Form 1100-001
(R 2/11)

NATURAL RESOURCES BOARD AGENDA ITEM

Item No. 3.B.5

SUBJECT: Predation Management Addendum to Sharp-tailed Grouse Management Plan

FOR: APRIL 2012 **BOARD MEETING**

TO BE PRESENTED BY / TITLE: Scott Walter/WDNR Upland Wildlife Ecologist

SUMMARY:

The sharp-tailed grouse management plan was approved at the June 2011 NRB meeting, but the Board requested that BWM staff return with a review of predator management as a potential tool to benefit sharp-tailed grouse in Wisconsin. At the August meeting, the Board then requested that this information be summarized in an addendum to the plan, to include 1) a summary of the relevant literature, 2) options available to implement predation management for sharp-tails in Wisconsin, and 3) the Department's recommendation regarding the most prudent approach to this issue.

The literature on the impacts of predator control on bird populations is extensive; we reviewed >50 articles on this topic, including 2 large meta-analyses that summarized the results of >180 studies. While the literature suggests that predator removal can reliably be used to increase nest survival in birds, the relatively fewer studies that examined post-fledging survival, fall population size, and/or subsequent breeding population size provided less consistent results, with many studies failing to document increases in these measures in response to the removal of predators. More specifically, predator control was found to be an ineffective means of increasing numbers of upland game birds in the vast majority of studies reviewed, including the single study that measured population responses by sharp-tailed grouse.

Any predator control program to benefit sharp-tailed grouse in Wisconsin could not include raptors, due to restrictions of the Migratory Bird Treaty Act, and the documented high nest survival for sharp-tails in Wisconsin suggests that the removal of mammalian predators would not lead to increased grouse numbers. Sharp-tailed grouse have responded positively in the region to increases in habitat availability, and an overview of current habitat efforts in Wisconsin will be provided, as well as a summary of future research priorities.

The attached addendum has been reviewed and supported by partners involved with the development of the original sharp-tailed grouse management plan, and the Wisconsin Trappers Association further supports our recommendation.

RECOMMENDATION: The Department recommends Natural Resource Board Approval of the Predation Management Addendum to the Sharp-tailed Grouse Management Plan.

LIST OF ATTACHED MATERIALS:

No	☑	Fiscal Estimate Required	Yes ☐	Attached
No	☑	Environmental Assessment or Impact Statement Required	Yes ☐	Attached
No	☐	Background Memo	Yes ☑	Attached

APPROVED:

Tom Hauge — Bureau Director, — Date 3/20/12

Kurt Thiede — Administrator, — Date 3/30/12

Matt Mooney — Secretary, Cathy Stepp — Date 4/4/12

cc: NRB Liaison
DNR Rules Coordinator

Addendum *14 March, 2012*

PREDATION MANAGEMENT REVIEW & FEASIBILITY SUMMARY

BACKGROUND

Population sizes of wildlife species such as Sharp-tailed grouse are often limited by potentially interacting intrinsic and extrinsic factors. Loss and fragmentation of barrens habitat due to changing land use patterns is considered to be the primary driver in declining populations, but sharp-tail numbers are also affected by factors such as predation, changes in food availability, extreme weather events, and the fitness consequences of reduced genetic diversity.

It is common to simplify the relationship between predators and prey, but predation, like other factors, alters prey population size by influencing several life cycle components. Variation in these components determines how populations fluctuate over time. Predation of sharp-tailed grouse operates mainly by reducing nest success and the survival of chicks and adult birds. Determining the feasibility of employing predation management to increase Wisconsin sharp-tailed grouse numbers requires an understanding of how managing predation levels affects grouse numbers via improved survival during at least one of these key life cycle stages. This addendum strives to achieve this understanding and has the following specific goals:

- To conduct a thorough literature review and assess the role of predation in sharp-tailed grouse population dynamics in Wisconsin,
- To assess the efficacy of predation management options to enhance/increase sharp-tailed grouse populations in Wisconsin, and
- To provide recommendations regarding the utility of predation management as a strategy to help meet the goals of the WDNR sharp-tailed grouse management plan.

