to develop a Management and Research Plan for Moose in Minnesota (see Enabling Legislation sidebar).

Figure 1. Change in moose distribution in Minnesota, 1965-2009. Dark gray indicates primary moose range, light gray indicates low densities of moose (from Mark Lenarz, MN DNR, unpubl. data).



The MAC Process

Acting on the directive of the Legislature, in September 2008 the DNR formed the Moose Advisory Committee (MAC) to consult with regional authorities on moose biology and other stakeholders to thoroughly review options for moose management and research. Committee members were selected by the DNR to represent a cross-section of moose experts, land managers, wildlife managers, tribal staff, and other key stakeholders. The MAC was charged with the responsibility for making recommendations to the DNR and other stakeholders for moose management and research.

The MAC consists of 18 members of diverse backgrounds, all with an interest in the future of moose in Minnesota. Several members of the DNR served on the committee because of their professional expertise and specific knowledge of moose demographics in the state. The MAC had an initial organizing meeting in September 2008, and then hosted several out-of-state moose experts for a fact-finding Moose Summit in December 2008 in Duluth. During the Moose Summit the MAC heard from and had an opportunity to consult moose biologists and managers from Manitoba, Ontario, North Dakota, Michigan, and New Hampshire. Between January and July 2009 the MAC met approximately monthly. Several subcommittees were formed within the MAC to address specific areas of management and research. Sub-committees met 2-3 times to discuss recommendations for their sub-section. Recommendations were presented to the entire committee during monthly meetings and revisions were made and discussed until general agreement about each recommendation was reached. This report presents the findings and conclusions of the MAC in the form of several recommendations to the DNR, together with background and rationale for these recommendations.

Enabling Legislation

2008 MN Legislature Ch. 368, SF 2651, Article 2 Section 76

MINNESOTA MOOSE MANAGEMENT AND RESEARCH PLAN.

The commissioner of natural resources shall consult with research scientists, wildlife managers, tribal interests, other agencies with moose research and management expertise, and other key stakeholder groups on the development of a moose management and research plan for Minnesota. The plan shall address moose populations and habitats, including, but not limited to, the northwest Minnesota herd; likely causes of observed changes and trends; moose habitat and hunting management; and monitoring, research, and evaluation needs. The plan shall establish future moose management and research goals and strategies within the context of habitat and climate trends in Minnesota. By January 15, 2009, the commissioner shall provide a progress report on the plan to the Senate and House of Representatives committees with jurisdiction over natural resource policy.

Context for Recommendations

The Legislature directed the DNR to develop a plan for moose management and research, and further specified that the plan address trends in moose populations and habitats, causes of population changes, hunting and habitat management, research, monitoring, and evaluation needs. The MAC considers research an integral part of a comprehensive management strategy for moose, but because of its unique requirements we have treated research as distinct from ongoing management, which is assumed to mean any other DNR activities that relate to habitat

alterations, moose harvest, providing the public with information and education, annual monitoring of population performance (often integrated with research because methods are similar), and communication with the public and the Legislature regarding the well-being of moose in Minnesota.

The dramatic decline of moose in NW Minnesota was well documented and investigated by an intensive research project in the late 1990s (Murray et. al. 2006). While no single factor appeared to explain the decline of moose in the NW, a significant increase in temperature was considered ultimately responsible, as evidenced by comparable declines in moose in adjacent parts of Manitoba and North Dakota. Unless there is a change in the environmental factors that are stressing moose in NW Minnesota, that population will likely not recover. However, suitable habitat should be maintained in NW Minnesota so moose can re-colonize if the environment again becomes favorable to moose in the future.

In contrast to the conditions in NW Minnesota, habitat in NE Minnesota may be ameliorating adverse environmental changes. Research and management can help identify and enhance key habitats and otherwise modify conditions toward maintaining moose in NE Minnesota, at least in the short-term. In the long-term, several decades or more, there are likely to be significant ecological challenges to moose survival in Minnesota arising from climate change (Galatowitsch et al. 2009). Warmer and drier environments will cause more physiological stress in moose, increase the presence of deer and their associated parasites on the landscape, and reduce the forest environments that support moose. These expectations were the underlying foundation for establishing the MAC and they provide the impetus for our recommendations.

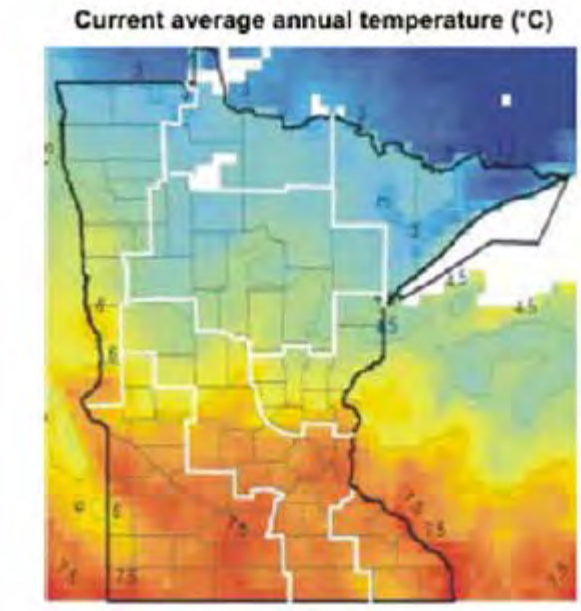
Management programs for moose in the mid-continent are now in uncharted territory. Along the southern boundary of moose range in North America (Fig. 2), in Minnesota and elsewhere, expectations for future climate change are shrouded in uncertainty and the response of moose populations to various limiting factors is simply unknown. There are no simple directives for wildlife managers to follow, and no guarantees that moose in Minnesota will be secure in the long-term. However, the MAC believes now is the time to act, when there are still several thousand moose in the NE forest zone and obvious uncertainties can be addressed by timely research (see Fig. 3).

Public support for maintaining moose in Minnesota can be expected to remain high, and we believe it is crucial for the DNR to engage the public interest in moose in a timely fashion. Diverse stakeholder groups are needed to collaborate in the singular goal of maintaining wild moose populations and the associated ecological, cultural, and economic values.

We note that three Native American bands of Chippewa have clear and specific treaty rights for off-reservation hunting in NE Minnesota, and currently tribal moose harvest amounts to a few dozen animals per year. At present, we do not consider harvest by band members as demographically significant for the moose herd in Minnesota. MAC recommendations are directed to the DNR and tribal wildlife managers are not required to consider them. However, the DNR will clearly need to continue considering tribal harvest in moose management plans. We recommend that the DNR maintain its strong programs of collaboration with the tribes, along with other partners in moose research and management.

Figure 2. Moose range in North America in the early 1990s (light gray) corresponded to the region of boreal forest (dark gray) (Karns 1997). Moose range in Minnesota occupies sub-boreal forests.

Figure 3. A climatic refuge may exist for moose in NE Minnesota. The historic pattern of average temperature (darker blue shading indicates lower temperature) in NE Minnesota (1970-1999) suggests the possibility of a future refuge for moose near the northern border adjacent to Lake Superior. However, by the mid-21st century many boreal forest species may disappear from Minnesota, many wetlands will disappear with higher evapotranspiration and longer droughts, and climate in the region is projected to resemble that recently experienced in southeastern Minnesota (Galatowitsch et al. 2009)



Summary of Recommendations

We view our recommendations as being useful in an adaptive management approach including monitoring, periodic review and modification. In this section we provide summaries of our recommendations. Order of presentation does not indicate an intent to prioritize.

Social Dimensions

Maintaining moose in Minnesota will require that management and related research be accorded a high priority among the public, resource management professionals, and members of the Legislature. In order to build a broad constituency of public support for moose in Minnesota, it is important for the DNR to engage the public in a timely manner, especially about the effects of future climate change on moose and the rationale for continued hunting of moose. The DNR should be transparent in its decision-making regarding moose management, and should encourage studies that capture the varied benefits of moose for Minnesotans. Greater intra-agency coordination within the DNR would assist moose management. A close working relationship with the legislature needs to be fostered to promote policy and management actions that help perpetuate moose. Management of moose should be based on sound science and sensitive to social concerns and impacts.

Communication

Reaching the public is a continuous challenge, and a plan for communicating moose information to the public is recommended. Information on the status and management of moose populations in Minnesota should be easy to find on the DNR website, and outreach materials should be developed that can be used for various educational venues such as school curricula and tourism materials.

Research

There is a continuing need to monitor moose population performance, density and demographics, which is the biological foundation for all decision-making. Monitoring techniques should be constantly evaluated for improvement. Monitoring and research are directly linked by personnel, methods, and evaluation. Key research questions include gaining a better understanding of the factors influencing moose reproduction and survival in NE Minnesota, particularly causes of mortality, and moose response to heat stress, with emphasis on characterizing habitats that may be critical as thermal refugia.

Moose Harvest

It is important for the DNR to monitor the effects of continued harvest on the moose population. If there is a sustained moose population decline the DNR will need to explain why moose harvest can continue. The DNR should also be prepared to close the moose hunting season if certain conditions (chronic population decline or undue impacts of harvest) are met. It is recommended that the hunting season be closed if the bull:cow ratio drops below 67 bulls/100 cows for three consecutive years, or if harvest success drops below 30% for three consecutive years. Moose hunting in specific zones should be closed if average three-year harvest success drops below 10% in the BWCAW, or 20% outside the BWCAW. Moose hunters should be surveyed to evaluate these and alternative thresholds for closing moose harvest.

Deer Management and Deer Impacts on Moose

In the past decade mild winters have led to increased deer density in northern Minnesota. Although the relationship between deer numbers and mortality in moose is unclear, it is well established that deer carry parasites and diseases that are detrimental to moose. Within moose range, deer should be managed to maintain fall pre-hunt densities <10 deer per mi^2 and a ban on recreational feeding of deer should be established. Research and monitoring should be undertaken to better understand deer-moose interaction, and deer management units should be realigned to correspond to moose range.

Habitat

The DNR should take a leadership position in understanding and documenting both the status of moose habitat in MN, across all land ownerships, and the way forest management activities impact moose. Management for high quality moose habitat will be increasingly important for maintaining moose populations. Best management practices and habitat plans should be developed that prioritize moose habitat management in key areas within the moose range, especially those that are likely to be least affected by climate change. Moose habitat management should accommodate the need for aquatic feeding areas and thermal refugia, as well as the traditional emphasis on fine-scale mixed forest stands with ample deciduous regeneration. Successful moose habitat management will require commitment from the USDA Forest Service, plus state, county, and private landowners.

Funding

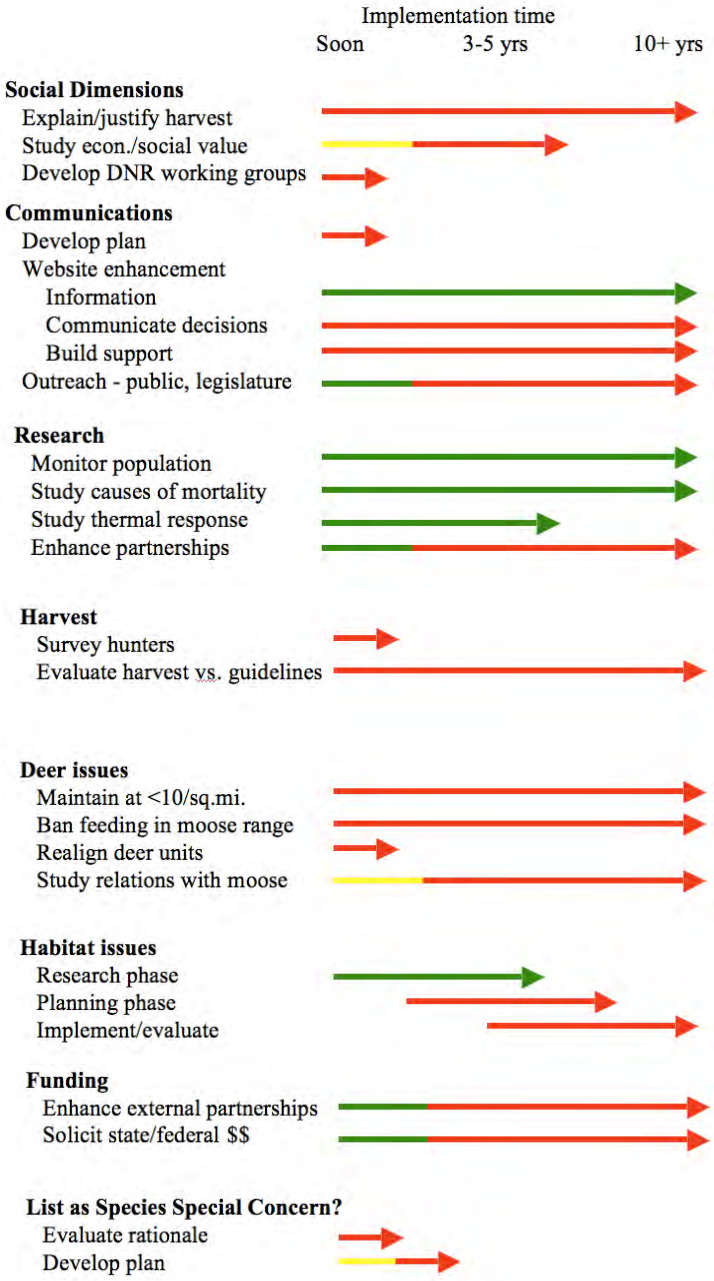
Legislative appropriations and allocations of funding will drive decisions regarding staffing and necessary infrastructure. The value of moose to the tourism economy and as a north woods icon has statewide significance. Therefore funding for moose research and management must come from sources in addition to hunting license revenues. We recommend that moose management be accorded an elevated priority for funding within the annual budget of the DNR, and that the DNR continue working with other agencies and academic institutions to obtain funding for research on moose in Minnesota. Such partnerships have already generated $900k for moose research in the past decade, and there needs to be continued effort to leverage funding and other resources from external sources. Other funding sources, such as the new Lessard-Sams Outdoor Heritage Council may also provide a mechanism to broaden the funding base for moose, at least with respect to habitat acquisition and preservation.

Designation of Moose as a State-Listed Species

The committee was unanimous in believing that it is inappropriate at this time to designate moose as either Threatened or Endangered, as defined in Minnesota Statute 84.0895. After considerable discussion, a narrow majority of committee members (9:8:1) supported state-listed status as a Species of Special Concern (SSC) in Minnesota. We recognize that this will be an important and difficult decision for the DNR, but the committee focused on the state-wide status of moose in relation to listing criteria. The MAC recognizes a need for accelerated or emergency review and listing of species, as there is potential for rapid change in species status.

The Summary of Recommendations includes actions in multiple areas. A timeline such as we have drafted (Fig. 4) should be a part of the Moose Management plan to be written by the DNR.

Figure 4. Timeline for planned activity for moose management and research. Yellow lines indicate need for planning and preparation, green arrows indicate ongoing activity, red arrows are new activities needed.



Recommendations – Background and Details

Most of the following sections are subcommittee reports with minor editing to maintain consistency.

Social Dimensions

Overview

Management decisions regarding the future of moose in Minnesota are inherently influenced by social factors related to perceptions about moose population decline, the value of moose to local economies, and the symbolic nature of moose. In particular, future hunting seasons for moose will be reviewed in relation to biological, social, and legal criteria. Social concerns about hunting a declining moose population may at some point contradict a biologically-based rationale for continuing hunting. This is due to the high profile of moose in the state and their importance for non-hunting purposes. Given the complexity of the issue and the level of scientific uncertainty, acknowledging the role of social concerns in the decision making process will be critical to the success of moose management.

Recommendation: The DNR must be transparent in making decisions regarding moose management.

The public should be kept informed of on-going management decisions. The public needs to have an understanding of why certain actions are necessary, and also the assumptions and information used to determine those actions. That information must be presented on an ongoing basis and continually updated. It is particularly important that the DNR be willing to acknowledge the considerable uncertainty surrounding moose populations and trends.

The DNR is aware of the concern the public has for declining moose populations and is sensitive to the perceived impact of hunting on long-term viability. Where and when the public is asked to provide input, it must be accompanied with acknowledgement about how that input will be used in the decision-making process. In addition to seeking scientific input from biologists and trained experts, the DNR should also consider seeking broad public input regarding significant issues that arise pertaining to moose management (e.g., hunting bans).

Specific actions to increase public involvement might include:

- Establish a public dialogue and moose population goal setting process – solicit public input regarding the non-hunting values of moose, economically and culturally (using the goal-setting processes used by the DNR for deer).
- Communicate openly with the public about the biological challenges facing moose in Minnesota, particularly climate change impacts on projected moose population levels, real and perceived impacts of hunting, and the rationale for management actions.
- Communicate the process by which the DNR will re-evaluate decisions regarding, a) the number of hunting permits issued, b) projected population impacts, and c) criteria for making these decisions.

Recommendation: Incorporate economic and social impacts into moose management planning.

Observations and reports from tribal representatives, hunters, Chambers of Commerce, resort owners, community members, and tourists indicate that moose are a critical component of the cultural identity and economy of northern Minnesota. Economically, the "value" of moose can be measured in terms of how much moose hunting contributes to local economies through trip-related expenditures and through the reinvestment of hunting license dollars for moose management. While no definitive study on the economic value of moose has been conducted, a 2006 DNR survey of 279 moose hunters yielded an estimate of 3,675 moose hunting days expended. From the perspective of license revenues, nearly $90,000 was generated in application and license fees in 2009. Moose also contribute substantially to local economies through purchases of related souvenirs, travel to and within the region for the opportunity to view moose, and related lodging receipts. Many communities use moose as a trademark or advertising tool to promote or sell the area in which they live—the Minnesota Secretary of State website identifies more than 300 registered businesses with "moose" in name.

Socio-culturally, the value of moose to Minnesota residents is difficult to quantify but is assumed substantial. Incorporating broad measures of the value of moose into state management plans, beyond economic impacts, is necessary to capture intrinsic value and ensure decisions made on behalf of moose incorporate an appreciation and sensitivity to them as a cultural symbol.

Specific actions might include:

- The DNR could administer a survey of residents, non-residents, resort owners, hunters, and community members' attitudes towards the "value" of moose. The survey could include economic and cultural measures (e.g., attitudes towards hunting, willingness to pay, economic impact of moose-related tourism, acceptable levels of uncertainty).

- Identify metrics for incorporating the cultural importance of moose (e.g., cultural identity, viewing opportunities) into DNR management plans.

Recommendation: The DNR must build a broad constituency of support for moose management and work closely with stakeholders and partners.

A broad constituency of hunters and non-hunters alike is necessary to provide balanced public input, assist with monitoring efforts, and to support management actions necessary to maintain viable moose populations. Moose management is disproportionately paid for by hunting license fees even though moose are also important to state tourism and recreation, and to the non-hunting public. Because the value received from investments in moose management benefits the public as a whole, it is important that additional sources of financial support be obtained by building a broad constituency among hunters and non-hunters. A broad constituency may help to diversify funding support as well as to incorporate the ideas of various interests, including fielding requests from the legislature. One of the concerns is that policy advocates may be emboldened to pursue actions that a) unintentionally, or inadvertently, divert resources and attention away from important moose management activities, or b) overly complicate the management process; a broad constituency will reduce the risk of these actions occurring.

Specific actions might include:

- Develop a strategy for informing the legislature about moose management actions and needs that includes efforts to coordinate requests with ongoing DNR activities.

- Develop sustainable moose research and management funding sources based on a broader constituency of hunters and non-hunters (e.g., legislative funding, Legislative-Citizen Commission on Minnesota Resources [LCCMR], Lessard-Sams Outdoor Heritage Council [L-SOHC])

Recommendation: Facilitate intra- and inter-agency coordination for moose management and research.

The MAC recommends that moose management and research be accorded a high priority in the intra- and inter-agency decision processes where appropriate. An interdisciplinary approach to problem solving is necessary given the complexity and degree of uncertainty surrounding moose management and its interaction with other DNR responsibilities. In particular, the DNR Divisions of Fish & Wildlife and Ecological Resources must work closely together, within and in addition to the subsection planning process, to identify and take actions relevant to moose hunting, habitat improvement, disease, and other factors potentially affecting moose populations. Collaboration with external agencies is also necessary. Integration of these efforts will be especially important in response to decisions about whether and at what level of state classification to list moose -- threatened, endangered, or as a species of special concern -- and decisions about appropriate management activities and research.

Specific actions might include:

- Utilize information generated by the MAC during the consultative process to inform the species listing process.

- Establish an internal DNR working group that includes experts from each pertinent Division.

- Coordinate moose management and research across divisions and with external partners including the ongoing efforts of tribes, counties, state agencies, academia, and organizations (e.g., Minnesota Forest Resources Council [MFRC]), and federal collaborators (e.g., USDA Forest Service, US Fish and Wildlife Service, National Park Service, U.S. Geological Survey).

Communication

The following are recommendations to the DNR for the dissemination and use of information critical to moose management decisions.

Recommendation: Develop a communications plan that guides information sharing, assures accuracy, and solicits public comments.

A communications plan directed at informing the public of pertinent management decisions is needed. The communications plan should provide accurate and up-to-date information about on-going research as well as transparent information about the solicitation and use of public input in making management decisions. Unrealistic expectations for what the DNR can accomplish in the context of future moose populations may lead to an eroding of public confidence. The purpose of the communications plan is to convey the intent and scope of management actions taken, provide consistent and accurate content to the public, and facilitate management of public expectations by the DNR. The plan would also prioritize the types of media outlets and information sharing tactics to use for different publics (e.g., brochures, press releases, websites, mailings, public meetings).

Recommendation: Develop a website to communicate new information and background materials.

Public meetings and targeted press releases are an important component of a communications plan. In addition, a website devoted to new releases of information is useful to a transparent decision-making process. The website could provide key information about complex issues that might inform the public on certain aspects of moose management (e.g., hunting, species listing, and population dynamics). The website needs to convey the level of uncertainty necessary to set realistic public expectations about accomplishments and the need for a broad constituency of support. Finally, the website could provide a bulleted list of points or guiding principles on the importance of moose from both hunting and non-hunting perspectives.

Recommendation: Develop a variety of outreach materials and strategies for public education.

Create a series of education outreach materials that could be used in the classroom, presentations to community groups, and for general public consumption. The DNR could prepare PowerPoint slides on the importance of moose, management actions being taken, and uncertainty surrounding outcomes. The slides, and any accompanying materials, could be available on the DNR website. State and federal employees could be encouraged to present these talking points and educational materials to community groups. There is also an opportunity to use the public to assist with statewide monitoring including voluntary reporting of moose observations.

Research

Overview

Monitoring by aerial surveys alone is not sufficient to solve the moose population problem. Additional research is needed on habitat requirements, particularly in relation to changing climate. Aerial survey results give an indication of population levels while research attempts to explain causes for fluctuations in populations. We recommend other areas of research that go beyond a single species, namely deer-moose interaction and evaluation of economic and social values, and these are described in their respective sections in this report.

With the dramatic decline of the moose population in NW Minnesota (Murray et al. 2006), signs that the moose population in the NE may be in trouble are a cause for concern (Figs. 5 and 6). Symptoms like low survival and low reproductive rates among adult radio-collared (with very-high-frequency or VHF collars) moose, low recruitment rates estimated from annual aerial surveys, and anecdotal information such as declining moose observations and hunter success rates all indicate a potential problem. About 60% of adult mortality from the current NE VHF research is classified as unknown, but often appears to be health-related (M. Schrage, *unpubl. data*)**.** In addition, the research has found correlations between measures of heat stress and subsequent adult survival (Lenarz et al. 2009). Yet uncertainty remains about a change in the moose population because the midwinter aerial survey does not indicate a statistically significant decline, and the trend across years is relatively flat (Lenarz 2009b).

In response, the MN DNR, the 1854 Treaty Authority and the Fond du Lac Band have maintained a conservative hunter harvest level for the NE herd and hunting was discontinued in NW Minnesota after 1996. Yet reducing or eliminating harvest may not be enough to maintain a stable moose population as there is little indication that hunter harvest is an important source of mortality in the NE population, and discontinuing hunting failed to recover the NW population (Figs. 5 and 6). In the face of this uncertainty, we identified research needed to address critical shortcomings in our understanding of moose mortality. Long-term monitoring of the population for signs of change is required. Causal factors behind symptoms suggesting population decline should be identified, leading to management action that may prevent a population decline in the NE similar to what occurred in NW Minnesota.

We also need to consider research projects that provide understanding of cover and forage type selection by moose and collect data on moose responses to weather events in order to provide guidance to land management agencies in Minnesota. Initial returns of management knowledge could be available within 2 years of initiating such research, with a 3-4 year window providing the basis for a comprehensive understanding of how moose are responding to changes in habitat and climate in Minnesota.

Research also should address some of the longer-term issues associated with moose in Minnesota. Climate change models predict that in the coming decades, temperature stresses on moose will increase in both summer and winter. Understanding how moose respond to warmer temperatures will help guide future land management and moose management decisions here in Minnesota.

Figure 5. Estimated moose population in northwest Minnesota, 1983-2007 (Murray et al. 2006 and M. Lenarz, *unpub. data*). Error bars reflect 90% confidence intervals.

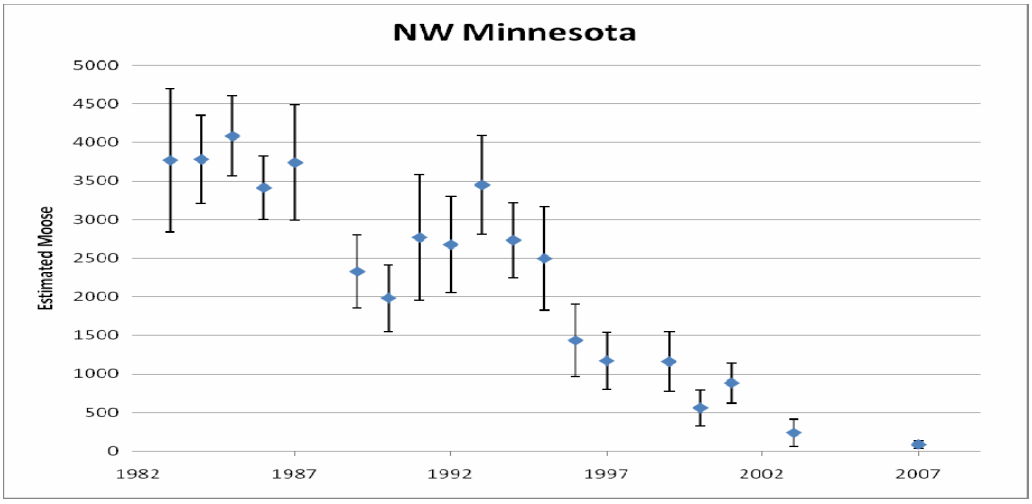
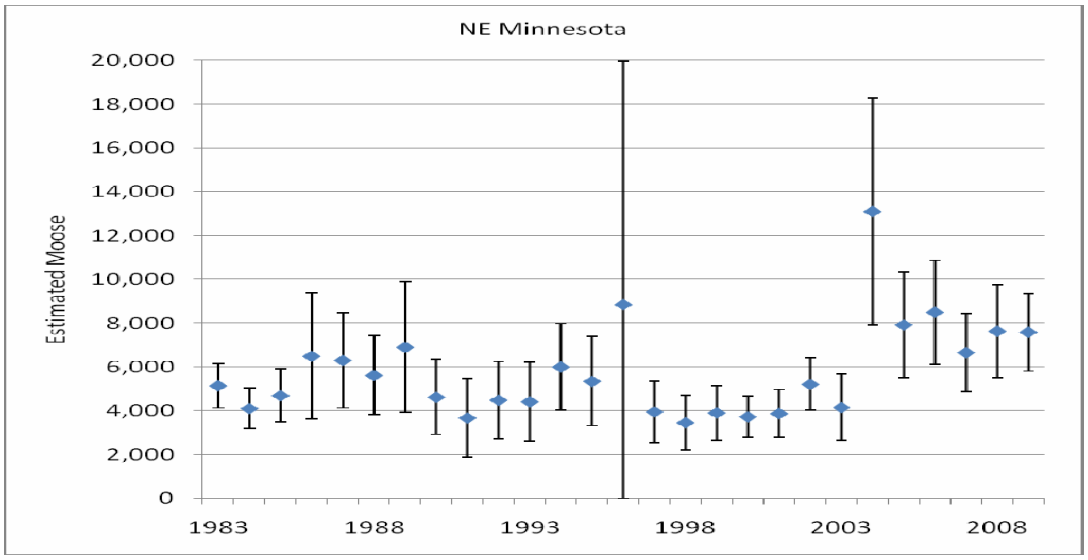


Figure 6. Estimated moose population in northeast Minnesota, 1983-2009 (M. Lenarz, *unpub. data*). Error bars reflect 90% confidence intervals. Beginning in 2004, the DNR began using helicopters on the survey and corrected visibility bias using a "sightability model." Estimates prior to 2004 are not directly comparable with the new survey techniques. The 2004 estimate is biased high because of misunderstandings among observers on how to measure "visual obstruction," a covariate used in the sightability model to correct for visibility bias. Error bars for 1995 were large because of poor counting conditions.