Definitions. When considering what strategies may be applied to mitigate the impact of predators on wildlife populations, there is a clear distinction in the literature between *predator control* and *predation management*. It is important to clearly define these two distinct approaches:

Predator control/removal: *Active control of predator numbers by lethal or non-lethal mechanisms (shooting, trapping, translocation).*

Predation management: *Management of the environment to minimize the effects of predators on the focal prey population. Examples include altering the habitat to reduce predator access or effectiveness and erecting exclosures around nests. Predation management therefore does not directly impact the number of predators in an area, but aims to reduce predation rate on select prey species.*

LITERATURE REVIEW - THE ROLE OF PREDATION IN SHARP-TAILED GROUSE POPULATION DYNAMICS

IMPACT OF PREDATORS ON SHARP-TAILED GROUSE

Sharp-tailed grouse are prey for a wide array of avian and mammalian predators. Most upland game bird mortality is due to predation. Across grouse species, approximately 85% of reported mortalities are the result of predation , with the remaining 15% attributable to accidents, disease, and other factors (Bergerud and Gratson 1988). Like other ground-nesting species, sharp-tailed grouse typically experience high predation, with annual nest and adult mortality rates ≥40% frequently reported. Large clutch size, precocial development, and discrete patterns of habitat selection have likely evolved in response to strong selective pressures imposed by predators, and allow sharp-tailed grouse populations to persist and even flourish with this level of annual mortality.

Predation can affect sharp-tailed grouse at all life stages, but the primary predator varies with grouse life stage. Adult sharp-tailed grouse most frequently are preyed on by avian predators including northern goshawks, red-tailed hawks, great-horned owls, and other raptors. In Wisconsin, 37 out of 44 (84%) sharp-tailed hens killed by predators were believed to have been taken by raptors (Connolly 2001). Adult annual mortality for sharp-tailed grouse ranges from 17% - 55% (average = 47%; Schroeder and Baydack 2001, Schroeder 1994), these values are comparable to adult annual mortality in prairie grouse as a group (49%; Schroeder and Baydack 2001).

Eggs are primarily eaten by mammalian predators (Connelly et al. 1998), including fox, coyotes, skunks, raccoons, badgers, ground squirrels, and others. Nest success is often considered the most significant factor in prairie grouse population dynamics and is highly variable from year to year. Published nest success rates for sharp-tailed grouse average 54% (48% across all prairie grouse species; Bergerud and Gratson 1988). Past studies have documented sharp-tailed grouse nest survival ranging from 44%-55% (Amman 1957; Hamerstrom 1939; Hart et al. 1950; Sisson 1976), with more recent estimates suggesting higher nest success rates in Wisconsin of 60-65% (S. Hull, WI DNR, pers. comm., Connolly 2001; Fig. 3). The primary cause of nest failure is predation (73% of failed sharp-tailed grouse nests; 79% for all prairie grouse; Bergerud and Gratson 1988). In Wisconsin, predators were responsible for 21 of 27 (77.8%) nest failures (Connolly 2001). Eleven of these were due to mammalian predators consuming eggs, and the remaining were due to raptor predation of the nesting hen.

Chick survival is also a significant variable in prairie grouse population dynamics. Unfortunately, chick or brood survival is much more difficult to measure and few studies have documented the role of predators in chick mortality. Some studies have estimated 40-50% of chicks perish between hatching and the time of independence (~40% for sharp-tailed grouse and 44% for all prairie grouse; Bergerud and Gratson 1988). In particular, the majority of chicks die within the first two weeks of hatching, during which they are developing the ability to thermoregulate and are vulnerable to cool/wet weather. The survival of broods in Wisconsin varied from 30% on

unmanaged lands to 43% on managed lands (Connolly 2001). Because chicks were not equipped with transmitters, the cause of mortality could not be determined in this study. However, 8 out of 24 (33%) brood mortalities were due to predation of the adult hen, with 7 of these attributed to raptors.