Previous, Current and Proposed Research Projects

Annual moose survey: The annual survey provides data on moose population trends and demographic characteristics. Global Positioning System (GPS) locations of moose observed, age class, and sex are recorded. Numbers of deer on survey plots also have been collected in some years. Data produced from this survey include estimates of population size and sex and age ratios, and the information is used to understand causes of historical changes in populations and help model future changes.

VHF Telemetry: A study using VHF radio collars began in 2002 as a cooperative project between the MN DNR, the US Geological Survey, the 1854 Treaty Authority and the Fond du Lac Band of Lake Superior Chippewa in NE Minnesota (Lenarz et al. 2005). Initial objectives of the research were to determine survival rates of adult and calf moose, identify specific causes of mortality for adult moose, determine movements and home range size and improve the annual aerial survey of moose numbers. Between 2002 and 2008, 150 moose were captured and fitted with VHF collars. Current funding is scheduled to allow monitoring of the remaining collared moose through February of 2011.

Results from this research improved the aerial survey, determined large-scale movements, home range sizes, and survival rates of adult moose and calves. The project has been less successful in determining causes of mortality, as about 60% of adult mortality during the study was classified as unknown (but probably health-related). In addition, the research found correlations between measures of heat stress and subsequent adult survival (Lenarz et al. 2009).

A similar study conducted in NW Minnesota was begun in 1995 as a cooperative project between the MN DNR, the U. S. Fish and Wildlife Service, and the University of Idaho (Murray et al. 2006). The primary objective of the project was to determine the cause(s) for the decline that was occurring in the NW moose population. Between 1995 and 1998, 152 adult females and calf moose were captured and fitted with radio collars.

Research results documented low levels of adult and yearling survival and low pregnancy rates among adult cows. The researchers concluded that climate, acting in tandem with pathogens and chronic malnutrition, had caused the decline of moose numbers in NW Minnesota.

Disease Screening: In 2007 and 2008, biological samples (e.g., liver, lung, feces, blood, hair, cranial lymph nodes, brain) were collected from hunter-harvested moose and screened for a variety of disease agents. The results of this work have identified disease agents that moose from the NE population have been exposed to, as well as providing a baseline of “normals” which will allow for a better understanding of results from non-hunting mortalities and possible changes that may occur in the future.

Analysis of 2007 and 2008 samples from hunter harvested moose is still in progress. Intentions are to continue collections through 2009. Analysis of samples from collared moose, incidental sick moose, and road-kills will continue.

Voyageurs National Park (VOYA) GPS Telemetry: This is a cooperative study involving the National Park Service, the Natural Resources Research Institute and the US Geological Survey. The field objective is to deploy global positioning system (GPS) collars on 12-15 moose beginning in January 2010 and collect location and activity data at 15 minute intervals. Habitats used by moose under different weather conditions, especially when heat stress is most likely, will be identified and compared with estimates of temperature and activity recorded on the collar.

Grand Portage Indian Reservation GPS Telemetry: This is a cooperative study modeled after the VOYA study above and involving the Grand Portage Indian Reservation (GP), the Natural Resources Research Institute and the 1854 Treaty Authority. The primary objective is to deploy GPS collars on 12-15 moose beginning in January 2010 and collect data at 15 minute intervals. Location data of moose will be compared with estimates of temperature and activity recorded on the collar.

LCCMR GPS Telemetry: A proposal was submitted to LCCMR in May 2009 with partners including the Natural Resources Research Institute, the Minnesota DNR, the 1854 Treaty Authority, the Fond du Lac Band, and Minnesota Deer Hunters Association (MDHA). The study will have an educational component with the Minnesota Zoo and a moose reporting website for the public at UMD in cooperation with the MDHA. Objectives are to deploy GPS collars on moose in a managed forest environment in NE Minnesota to determine moose activity levels and corresponding environmental temperatures, identify critical habitat, develop best management practices and provide recommendations for moose habitat. Data collected here will complement the VOYA and GP study sites, which are at the extremes of current moose range in NE Minnesota.

Recommendation: Minnesota should continue with long-term monitoring of moose numbers through the annual aerial survey. Continued evaluation of current techniques is recommended in order to reduce variance in annual estimates. In addition, population modeling and the development of alternative techniques to track moose numbers is encouraged to obtain multiple views of population trends. A comprehensive analysis of existing data sets obtained from aerial survey and VHF research is needed.

Current efforts to monitor the NE moose population concentrate on the use of an aerial survey. Presently, annual costs of this survey exceed $30,000. However, the information is fundamental to understanding changes in moose numbers and distribution. The frequency of aerial surveys in NW Minnesota has been decreased because of poor survey conditions and low moose numbers. An effort to develop or coordinate a low-cost alternative to the aerial survey in the NW should be considered to provide managers and the public some trend and distribution information on that population.

The aerial survey provides important information on moose reproduction, sex ratios, distribution and numbers. However, variance associated with the population estimate may hide significant changes in numbers. Work should continue to improve these estimates. Data including GPS locations of moose and relative numbers of deer on survey plots have also been collected. These data sets should be analyzed for their value.

Current population modeling that incorporates vital rates measured during the VHF study indicates the NE moose population is declining (Lenarz 2009a). This inference is independently supported by reduced recruitment rates from the aerial survey, reduced hunter success rates and anecdotal comments from residents living in the moose range. Additional techniques to measure changes in moose numbers are needed to evaluate population trends.

Analyses of data collected on radio-collared moose in NE Minnesota indicated low levels of adult survival which varied considerably among years (Lenarz et al. 2009). Most studies of large mammal populations have shown that adult survival is more important in determining the rate of increase than fertility rates (Caswell 2001). Determination of survival rates is very expensive, however, because this information is generally determined using radio-collared animals. Development of indices that predict moose survival may ultimately be very important in future management of moose in Minnesota.

Recommendation: Research is necessary to better understand the ultimate and proximate causes of the high mortality documented in NW and NE Minnesota. The roles of thermal stress, parasites, disease, and parasite and disease vectors need to be better understood. There needs to be recognition of potential geographic variation in mortality across moose range in Minnesota and better understanding of how local and regional environmental conditions may impact moose health, reproduction and mortality. Causes and rates of mortality may vary spatially and temporally and on-going monitoring is recommended.

Research from 1995 – 2000 in the NW and research begun in 2002 in the NE and based on VHF radio collars has documented high levels of mortality in Minnesota's moose. Much of this mortality appears to be health-related and may be linked to heat stress. Research should focus on identifying potential agents and vectors of disease and parasites, their importance to moose and how their importance may change in time and space across moose range. For example, results from the NW Minnesota study indicated liver flukes were often considered a proximate source of mortality likely contributing to 21-32% of deaths of collared moose (Murray et al. 2006); however this conclusion has not been supported in the NE study. In another example, moose numbers appear to have declined more in St. Louis County than in parts of their range further north and east. The reasons for this are not well-understood. Although probably not a proximate source of mortality, the role of heat stress in predisposing moose to other sources of mortality needs to be better understood.

As a result of the work of this committee and the subsequent moose plan development, management recommendations designed to improve moose survival are likely to be adopted in Minnesota. In addition, the effects of climate change are expected to increase in coming years. It is necessary to monitor changes in causes and rates of moose mortality in order to evaluate the effectiveness of any management recommendations and evaluate the effects of climate change.

Recommendation: Research is necessary to develop a better understanding of how moose respond to their environment and use habitat to meet their thermal and foraging needs. Improved long-term monitoring of climate, habitat changes, and their impacts on moose across Minnesota is necessary. In addition, moose populations across the southern edge of their range in North America do not appear to be affected equally by heat stress, but the reasons for this variation are unclear. Understanding geographic variation in moose response to heat stress may assist wildlife managers in developing strategies to benefit moose.

Basic information on moose habitat requirements and preferences in Minnesota is lacking. Habitat research in Voyageurs National Park and the Grand Portage Indian Reservation, while valuable to those jurisdictions, will not address the range of variation in the managed forest environment across most of the NE moose range. Moose across most of their range in NE Minnesota utilize a managed forest environment where the different strategies and priorities of county, state, federal and private land managers create a mosaic of conditions. Habitat requirements and preferences of moose in NW Minnesota are unknown.

It is well established that climate change is occurring in the Great Lakes region and predictions call for spring and summer temperatures to increase as much as 2°C in the next 25 to 50 years. Moose are superbly adapted to colder environments but they are intolerant of heat, and even minor increases in temperature will likely be important to their survival. Importantly, recent research in NE and NW Minnesota has suggested that there is a link between heat stress and moose survival. Moose in Minnesota likely can use a variety of habitat features to ameliorate the effects of warmer temperature and such features would represent critical habitat to moose. The availability of this critical habitat is likely to become altered in response to natural forces (fire, wind), human activity (forest harvest), and climate change and it is important to better understand how such changes will affect the moose population.

Summary of Research

Long-term monitoring of moose numbers should have the highest research priority in order to track changes in the moose herd. However, research to better understand mortality and survival rates and how moose use their environment is critical for understanding why changes are occurring in moose numbers. Without this supporting information, moose managers will be unable to make informed moose management decisions. The research recommendations outlined by this committee will require a continued commitment of the DNR to maintain the funding, personnel and equipment necessary to do quality moose research.

Research is an open ended process. Answers and management implications are not always immediately obvious and ongoing research frequently raises new questions and unexpected results. The value of long-term research projects to explain trends and differentiate the effects of short-term variation due to changes in weather, predator populations, hunter harvest, habitat or other sources of environmental variation cannot be overstated. Wildlife managers and policy makers need to leave the door open for new research ideas to adapt to changing conditions and information.

Moose Harvest

Overview

The moose hunting season was closed in 1922 after the cumulative effects of settlement reduced moose numbers to very low levels. The hunting season was reopened in 1971 and limited numbers of hunters were issued permits to take moose in both NE and NW Minnesota (Karns 1972). In 1997 the hunting season in northwestern Minnesota was closed because the population underwent a dramatic decline (Murray et al. 2006). Over the last 10 years, state and tribal seasons have continued in NE Minnesota and the total annual harvest has averaged 184 moose. Since 2007, state-licensed hunters have been restricted to harvesting antlered bulls (Lenarz 2007).

Moose are harvested by both state-licensed hunters and tribal members under separate seasons and regulations. The following discussion of moose harvest applies to state licensed hunters only and does not include several dozen animals taken annually by tribal hunters (Table 2).

The public tends to view any moose hunting in northeastern Minnesota as contributing to a population decline. However, the current bulls-only harvest removes only 2% from the fall population annually, and it has very little impact on the rate of population change. Harvest will accelerate population decline only if there are too few bulls to breed all of the cows (Bubenik 1987).

The DNR's population model incorporates mortality and reproduction information from ongoing research and indicates the northeastern moose population has declined in recent years. Ongoing research has documented levels of non-hunting mortality that are substantially higher than sustainable levels reported in North America. However, aerial surveys do not corroborate a decline. If this high non-hunting mortality continues the model indicates moose numbers will continue to decline even if all hunting was stopped.

From a purely biological standpoint, harvest strategies can be implemented for any size moose population provided that monitoring is sufficient to allow confidence in the population's size, composition, and distribution. However, we recognize that the question of whether moose hunting should continue in northeastern Minnesota also has social and legal components. If the moose population declines below some threshold level, social pressures may lead to cancellation of moose harvest. Legally, if moose are listed as Threatened or Endangered in the state then harvest must be stopped.

The MAC attempted to identify thresholds that could be used to close the hunting season. These thresholds are based on limited scientific data or professional judgment. We based thresholds on presumed levels of hunter satisfaction or on the assumption that a reduced bull:cow ratio will affect reproduction. While we believe these thresholds to be reasonable they should be open to modification as new information becomes available.

Recommendation: Close the moose season if the bull:cow ratio estimated during the aerial moose survey drops below 67 bulls/100 cows for three consecutive years. If closed, we recommend re-opening the moose season when the bull:cow ratio exceeds 67 bulls/100 cows for three consecutive years.

It is generally accepted that productivity of moose populations will decline if the proportion of breeding bulls in the population drops below a threshold where all of the breeding age cows are not impregnated (Rausch et al. 1974, Bubenik 1987, Crete et al. 1981, Solberg et al. 2002). The critical threshold is dependent on the breeding behavior displayed by the population. In the more open, tundra habitats of Alaska and Canada, bull moose breed with aggregations of cows (Lent 1974, Bubenik 1987) and the threshold is likely fairly low. In contrast, bull moose found in the boreal forests of Minnesota and eastern Canada are thought to breed fewer cows, and a higher bull:cow ratio is required.

There are no data, however, that identify the level of this threshold for moose populations in Minnesota or eastern Canada. Based on simulation modeling, Crete et al. (1981) recommended a bull cow ratio of 67 bulls/100 cows for moose in Ontario while Bubenik (1987), based on concerns over insufficient numbers of prime age bulls (aged 5-12) recommended that the bull:cow ratio should approach parity. Yearling bulls are usually excluded from active breeding by the more mature dominant bulls (Lent 1974, Bubenik 1987) but can breed (Schwartz et a. 1982). Unless it is demonstrated that there are insufficient bulls to impregnate the cows in the northeast moose population, we recommend using the threshold proposed by Crete et al (1981) which assumes that each adult bull can successfully breed 1.5 cows.

Until recently, the bull:cow ratio observed on the aerial moose survey in northeastern Minnesota has remained fairly stable but in the last 6 years, this ratio has trended downward (Table 1). If this decline continues, the threshold of 67 bulls/100 cows for three consecutive years could be reached in five years.

Table 1. Bull:cow ratio (with 90% confidence interval) as estimated from aerial surveys in northeastern Minnesota.

Survey	Northeast Bulls:Cow	90% Conf. Interval
1998	0.98	42%
1999	1.30	28%
2000	1.34	19%
2001	1.05	26%
2002	1.22	17%
2003	2.01	29%
2004	1.24	25%
2005	1.04	33%
2006	1.09	18%
2007	0.89	32%
2008	0.77	22%
2009	0.94	25%

Recommendation: Close individual moose zones to hunting if the harvest success of state hunters averages less than 10% over 3 consecutive hunting seasons in the BWCAW zones or 20% over 3 consecutive hunting seasons in zones outside the BWCAW. We also recommend that managers have the option of reopening closed hunting zones after 3 years if adjacent zones remain open.

The DNR is unable to estimate moose numbers within each of the 30 hunting zones each year because of inadequate time, aircraft, and funding for individual aerial surveys. However, annual hunter success is calculated for each zone and, although affected by hunter access and other factors, likely represents a good index of local moose density. The MAC proposes to use harvest success by zone as a threshold for closing moose hunting in local portions of the northeast moose range. We recommend a threshold based on an average of 3 consecutive years because moose permit numbers are generally low in each zone (median = 7 for 2009) and the success or failure of even one hunting party can markedly change the success rate in any given year.

The proportion of hunters that harvested a bull moose has steadily declined in recent years and in general, and hunters in the BWCAW have been less successful than hunters in the zones outside the BWCAW (Table 2, Fig. 7). Success rates vary widely among zones and in 2008 ranged from 0 to 88% (mean = 45%). It is difficult to project when individual hunting zones would close under these thresholds because each zone would likely have its own trajectory. Following the 2008 hunting season, average 3-year hunter success exceeded 20% in all zones. However, in 2008, hunter success was less than 10% in 1 BWCAW zone and less than 20% in 2 zones outside the BWCAW. If current levels of hunter success remain low, under recommended thresholds these 3 zones could close by the fall of 2011 (Figs. 7 and 8).

Table 2. Data on state-licensed moose hunters and harvest by tribal members, 1993-2008. Applicants, permit numbers, bull moose harvested, success rates of state-licensed moose hunters, and total harvest (bulls and cows) by bands in NE since 1993.

Year	Party applicants	Permits	Bulls harvested	Bull hunter success	Total tribal harvest
1993	2934	315	200	63%	96
1994	3022	189	115	61%	74
1995	3181	188	129	69%	77
1996	3830	207	123	59%	63
1997	3958	198	124	63%	66
1998	4157	182	90	49%	71
1999	3919	189	101	53%	68
2000	No hunt				63
2001	3164	182	108	59%	62
2002	2580	208	118	57%	79
2003	2328	224	127	57%	63
2004	3062	245	127	52%	61
2005	3060	284	137	48%	67
2006	2952	279	133	48%	48
2007	2566	233	115	49%	47
2008	2706	247	110	45%	40

Figure 7. Hunter success at harvesting bull moose in northeastern Minnesota, 2001-2008.

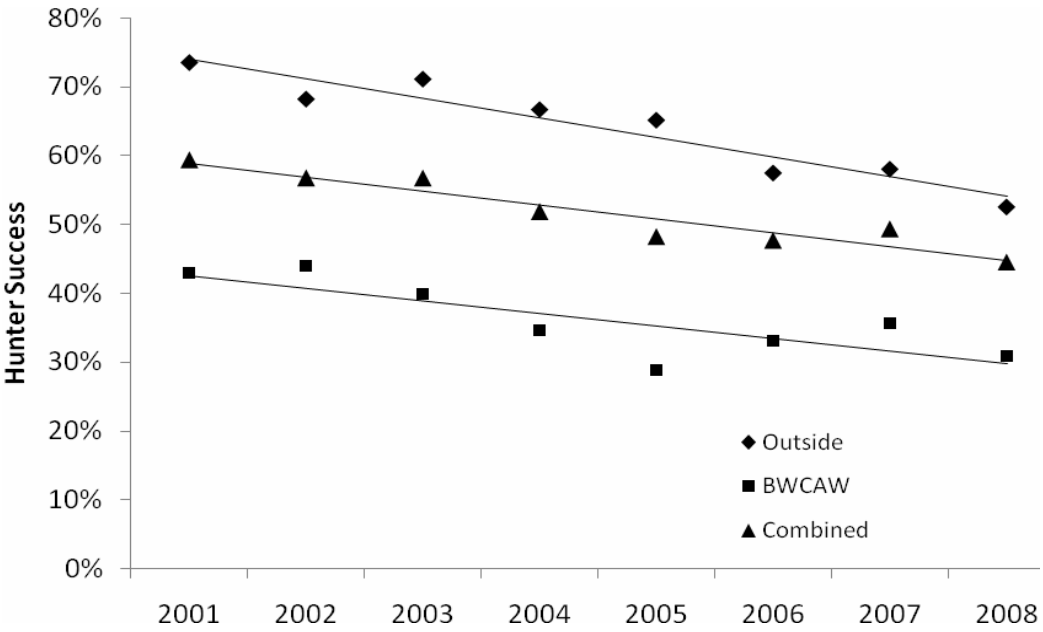
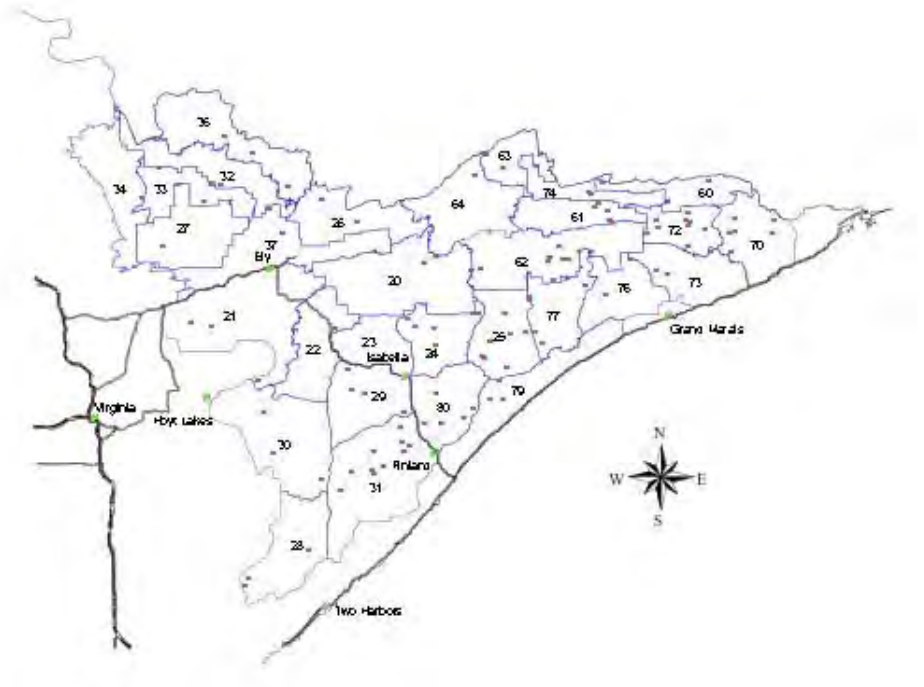


Figure 8. Locations of moose hunting zones in NE Minnesota and moose harvested in 2008. Each red dot represents a moose killed during the 2008 season, and green dots correspond to cities and towns.



This recommendation is based on both hunter satisfaction and on moose biology. Moose hunting licenses are expensive ($310) and since 1991, hunters have been restricted to a once-in-a-lifetime moose hunting opportunity. With these limitations, we believe DNR should manage moose so that hunters expect a reasonable chance at harvesting a moose.

Recommendation: Close the moose season in northeastern Minnesota if hunter success drops below 30% for 3 consecutive seasons. If the moose season is closed, we recommend reopening the hunting season if the aerial survey indicates that the population increased above the number at closure and demonstrated an increasing trend for a minimum of 5 consecutive years.

The bulls-only success of hunters in northeastern Minnesota has steadily declined since at least 2001 (Table 2, Fig. 7) and will likely decrease even further if moose numbers continue to decline. As above, the MAC recommends closing the season based on the level of hunter success for the entire NE moose zone. Based on professional judgment we set the critical threshold at 30%. Potential moose hunters should be polled to further refine this threshold.

It is difficult to project how soon this threshold could result in a state-wide closed season. If the success rate of moose hunters continues to decline at the current rate, it is likely that hunter success would drop below 30% in approximately seven years. However, closure of individual hunting zones (as recommended above) could stabilize the overall success rate and extend hunting for several more years.

The aerial survey may be the only source of biological information on the moose population if the hunting season is closed. Information from this survey should be used for reestablishment of the hunting season if moose numbers begin to increase.

Recommendation: Conduct a survey among potential moose hunters to determine success thresholds to close moose hunting in individual hunting zones or stop hunting moose in northeastern Minnesota.

As indicated in the previous two recommendations, we have indentified useful thresholds to stop moose hunting. These thresholds are based on our perceptions of minimum hunter satisfaction. However, before invoking these levels, potential moose hunters should be queried (perhaps as part of the application process for moose permits) as to what level of hunter success would be acceptable.

Deer Management

Overview

White-tailed deer occur across all of Minnesota's moose range and may carry parasites and possibly diseases that can adversely impact moose. Due to concern for the moose population in Minnesota, the DNR seeks to maintain relatively low deer densities within moose range. Little is known about the extent to which moose succumb to parasites and diseases that are maintained by the presence of deer in the landscape. Ultimate cause of death is often difficult to determine as many environmental factors likely contributed to mortality in individual cases. Although known to be potentially fatal to moose, the *rate* at which moose die from infections of parasites such as brain worm and liver flukes is also unclear.

Historical Deer Management

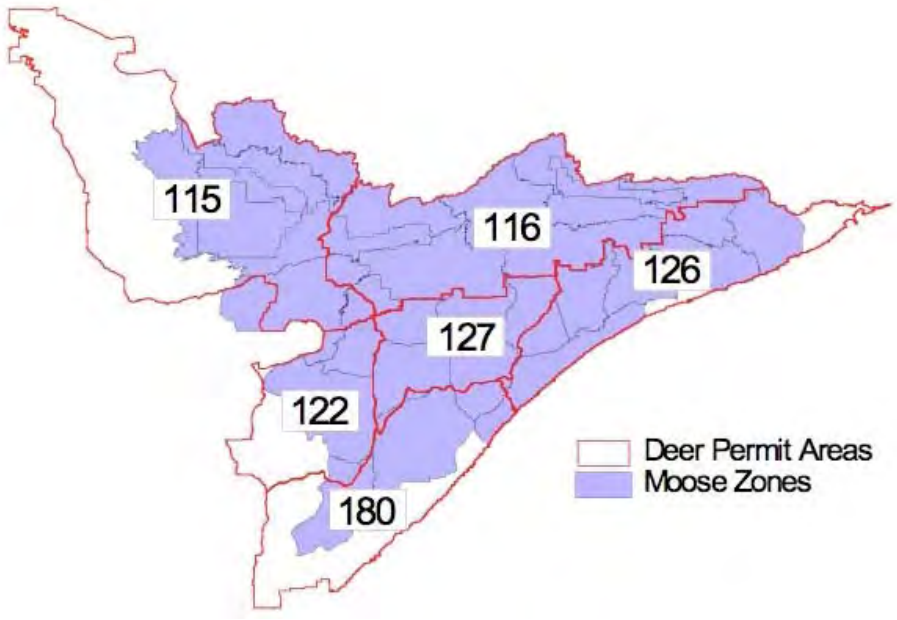
The state of Minnesota started managing deer populations through regulated hunting as early as 1858. Over the past century, deer populations have fluctuated throughout the state in response to changing habitat, varying winter severity, and harvest. These factors, especially the latter two, forced hunting season closures during the early 1940s and 1951. A statewide deer population crash occurred in the late 1960s, which prompted the final statewide season closure in 1971.

Historically, Minnesota allowed the harvest of one either-sex deer statewide, which may also have contributed to some of the 'boom and bust' that was observed in deer populations. After the 1971 season closure, a new system of management was developed that allowed for annual hunting seasons and growth of the deer population. To do this, hunters were allowed to harvest one buck per year and a finite number of antlerless permits were issued by deer permit area. These permits functionally turned a hunter's buck license into an either-sex license. There are currently six deer permit areas within the NE moose range (Fig. 9).

While the hunting zones, season lengths, and opening dates have changed slightly over the years, today's seasonal framework generally reflects the system developed in the 1970s. A hunter who purchases a firearm license can take a buck or an antlerless deer by permit. The antlerless permit quota depends on hunter success rates and current deer population status relative to the population goal. Demand for antlerless permits has typically exceeded supply in most deer permit areas. Therefore, a lottery preference system has been utilized since the early 1980s so antlerless permits could be equitably distributed among hunters through time. Beginning in the 1990s, DNR allowed for the issuance of additional over-the-counter antlerless-only permits to help reduce deer populations in permit areas that exceeded established goals. These permits were area-specific and limited in number. Beginning in 2003, a generic antlerless permit was created (bonus permit) and statewide deer management was changed so that deer permit areas were designed as either:

1. Lottery – bag limit of one, finite number of either-sex permits (historical method)
2. Managed – bag limit of 2 deer, no lottery, one buck limit, 1 bonus permit
3. Intensive – bag limit of 5, no lottery, one buck limit, 4 bonus permits

Figure 9. Distribution of deer permit areas and moose hunting zones in NE Minnesota.



Beginning in 2007, a new season was created called *early antlerless*, which allowed for a 2-day mid-October season and the harvest of 2 additional deer. Deer permit areas are evaluated annually as a function of status relative to goal and the area is then placed in the appropriate management category.

Minnesota's deer program has been a success based on hunter numbers, deer harvests, and population trends. For the last 30 years the current framework has brought stability to deer population management in Minnesota relative to previous decades where liberal seasons were often followed by season closures. Population management through season structure and regulation that began in the mid-1970s gradually increased the proportion of adult females in Minnesota's deer population. This, along with winter weather patterns, has been the most significant factor in growing and stabilizing Minnesota's forest deer populations.

Deer Population Goal Setting

***Recommendation: MAC prefers to err on the side of affording maximum benefit to moose, and so feels deer management should be part of a comprehensive moose management strategy. Deer densities should be managed at population levels that do not prevent growth and sustainability of the moose population. Our best estimate of this level is a fall pre-hunt density of <10 deer/mi^2. Possible tools to consider include*:**

- deer permit areas within the moose range should be 'managed' as the default deer management strategy. This designation would provide for either-sex deer harvest without making a lottery application.
- Realign deer units to correspond to moose range to facilitate managing for lower deer population goals in the moose range.

Beginning in 2005, DNR Wildlife established a public process for setting statewide deer population goals. Stakeholder teams were established who made recommendations on deer population direction. Recommendations were then taken to public input via a web-based presentation and survey. Team and public information was consolidated and provided to area wildlife staff for their review. Final recommendations were subsequently approved by Fish and Wildlife Section Management.

Northeast Minnesota

Deer population goals were established in 2005 for all deer permit areas in the NE moose range (Table 3). Overall, both the stakeholder teams and the public believed deer populations were high and should be reduced, in part because of a common belief that high deer density had negative impacts on moose. The recommendations by deer permit areas are presented in the table below.

Table 3. Year 2005 deer population goals for permit areas in northeast Minnesota.

Permit area	2005 pre-fawn deer/mi^2	2009 pre-fawn deer/mi^2	Goal recommendation	Pre-fawn population goal
115	10	8	Decrease 25%	8
116	1	1	Slight decrease	1
122	17	15	Decrease 25%	12
126	6	5	Decrease 25%	4
127	2	1	Decrease 25%	1
180	16	16	Decrease 25%	12

Current Population Status

Northeast Minnesota

Deer harvest and populations have fluctuated dramatically throughout the NE moose range. However, after the severe winters in the mid-1990s, deer harvest has increased steadily. Total deer harvest throughout the moose range peaked in 2007 (10,838); however, it is important to note that buck harvest actually peaked in 2003 (6,196). With the changes to antlerless permitting, a proportion of the buck harvest was replaced with antlerless deer harvest, which peaked in 2007 (4,979; Fig. 10). This shift in harvest has likely contributed to stabilization or reduction of total deer populations in that pre-fawn populations are estimated to have peaked in 2003 and, while still near historic highs, have generally decreased through 2008. The exception is deer permit area 180, which peaked in 2007 (see Figs. 9 and 11).

Figure 10. Registered deer harvest for deer permit areas in the moose range, 1997 – 2008.

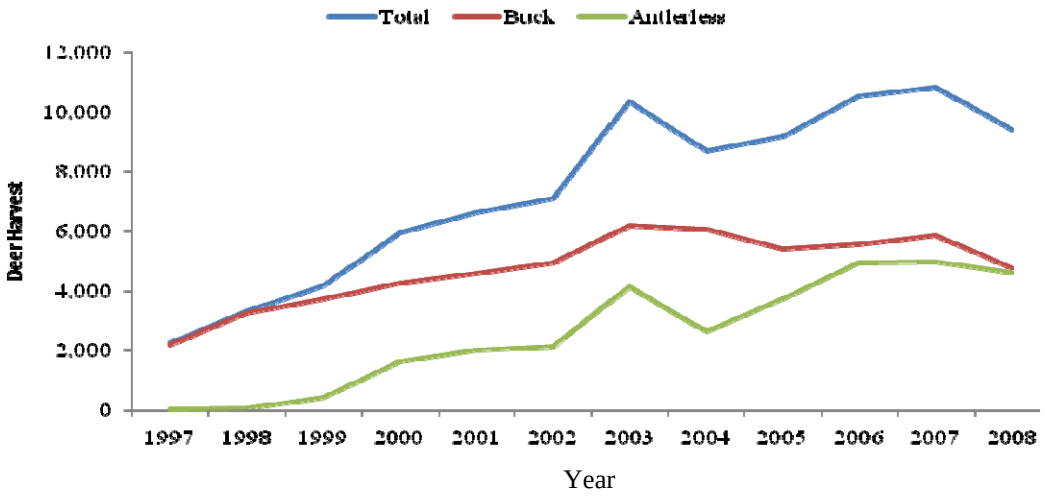
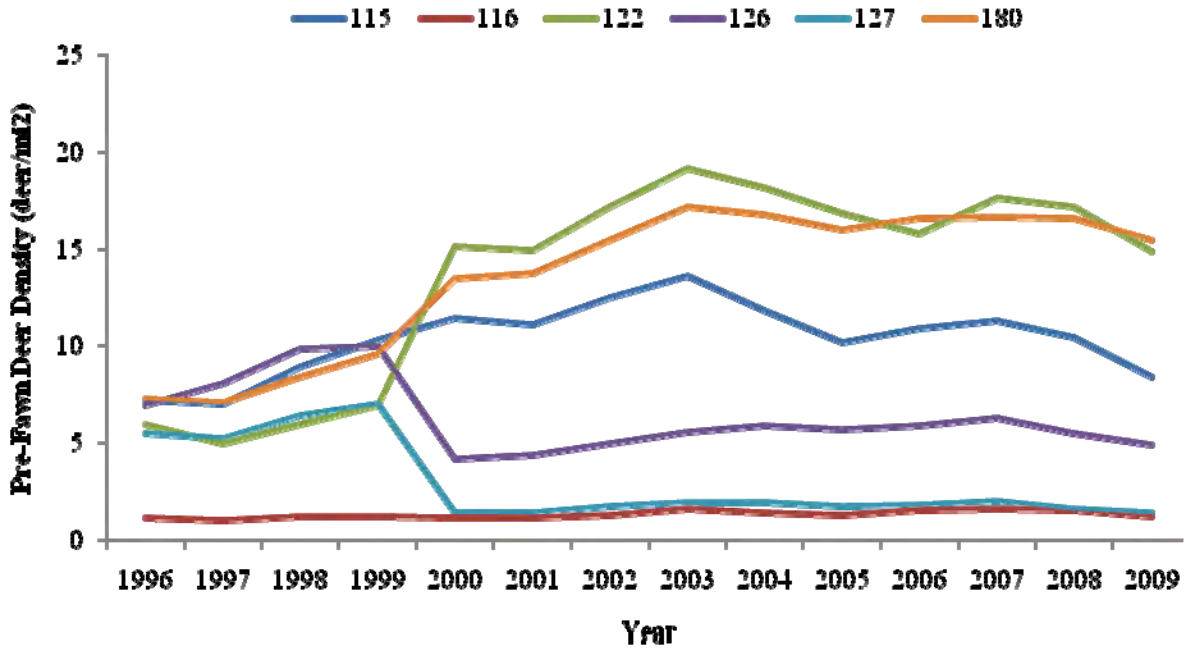


Figure 11. Estimated pre-fawn deer population density, 1996 – 2009.



In adjacent areas of NW Ontario, two indices of deer population density (hunter-reported observations and deer recorded incidentally during moose aerial census flights) have likewise increased during the past decade. From this information we conclude that deer population density in the moose range has probably increased steadily in the past decade, a period when most winters were relatively short and of low severity for deer. That increase has been tempered by more aggressive antlerless deer management strategies consistent with the desire to lower total deer populations. Due to aggressive harvest management and increased winter severity in 2007-08 and 2008-09 the deer population is likely in decline at this time.

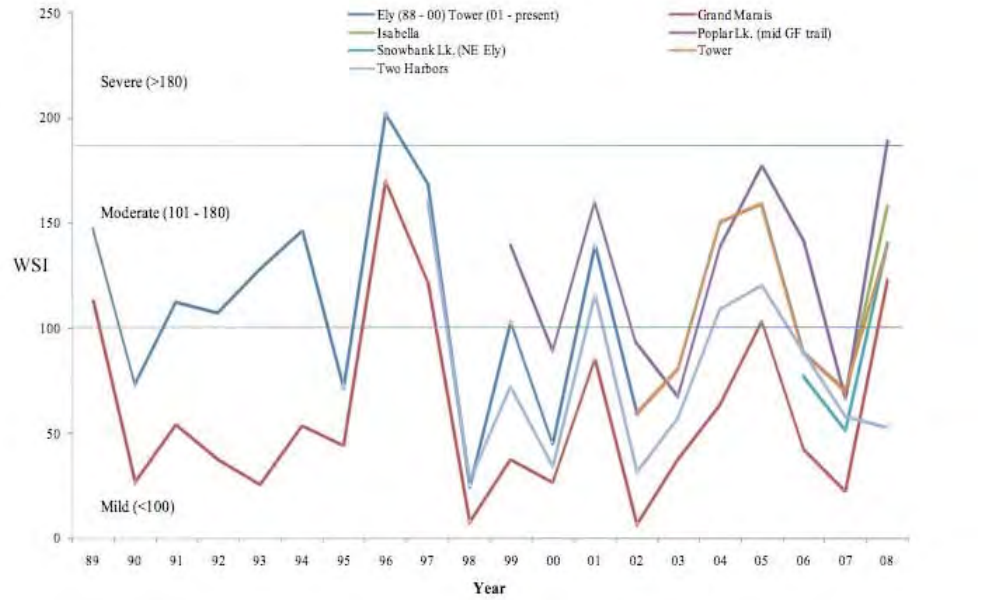
Winter Severity

Northeastern Minnesota is characterized as a heavily forested, rolling terrain with sporadic severe winters. As winter weather does affect deer survival, the DNR has been measuring winter severity since 1968. The winter severity index (WSI), is an index to estimate weather-related impacts. The WSI is calculated by adding the number of days temperatures were below 0^{o}F and the number of days that snow depth exceeds 15". For example, a day would get an index of 2 if the temperature was -5^{o}F and there was 20" of snow on the ground. Index values vary greatly across the moose range but winters have generally been considered mild to moderate since the severe winters of 95/96 and 96/97 (Fig. 12). Roughly, WSI values can be interpreted as such,

- < 100 - mild
- 101 – 180 - moderate
- > 180 – severe

An established deer feeding protocol also states that DNR may consider supplemental feeding of deer if the WSI is estimated to reach 100 by mid-February.

Figure 12. Recorded winter severity index values (WSI) for stations in the moose range, 1989 – 2008 (MN DNR).



Deer Feeding

Recommendation: To assist in keeping deer numbers low, a ban on recreational deer feeding within the established moose range should be established.

A portion of the public believes that deer should be provided with supplemental feed when winter is severe and mortality may occur. Beyond the discussion as to the merits of feeding deer in severe winters, there are the scores of individuals who feed deer simply to increase their probability of over-winter viewing. Given that, recreational deer feeding is a controversial issue throughout many states, despite the fact that more negative than positive attributes have been described. For example, deer can be classically conditioned to visit feeders through a learning process (Henke 1997), thus congregating them around a food source. This congregation around artificial feeding locations creates a host of problems including the increased risk of spreading disease (e.g., bovine tuberculosis, chronic wasting disease), destruction of native vegetation, and disruption of natural migratory patterns. Previous studies have shown that supplemental feeding may increase overwinter deer survival (Lewis and Rongstad 1998) or population productivity (Ozoga and Verme 1982). In Minnesota, the emergency deer feeding issue arises whenever winters are severe and was most recently addressed during the winters of 1995-96 and 1996-97. Following the 95-96 winter, a deer feeding task force was assembled to make future recommendations regarding emergency deer feeding (Minnesota DNR 1997). Functionally, the policy states the Department will only feed deer when the winter severity index is predicted to be in the severe range and the deer population will likely be reduced below management targets. Additionally, a request to feed deer must come from an organization and *not* individuals who are interested in feeding deer. Within the same document, there is a review on artificial feeding as a deer management strategy.

The only addition to the 1997 document is the new knowledge of the etiology of disease transmission over common food sources. In Michigan, bovine tuberculosis is sustained in the wild deer population (Clifton-Hadley and Wilesmith 1991) and extensive surveillance and eradication strategies have been employed since 1994 (O'Brien et al. 2001). The discovery of chronic wasting disease in Wisconsin prompted that agency to enact rules that banned feeding and baiting in the CWD zone (Bartelt et al., 2003). In northwestern Minnesota, bovine tuberculosis was discovered in 2005 and extensive work (including a recreational deer feeding ban) has been conducted to eradicate the disease from the deer population. The most recent data indicates a very low prevalence rate in wild deer as only 24 positive deer have been identified from almost 5,500 samples.[1]

The current issue surrounding deer feeding should not be confused with the practice of deer baiting, which is defined as placing food with the intent of harvesting a deer. Deer baiting has been illegal in Minnesota since 1991 and there has been an increased emphasis from DNR Enforcement to address compliance.

It is known that supplemental feeding can improve survival and productivity of wildlife including deer (e.g., Bishop et al. 2009). Research in NE Minnesota has shown some deer herds migrate many miles from summer to winter range. Often these winter ranges are near developed

[1] http://files.dnr.state.mn.us/outdoor_activities/hunting/deer/bovine-tb/09tb-brochure.pdf

areas where supplemental food sources are available. These supplemental food sources serve to improve deer survival and productivity. The summer ranges are remote (such as the BWCAW) and hunting pressure light or nonexistent. Supplemental feeding can serve to offset the impacts of winter severity on deer populations and further increase deer numbers especially in less severe winters. Moose and deer range in NE Minnesota is characterized by large blocks of dense forest often with limited or difficult access. Controlling deer numbers through hunter harvest as a means to benefit moose will be increasingly difficult if, as predicted by many sources, severe winters occur less and less often. Intervals between severe winters may see higher deer numbers due to supplemental feeding with possible negative impacts on moose.

Deer Impacts on Moose

History

Many moose biologists and members of the general public believe there is a connection between deer, moose and meningeal worm (brainworm, *Parelaphostrongylus tenuis*). Brainworm can be fatal in moose and animals exhibiting clinical signs of infection have been reported in Minnesota as far back as 1912 (Fenstermacher and Olson 1942). However; it was not until the early 1960s that the relationship was verified (Anderson, 1964). Moose in Minnesota continue to suffer mortality from brainworm (Murray et al. 2006, Lankester et al. 2007, M. Schrage unpubl. data).

The brainworm cycle

The brainworm parasite normally occurs in white-tailed deer in eastern North America. The parasite is generally considered absent west of the 100th meridian (central Montana to central Texas). The adult worms reside in the cranium of the host deer and lay eggs into the blood stream. The eggs eventually lodge in the lungs where first stage larvae develop. The larvae are coughed up and then swallowed and eventually are passed back out on the surfaces of the deer's feces. Lankester and Samuel (1998) believed larvae could survive for several months on feces and in the surrounding soil due to their resistance to drying and freezing. Eventually, one of several species of snails or slugs (gastropods) encounters the larvae. The larvae penetrate the gastropod and develop through additional stages. The parasite is passed to deer (or moose) when the gastropod is consumed during foraging. The larvae penetrate the stomach wall, enter the nervous system and complete their development into adults (Lankester and Samuel 1998). Although many infected deer shed no larvae because they are infected with only a single sex of brainworm, adult worms are long-lived and may pass eggs for many years (Somke et al. 1995). Deer appear to suffer few ill effects; however; symptoms of brainworm infection in moose may include circling, weakness in the hindquarters or inability to stand as well as turning of the neck and head to one side, lethargy, apparent blindness, loss of fear and rapid eye movement (Lankester and Samuel 1998).

Connections between deer and moose

It is well documented in Minnesota and other jurisdictions where deer and moose range overlap across eastern North America that moose are subject to brainworm-related mortality (Telfer 1967, Gilbert 1974, Upshall 1987, Lankester et al. 2007). What is less clear in the literature and subject to debate among moose biologists is the degree to which deer are responsible for historic declines in moose. Although many authors present evidence indicating a correlation between increasing deer and decreasing moose numbers (Telfer 1967, Gilbert 1974, Whitlaw and

Lankester 1994a, 1994b) other authors argue the evidence is inconclusive and find no basis to conclude changes in deer numbers can significantly impact moose numbers via transmission of brainworm (Nudds, 1990, Bogaczyk et al. 1993, Lenarz et al. 2009).

Much of the published literature attempts to connect changes in deer density with changes in moose population size. Deer density estimates in the papers reviewed were often modeled estimates based on hunter harvest. In others, the information was anecdotal based on impressions and experience of employees of natural resource agencies (Whitlaw and Lankester 1994a, 1994b). There appeared to be no direct estimates of deer numbers in the literature reviewed and moose numbers were either directly surveyed through aerial surveys or trends were estimated through changes in hunter harvest (Whitlaw and Lankester 1994a, 1994b).

There were only 2 published papers reviewed that demonstrated a percentage of total moose herd mortality related to brainworm. Murray et al. (2006) could only find evidence for brainworm in 6% of cases of non-human related mortality in northwest Minnesota, which has post-season deer densities <12mi^2. However, Aho and Hendrickson (1989) in Michigan found brainworm to be the leading cause of mortality in moose accounting for 38% of all deaths. At the time deer were estimated at 13 deer/mi^2.

Schrage (unpubl. data) found 72% of 25 cases of moose acting abnormally in northeast Minnesota between 2002 and 2008 showed evidence of brainworm infection. In the same area, Lankester et al. (2007) found 61% of 36 reported cases of moose acting abnormally between 1986 and 2000 showed evidence of brainworm. It should not be assumed these were random samples as brainworm may take longer to kill a moose than other diseases or parasites and infected animals may seek open areas thus making them more likely to be found (M. Schrage, pers. obs. and E. Butler, pers. comm.). Lenarz et al. (unpubl. data) found 18 of 108 captured moose in their northeastern Minnesota study tested positive for brainworm exposure. Some of these moose lived for years after exposure had been documented and successfully produced calves. However, the number of moose that were exposed to brainworm after capture and handling is not known, nor is it known whether or not animals exposed prior to capture were re-exposed (perhaps at lethal levels) at a later date. Murray et al. (2006) found 30% of 56 cases of moose carcasses reported by the public to be suffering from brainworm in northwest Minnesota, but also cautioned against assuming this represented the true level of brainworm-related mortality in the moose herd.

How low should deer densities be?

After reviewing patterns of moose and deer abundance, Whitlaw and Lankester (1994a and 1994b) recommended fall deer density not exceed 10-13 deer/mi^2 in areas where managers wanted to favor moose. In northeast Minnesota, Karns (1967) recommended keeping deer densities below 12 deer/mi^2 in order to benefit moose. As stated in preceding paragraphs, the deer density recommendations made by these authors are not universally agreed upon. We recommend a general strategy to manage deer at fall pre-hunt densities <10 deer/mi^2 within moose range in NE Minnesota. This estimate is conservative and is intended to err on the side of protecting moose. It is based on a review of moose and deer population data from Ontario, Minnesota and other North American jurisdictions in Whitlaw and Lankester (1994a and 1994b).

Complicating factors

The presence of gastropods is required for the intermediate larval stages to develop and for the parasite to be passed on to deer and moose (Lankester and Anderson, 1968). In the absence of gastropod hosts brainworm larvae cannot be passed to moose. Schmitz and Nudds (1994) found that models describing the effects of brainworm on moose were most sensitive to changes in the rate of increase of gastropod hosts. Bogaczyk et al. (1993) suggested gastropod activity and populations in their study in Maine might have fluctuated with cooler temperatures, lower precipitation and late spring frosts. McCoy and Nudds (1997) determined that differing habits between gastropod species might render them more or less vulnerable to brainworm infection and ingestion by deer or moose. Aho and Hendrickson (1989) felt data from other studies of moose, deer and brainworm were not necessarily directly applicable in Michigan because of possible differences in weather, soils, vegetation and density and species of gastropod hosts for brainworm. Slomke et al. (1995) urged better understanding of factors influencing survival of larvae, prevalence and intensity of infection in gastropods and how they may change transmission rates to deer and moose.

In addition to variation in gastropod populations, deer fawns pass more larvae than do adults and all deer pass more larvae in spring. Adult deer exhibited consistent infection rates (Peterson and Lankester 1991, Slomke et al 1995). Therefore transmission to moose may increase if deer populations contain a higher percentage of fawns or if deer overlap moose range in the spring. Whitlaw and Lankester (1994b) felt that mean intensity of brainworm in deer feces might be a better indicator of risk to moose populations than simple deer density.

Liver flukes

As well as brainworm, deer also serve as primary hosts of the liver fluke parasite (*Fascioloides magna*). Liver flukes are not believed to have the same significance for moose as brainworm (Lankester and Samuel 1998); however; Murray et al. 2006 attributed 31% of radio-collared moose mortality in northwest Minnesota to liver fluke. Schrage (unpubl. data) found 4% of moose reported acting sick by the public were infected with liver flukes in northeast Minnesota. Published literature has little to suggest a negative relationship between deer, moose and liver flukes, however; where multiple compounding factors add stress and may ultimately lead to a moose's death, its importance should not be discounted.

Conclusions – Parasites and Diseases

Recommendation: Better research and monitoring into causes of moose mortality, changes in deer densities, gastropod populations and the prevalence of brainworm on the landscape is needed. Without better information, it will be uncertain how reducing deer numbers will impact moose.

The relationship between moose, deer and brainworm is more complex than is often believed and requires additional study (Whitlaw and Lankester 1994b, Lankester and Samuel 1998, this review). Consistent and conclusive evidence on the percentage of moose dying from brainworm in Minnesota or other jurisdictions is lacking. Therefore, the conclusions of this committee are that it is unclear to what extent reducing deer numbers will improve moose numbers. Although likely positive to some degree, it may not substantially improve moose survival in Minnesota. Murray et al. (2006), Lenarz (2009a) and E. Butler (unpubl. data) indicate moose in Minnesota likely face a host of health issues, and reducing deer numbers in the absence of a more comprehensive moose management strategy may not lead to significant and sustained recovery of moose numbers.

Habitat

Overview

In MN, moose habitat can be characterized as young forest stands, older forest stands with gaps of regenerating forest, wetlands, muskeg, marsh, riparian areas and brushlands with abundant deciduous browse within reach of moose and adequate winter and summer thermal cover. Functionally, habitat provides forage and cover. Moose forage has a primarily deciduous browse component and a seasonal aquatic component. Cover has several potential components for moose: protection from heat, protection from deep snow, moderation of cold temperatures, predator avoidance and presence of calving locations. In addition to the functional aspects of habitat, spatial distribution of habitat must also be considered at a variety of scales (from sub-home range to the landscape level).

As moose are increasingly challenged by warmer temperatures and changing precipitation patterns due to climate change, changes in land ownership and changes in forest management practices that occur within MN moose range have the potential to significantly affect the quantity, quality, and distribution of moose habitat. Examples include but are not limited to: habitat fragmentation due to expected and occurring ownership changes and shifting landowner objectives, changes in the extent of forest management due to national and state economic effects on the primary wood- using industry in Minnesota, and increased harvesting of smaller diameter trees and brush used by moose for browse as the demand for woody biomass increases. Focused management to provide high quality habitat (forage and cover) may be necessary to slow population declines and maintain or recover moose in appreciable numbers in Minnesota.

There is no recent historic evidence to suggest that habitat alone has limited moose numbers across their full range in Minnesota. However, habitat quality, including the spatial arrangement of cover types can limit moose numbers within smaller geographic areas. Improving habitat for moose may assist managers in maintaining or recovering moose numbers. We recognize important differences between the plant communities and moose habitat requirements of NW and NE MN. NW moose habitat is a mixture of public and private lands that are dominated by brushlands interspersed with mesic hardwood forests, aspen parkland, peatlands, agriculture, and prairie. NE moose habitat can be described as near-boreal forest dominated by large blocks of public land. Recommendations to improve moose habitat are for the most part the same but in some cases they may not be applicable across the state.

The following recommendations, including the proposed best management practices we've outlined, are meant specifically for the primary moose range of Minnesota which can be roughly defined as those areas where moose are or were monitored through aerial surveys. (Figs. 13 and 14).

Figure 13. Northeast moose survey area and sample plots (shaded) flown in the 2008 aerial moose survey.

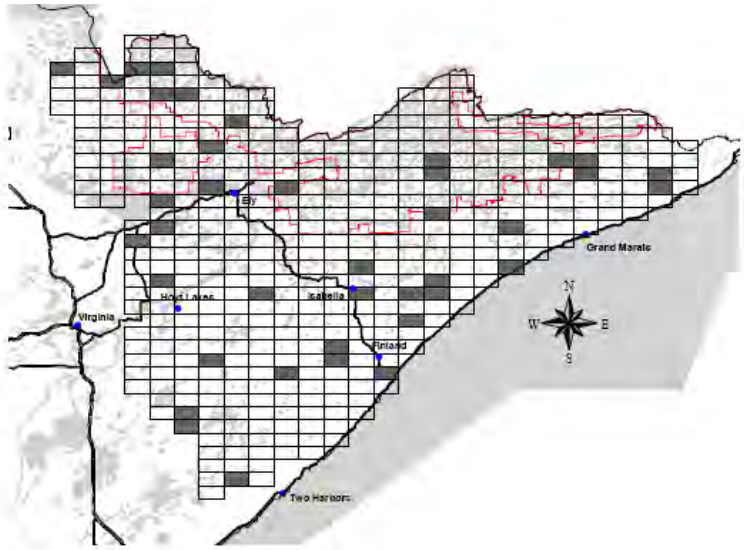
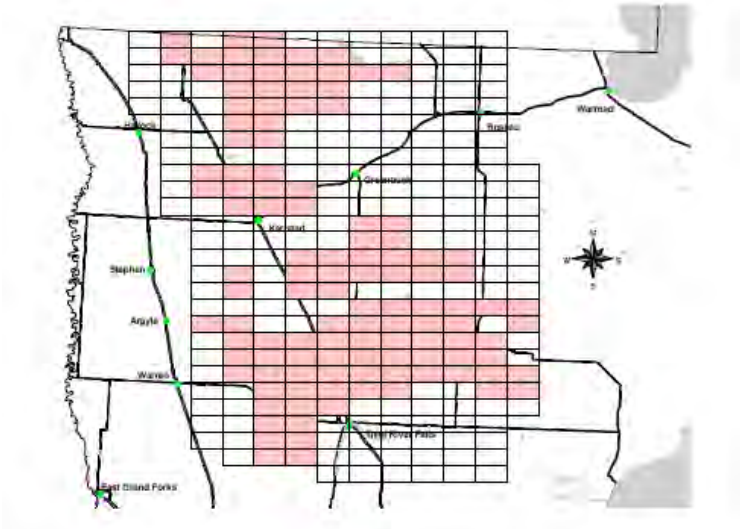


Figure 14. Northwest moose survey area 2007. Stratification was revised in 2006 to identify plots that might contain moose (shaded blocks).



Minnesota Habitat Management Recommendations (both NE and NW)

- Due to mixed ownership patterns and variable land management responsibilities, MN DNR should work with other land management agencies in the development and implementation of the moose plan.

- Review and evaluate the Ontario moose habitat guidelines currently under development for application in Minnesota.

- Develop best management practices for developing and maintaining quality moose habitat for voluntary use by all forest land managers.

- Conduct a landscape level analysis of moose habitat. Where moose habitat is poor, consider forest management practices that may address components of moose habitat that are identified as needed during planning and operations. Specifically, the following should be considered when moose habitat development is desired:

    - Increase stand complexity, promote shrub production and diversity and maintain thermal cover components by the use of variable thinning, use intermediate and partial harvests as a means to mimic varied disturbance patterns such as stand decline due to age, fire, wind-throw and insect and disease outbreaks.
    - Promote regeneration techniques that encourage mixed stands similar in composition, age and size to those existing under the range of natural variation and discourage the establishment of stands uniformly dominated by a single species.
    - Utilize forest management/habitat management techniques that will promote browse production and diversity while maintaining juxtaposition of winter and summer thermal cover and aquatic feeding areas.
    - In order to protect desirable browse species as much as possible while reducing competition with conifer seedlings, the use of mechanical treatment, spot chemical treatment or hand release should be encouraged.
    - Promote a more regular use of wild and prescribed fire where appropriate to treat fuel loads and/or prepare forest stands for regeneration. Fire improves the quantity and quality of moose browse and may serve to remove or reduce populations of winter ticks and gastropods, which are direct parasites or parasite vectors for moose.
    - Upland brush communities should be identified, protected and maintained by mechanical treatment and or prescribed fire to provide moose browse.
    - Protect and enhance summer thermal cover adjacent to and in close proximity to aquatic feeding areas.
    - Increase rotation age of aspen stands to increase understory browse component while retaining summer thermal cover

Specifically, in NE moose range:

- Utilizing existing plant community information and moose population and harvest data, identify key moose management areas within the primary moose range of NE MN where the goal should be to develop and maintain quality moose habitat.

- The diet sought by moose, rich in forage species diversity (Miquelle and Jordan 1979), can be best provided by a diversity of forest management practices that result in mixed species composition. Moose favor a mixture of many deciduous forage species (red maple *Acer rubrum*, mountain maple *Acer spicatum*, white birch *Betula papyrifera*, dogwood *Cornus* spp., trembling aspen *Populus tremuloides*, cherry *Prunus* spp., willow *Salix* spp., mountain ash *Sorbus decora*, and highbush cranberry *Viburnum* spp.) and, in winter, balsam fir *Abies balsamea*. These plant species are commonly found in northern mixed (boreal-hardwood) forests, and should be encouraged where native plant community classifications identify it as a suitable type.

Specifically, in NW moose range:

- Aspen parkland should be maintained through the use of prescribed fire, commercial timber harvest or mechanical treatment to maintain it as early successional habitat.

- Manage for patches of mature aspen dispersed across the agricultural landscape to provide for summer thermal cover.

Summary of Habitat Issues

There is no evidence to suggest habitat alone has recently limited moose numbers across their full range in Minnesota. Recent research in NE and NW MN indicated moose are increasingly challenged by warmer temperatures and a complex of health-related issues. While it is unlikely that habitat management alone can maintain or recover moose numbers, we believe it must be an integral part of future moose management programs if, at minimum, current moose populations are to be maintained in MN. Wildlife managers will need to address a suite of issues in order to keep moose on the landscape in large numbers, and management for high quality habitat may help compensate for other challenges facing the moose herd. These recommendations should be continually evaluated and revised in light of changing habitat and climatic conditions and as further research improves our understanding of moose habitat requirements.

Funding

The "value" of moose in Minnesota transcends hunting opportunity. Moose are viewed on the landscape as an iconic symbol of the Northern forest, and future management and research will depend upon adequate funding. Non-hunting Minnesotans have contributed minimal financial support for the management of moose. Nearly all wildlife-related activities (e.g., research, management, habitat acquisition) have been funded by hunters through the sales of licenses. Sales of hunting licenses are deposited in the game and fish fund and then allocated at a fixed level by the Minnesota Legislature. Those revenues fluctuate annually with increases and decreases in license sales. There is currently no dedicated moose funding source and all moose-related activities compete for finite dollars with other activities conducted by the DNR Wildlife Section.

MAC has recommended that management, research, and monitoring continue, and it recognized that DNR staff, aircraft, and other costs related to fieldwork and administration are all required. To be effective in addressing MAC recommendations, the DNR must have adequate resources. The recommendations made in this report will very likely require an increase in research and expansion of management efforts for moose. Additional funding will be needed from non-traditional sources. The MAC recommends that the non-hunting public should contribute in some manner to the maintenance of moose populations. Funding at the scale required must be acquired from multiple sources, including DNR funds, other state funds, and federal funds through cooperative research projects.

The DNR has established partnerships that have been involved in monitoring and research on moose in the past decade. The VHF study of moose in the NE was supported by over $400k in funds from the Tribal Wildlife Grant (TWG) program, and research to begin in Voyageurs National Park and on the Grand Portage Indian Reservation will entail an additional $500k in external funds (TWG and US Geological Survey/National Park Service) beginning in 2010. Additional research support might be available from other federal sources, LCCMR, and/or re-prioritization of existing Game and Fish funds (although MAC recognizes re-prioritization comes at a cost to other programs). With passage of a dedicated sales tax in 2008, the Lessard-Sams Outdoor Heritage Council may provide a mechanism by which habitat required by moose can be acquired or maintained with a broader funding base than hunting license fees. Forming partnerships with interested stakeholder groups may provide the necessary political support for continued prioritization of moose management efforts in Minnesota. The DNR should continue and expand monitoring and research partnerships with academics, USDA Forest Service and other federal agencies, non-government organizations, and tribal governments.

Designation as State-Listed Species

Minnesota state law (Minnesota Statutes, 2007: Section 84.0895 Protection of Threatened and Endangered Species) provides for additional protection or monitoring for species designated as Endangered, Threatened, or Species of Special Concern. There was unanimous agreement among MAC members that it is inappropriate at this time to designate the moose as either Threatened or Endangered in Minnesota. With the NE population numbering around 7,000 and forested moose habitat secure at least in the short-term, we feel the moose is neither in immediate danger of extinction nor threatened with extinction state-wide. Furthermore, a designation of "threatened" is incompatible with harvest of moose, which the MAC considers appropriate at this time. We believe that the current need for moose managers to deal differently with moose in the NE and NW is not well-served by a state-wide designation as either *Endangered* or *Threatened*.

There was considerable discussion within the MAC about whether or not a designation of Species of Special Concern (SSC) was appropriate at this time. This designation is provided for species that are on the periphery of their range or that require unique or highly specific habitats, and thus need careful monitoring of status. Moose in Minnesota are obviously on the periphery of their range, but that has been the case ever since moose recovered in the middle of the 20th century from early overharvest. Moose are considered habitat generalists, without unique or highly specific habitat requirements, but in the context of climate change it is not known with certainty what habitats are critical for moose survival.

While we were not able to come to consensus support for a Yes/No decision, in the final tally a slight majority of members supported designation of the moose as a SSC at this time (9 Yes: 8 No: 1 abstain). We recognize there are important consequences associated with SSC designation, but committee members were largely guided individually by their understanding of moose status on a state-wide basis, without trying to resolve all the legal issues associated with the language of the law.

Clearly there are reasons both for and against SSC designation, for example:

Reasons *for* listing moose as a SSC

- Moose are clearly intolerant of heat extremes and the southern edge of their distribution in North America is considered to be limited by prevailing temperature. The moose is on the periphery of its range in Minnesota and the extent of suitable range in the state has contracted because of climate change.
- On a *statewide* basis moose numbers have declined by over 30% since the mid-1980s even with closed seasons or conservative harvests.
- Annual mortality of moose in NE Minnesota is currently comparable to that documented in NW Minnesota during the chronic population decline there, and is correlated with mid-winter temperature.
- There have been long-term declines in calf recruitment and hunter harvest, consistent with anecdotal reports from the public that moose have declined in their NE range.

Reasons *against* listing moose as a SSC

- There are still approximately 7,000 moose in Minnesota, and aerial surveys do not suggest a chronic population decline in the NE.
- While measured mortality rates since 2001 suggest ongoing population decline, these data come primarily from the southern portion of the moose range in the NE and so might not apply throughout the NE.
- Moose have existed on the periphery of their range throughout history.
- Listing of moose as a SSC is not necessary at this time as the species is already being monitored carefully.

The MAC is concerned about the length of time necessary for designation as a SSC. Even if the moose is not designated as a SSC at this time, it is possible that evidence of chronic population decline might be forthcoming in the near future and listing as a SSC would be desirable. There is increased potential for transmission of new diseases among wildlife populations and species, and we believe the DNR needs a capability to review and change species status, at least on a provisional basis, without a review that extends for years. The federal government, through the Endangered Species Act, has a procedure for emergency listing of a species as either Threatened or Endangered. We urge the DNR to take steps to eliminate undue delays in listing a species, recognizing that action by the legislature might be necessary.

Literature Cited

Aho, R.W., J. Hendrickson. 1989. Reproduction and mortality of moose translocated from Ontario to Michigan. *Alces*, 25: 75-80.

Anderson, R.C. 1964. Neurologic disease in moose infected experimentally with *Pneumostongylus tenuis* from white-tailed deer. *Pathologica Veterinaria.* 1:289-322.

Bartelt, G., Pardee, J., and K. Thiede (eds.). 2003. Environmental impact statement of rules to eradicate chronic wasting disease in Wisconsin's free-ranging white-tailed deer herd. Wisconsin Department of Natural Resources, PUB-SS-980, Madison, USA.

Bishop, C.J., G.C. White, D. J. Freddy, B.E. Watkins, and T.R. Stephenson. 2009. Effect of enhanced nutrition on mule deer population rate of change. *Wildlife Monographs* 172:1-28.

Bogaczyk et al. 1993. Factors affecting *Parelaphostrongylus tenuis* in white-tailed deer (*Odocoileus virginianus*) from Maine. Journal of Wildlife Diseases, 29(2): 266-272.

Bubenik, A. B. 1987. Behaviour of moose (Alces alces) in North America. *Swedish Wildlife Research (Supplement)* 1: 333-366.

Clifton-Hadley, R. S., and J. W. Wilesmith. 1991. Tuberculosis in deer: a review. *Veterinary Record*, 129: 5 -12.

Crête, M., R. J. Taylor, and P. A. Jordan. 1981. Optimization of moose harvest in southwestern Quebec. *Journal of Wildlife Management*. 45:598-611

Fenstermacher, R, and O. W. Olson. 1942. Further studies of diseases affecting moose III. *Cornell Veterinarian*. 32:241-254.

Galatowitsch, S., L. Frelich, and L. Phillips-Mao. 2009. Regional climate change adaptation strategies for biodiversity conservation in a midcontinental region of North America. *Biological Conservation* (in press), doi: 10.1016/jbiocon.2009.03.030.

Henke, S. E. 1997. Do white-tailed deer react to the dinner bell? An experiment in classical conditioning. *Wildlife Society Bulletin*, 25(2): 291-295.

Karns,P.D. 1967. *Pneumostrongylus tenuis* in deer in Minnesota and implications for moose. The *Journal of Wildlife Management*, 31(2): 299-303.

Karns,P.D., 1972. Minnesota's 1971 moose hunt: a preliminary report on the biological collections. *Proc. N. Am. Moose Conf. Work*. 8:115-123

Karns, P.D. 1997. Population distribution, density and trends. Pages 125-139 *in* A.W. Franzmann and C.C. Schwartz (eds.), *Ecology and management of the North American moose*. Wildlife Management Institute, Washington, D.C., 733pp.

Lankester, M. W. and R. C. Anderson. 1968. Gastropods as intermediate host of meningeal worm, *Pneumostongylus tenuis*, Dougherty. *Canadian Journal of Zoology* 46:373-383.

Lankester, M and W. M. Samuel. 1998. Pests, parasites and diseases. Pages 479–517 in A. W. Franzmann, and C. C. Schwartz, editors. Ecology and management of the North American moose. Smithsonian Institution, Washington, D.C., USA.

Lankester, M., W. Peterson, O. Ogunremi. 2007. Diagnosing *Parelaphostrongylus* in moose (*Alces alces*). *Alces*, 43: 49-59.

Lenarz, M.S., M.E. Nelson, M.W. Schrage, A.J. Edwards. 2005. Moose population dynamics in northeastern Minnesota. Summary of Wildlife Research Findings. Minnesota Department of Natural Resources Division of Fish and Wildlife, Wildlife Populations and Research Unit.

Lenarz, M. S. 2007. 2007 Aerial moose survey. Minnesota Department of Natural Resources, St. Paul, USA. <http://files.dnr.state.mn.us/outdoor_activities/hunting/moose/moose_survey_2007.pdf>. Accessed 5 May 2009.

Lenarz, M. S. 2009a. A review of the ecology of Parelaphostrongylus tenuis in relation to deer and moose in North America. Pages xx-xx in M. W. DonCarlos, R. O. Kimmel, J. S. Lawrence, and M. S. Lenarz, editors. Summaries of wildlife research findings. Minnesota Department of Natural Resources, St. Paul, USA. In press.

Lenarz, M. S. 2009b. 2009 Aerial moose survey. Minnesota Department of Natural Resources, St. Paul, USA. <http://files.dnr.state.mn.us/outdoor_activities/hunting/moose/moose_survey_2009.pdf>. Accessed 5 May 2009.

Lenarz, M.S., M.E. Nelson, M.W. Schrage, A.J. Edwards. 2009. Temperature mediated moose survival in northeastern Minnesota. *Journal of Wildlife Management*, 73(4):503-510

Lent, P. C. 1974. A review of rutting behavior in moose. *Naturaliste Canadian (Quebec).* 101:307-323.

Lewis, T. L, and O. J. Rongstad. 1998. Effects of supplemental feeding on white-tailed deer migration and survival in northern Wisconsin. *Canadian Field Naturalist*, 112:75-81.

McCoy, K.D., T.D. Nudds. 1997. Interspecific variation in climbing by gastropods: Implications for transmission of *Parelaphostrongylus tenuis*. *American Midland Naturalist*, 137(2): 320-328.

Minnesota Department of Natural Resources. 1997. Emergency deer feeding program evaluation. Preliminary Report. 64 pages.

Miquelle, D.G. and P.A. Jordan. 1979. The importance of diversity in the diet of moose. *Proc. N. Am. Moose Conf. Workshop* 15:54-79.

Murray, D.L., W. Cox, W.B. Ballard, H.A. Whitlaw, M.S. Lenarz, T.W. Custer, T. Barnett, and T.K. Fuller. 2006. Pathogens, nutritional deficiency, and climate influences on a declining moose population. *Wildlife Monographs* 166.

Nudds. 1990. Retroductive logic in retrospect: The ecological effects of meningeal worms. *The Journal of Wildlife Management*, 54(3): 396-402.

O'Brien, D. J., Fitzgerald, S. D., Lyon, T. J., Butler, K. L., Fierke, K. R., Schmitt, S. M., Cooley, T. M., and D. E. Berry. 2001. Tuberculosis lesions in free-ranging white-tailed deer in Michigan. *Journal of Wildlife Diseases*, 37: 608 – 613.

Ozoga, J. J., and L. J. Verme. 1982. Physical and reproductive characteristics of a supplementally fed white-tailed deer herd. *Journal of Wildlife Management*, 46:281-301.

Rausch, R. A., R. J. Sommerville, and R. H. Bishop. 1974. Moose management in Alaska. *Naturaliste Canadian (Quebec).* 101: 705-721.

Schmitz, O.J., T.D. Nudds. 1994. Parasite-mediated competition in deer and moose: How strong is the effect of meningeal worm on moose? *Ecological Applications*, 4: 91-103.

Schwartz, C. C., W. L. Reglin, and A. W. Franzmann. 1982. Male moose successfully breed as yearlings. *Journal of Mammalogy* 63:334-335.

Slomke, A.M., M.W. Lankester, W.J. Peterson. 1995. Infrapopulation dynamics of *Parelaphostrongylus tenuis* in white-tailed deer. *Journal of Wildlife Diseases*, 31(2): 125-135.

Solberg, R. J., A. Loison, T. H. Ringsby, B-E. Sæther, and M. Heim. 2002. Biased adult sex ratio can affect fecundity in primiparous moose Alces alces. *Wildlife Biology*. 8:117-128.

Telfer, E. S. 1967. Comparison of moose and deer winter range in Nova Scotia. *Journal of Wildlife Management* 31:418-425.

Upshall, S.M., M.D. Burt, T.G. Dilworth. 1987. *Parelaphostrongylus tenuis* in New Brunswick: the parasite in white-tailed deer (*Odocoileus virginianus*) and moose (*Alces alces*). *Journal of Wildlife Diseases*, 23(4): 683-685.

Whitlaw, H.A. and M.W. Lankester. 1994a. A retrospective evaluation of moose, white-tailed deer and *Paraelaphostrongylus tenuis* in Ontario. *Canadian Journal of Zoology* 72:1-7.

Whitlaw, H.A. and M.W. Lankester. 1994b. The co-occurrence of moose, white-tailed deer, and *Parelaphostrongylus tenuis* in Ontario. *Canadian Journal of Zoology*, 72(5): 819-825.

Appendix 1. Moose Advisory Committee Summit Presentations – Duluth Minnesota, December 8, 2008

Speaker	Title	Affiliation
Mark Lenarz	Minnesota Moose	Minnesota DNR, Division of Fish and Wildlife, Wildlife Research Unit
Erika Butler	Minnesota Moose Health and Mortalities	Minnesota DNR, Division of Fish and Wildlife, Wildlife Health Program
Art Rodgers	Moose Population Trends in Ontario	Centre for Northern Forest Ecosystem Research, Ontario Ministry of Natural Resources
Vince Crichton	Overview of Moose in Manitoba	Game, Fur, and Problem Wildlife, Manitoba Conservation
Dean Beyer	Michigan's Moose Population	Michigan DNR
Bill Jensen and James Maskey	North Dakota Moose	North Dakota Game and Fish Department (BJ) and University of North Dakota (JM)

Links to pdf versions of these presentations are on this webpage:

http://www.nrri.umn.edu/moose/information/mnmac/MooseSummit2008.html

or

http://www.mndnr.gov/moose

Appendix 2. Moose Advisory Committee Meetings and Locations

Meeting Location	Meeting Date
Grand Rapids, MN	September 22, 2008
Duluth, MN	December 8-9, 2008
Grand Rapids, MN	January 26, 2009
Natural Resources Research Institute, Duluth, MN	March 23, 2009
Natural Resources Research Institute, Duluth, MN	April 22, 2009
Natural Resources Research Institute, Duluth, MN	May 21, 2009
Natural Resources Research Institute, Duluth, MN	July 2, 2009

Appendix 3. Deer management and moose interactions in northwest Minnesota

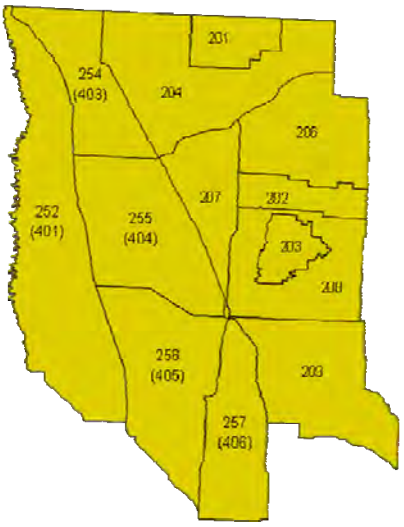
Deer Population Goal Setting

Deer population goals for Northwestern Minnesota were established in 2005. The stakeholder team believed that overall deer populations were high and needed to be reduced throughout the area. The only exceptions were Roseau River wildlife management area (201) and Agassiz National Wildlife Refuge (203), where it was concluded that populations should be allowed to increase (Table 4, Fig. 15). It is important to note that since goals were established, permit area boundaries have been moved and areas renumbered. In addition, with the emergence of bovine tuberculosis in the area, populations have been managed aggressively and will be held below goal until the disease is eradicated.

Table 4. Recent deer management goals by the DNR for Northwestern Minnesota (permit areas are shown in Fig. 15).

Permit area	2005 pre-fawn deer/mi^2	2005 goal recommendations	Pre-fawn population goal
201	5	Slight increase	6
202	9	Stay the same to slight decrease	8
203	7	Slight increase	8
204	5	Stay the same to slight decrease	5
206	6	25% decrease	5
207	7	25% decrease	5
208	4	Stay the same to slight decrease	4
209	7	25% decrease	5
252 (401)	2	25% decrease	1.5
254 (403)	7	25% decrease	5
255 (404)	8	25% decrease	6
256 (405)	7	25% decrease	5
257 (406)	6	25% decrease	5

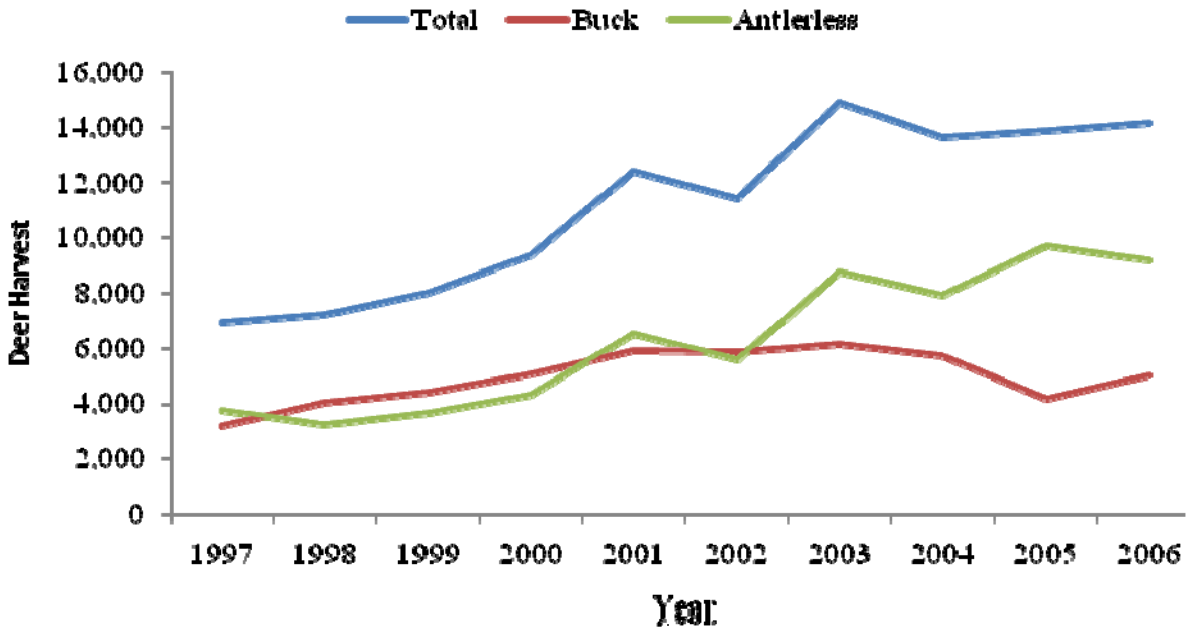
Figure 15. Deer permit areas in NW Minnesota.



Current Population Status

Deer harvest in NW Minnesota has generally exhibited an upward trend with an increasing proportion of the total harvest being antlerless (Fig. 16). Buck (n = 6,140) and total harvest (n = 14,930) peaked in 2003, while antlerless harvest (n = 9,723) peaked in 2005. Much of NW Minnesota has been designated as either 'early antlerless' or 'intensive', which are the two most aggressive deer management strategies.

Figure 16. Registered deer harvest for deer permit areas in the northwest moose range, 1997 – 2006*



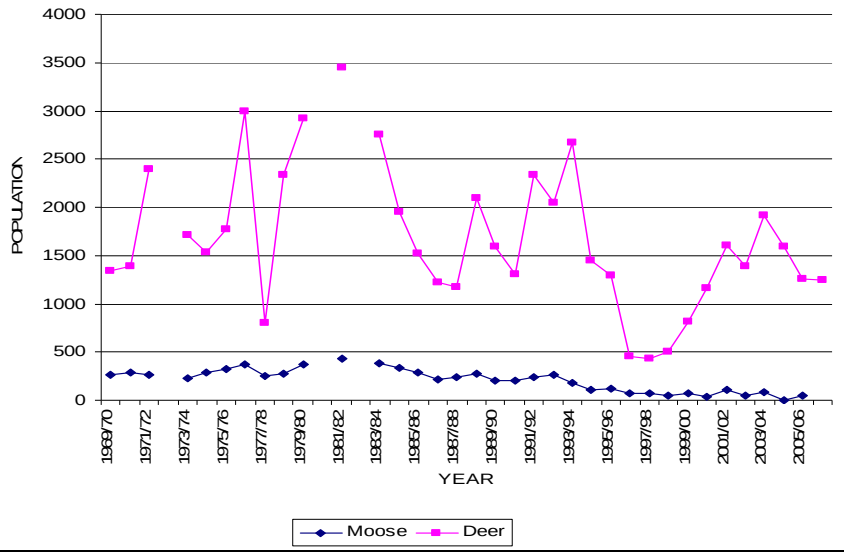
*Permit areas were re-aligned in 2007 and thereafter harvest is not comparable to earlier data.

Northwest Minnesota Moose/Deer Relationships

In NW Minnesota, Murray et al. (2006), found annual adult cow survival was 79%, compared to 88-92% in other studies in Canada and Alaska. Annual calf survival was very high at 66%. The population parameter that was low and caused the population to decline was pregnancy rates. In this study it was only 48% compared to an average of 84% in other studies. Twinning rates were also low at 19% compared to 38% in other places. This resulted in low calf/cow ratios after 1997.

Agassiz National Wildlife Refuge has been making estimates of both deer and moose populations based on aerial counts since 1969 (Fig. 16). These population estimates include the adjoining Wildlife Management Areas of Eckvold and Elm Lake and combined are approximately 130 square miles. This area supported approximately 10% of the NW Minnesota moose population and the populations are probably indicative of population trends throughout NW Minnesota. Deer and moose populations went up and down together until 1995 when moose numbers failed to go back up after both deer and moose numbers plummeted. While deer numbers were at a fairly sustained low from 1995 to 1999, the moose population did not respond positively. One interpretation (see Fig. 17) is that deer and moose populations have fluctuated together in response to severe winter weather until 1995, but it can be argued that the moose population went down because deer populations went up and then weather forced the deer populations down. Either way something else is at work now keeping moose numbers low. In NW Minnesota depressing deer populations by itself will probably not revive the moose population.

Figure 17. Aerial moose and deer populations estimates, Agassiz National Wildlife Refuge, 1969-2005.



The problem of reduced pregnancy rates in NW Minnesota is widespread, crossing political boundaries covering NE North Dakota and SE Manitoba. The problem is identifying what environmental or habitat conditions have changed in the past 30 years to reduce moose pregnancy rates in NW Minnesota. Temperature stress and copper deficiency were the two most likely causes found in analysis by Murray et al. (2006). Whatever this large-scale change is, it is probably beyond the reach of DNR management to rectify.