Bird Population Response to Predator Control

Documented predation rates on adults, nests, and young, and the intuitive assumption that reducing predator numbers should lead to increased survival has stimulated numerous attempts to use predator control to increase breeding population size. Reducing predator numbers also may seem to be a more realistic and acheivable goal than attempting to mitigate the effects of other limiting factors (e.g. disease, landscape-level habitat loss/change, weather) on bird population growth. The literature documenting the effects of predator control on prey population vital rates is varied and extensive. However, two comprehensive review papers have summarized this body of research, leading to a general understanding of the utility of predator control as a potential strategy for managing bird populations.

Two papers conducted meta-analyses of the predator control literature in order to determine the impacts of predator control on bird populations (Figure 1). Cote and Sutherland (1996) summarized 20 published studies, and found that predator control led to significant increases in both nest survival and fall population size, but not subsequent breeding population size. Smith et al. (2010) used a similar approach to assess the outcomes of predator control programs for 128 bird species from 83 published studies, and found that predator control led to improved nest survival and post-fledging survival, but no significant increase in post-breeding population size. However, Smith et al. (2010) documented a small but significant increase in breeding population size as a result of predator contol. Of the 83 studies summarized by Smith et al. (2010), however, only three were European studies in which raptors were removed; the majority of predator control studies reviewed focused on the removal of all or a subset of mammalian predators and/or non-raptor avian nest predators (e.g., gulls, crows).

These analyses clearly suggest that predator removal has general utility as a means of increasing nest survival in bird populations, but that benefits do not predictably extend beyond the nesting season. The two review studies reach entirely different conclusions regarding the ability of predator control to increase fall population size. In addition, only Smith et al. (2010) documented a significant effect of predator control on subsequent breeding population size, and the magnitude of this effect was much lower than the effect of predator control on the other population measures examined.

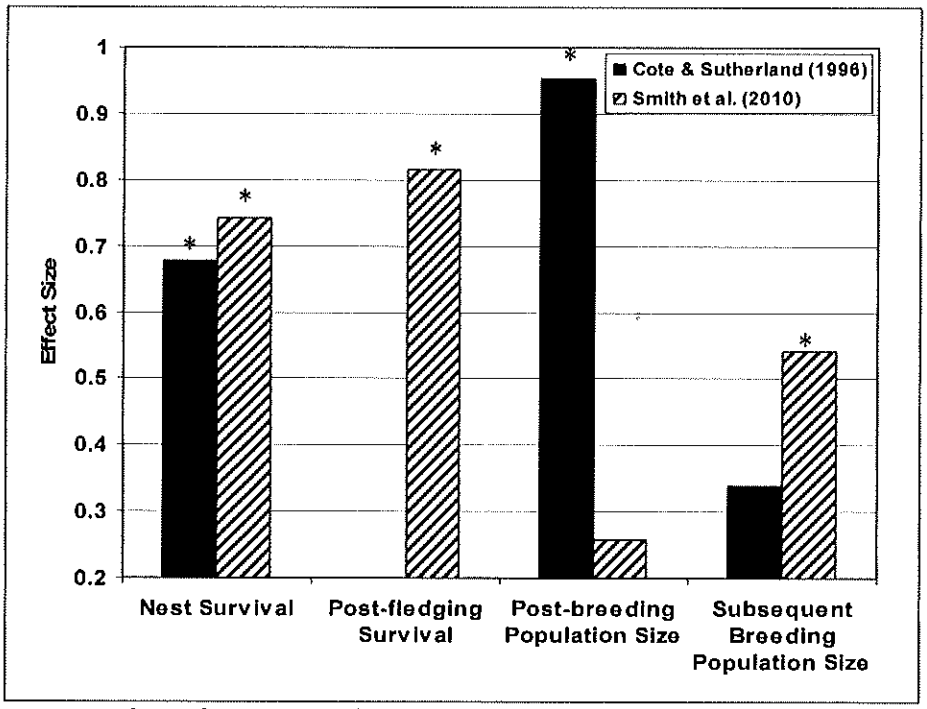

Figure 1. *The response of specific avion populotion meosures to predator control, summorized from Cote & Sutherlond (1996) ond Smith et al. (2010) where * denotes o significont effect of predotor control on the populotion meosure.*

UPLAND GAME BIRD RESPONSES TO PREDATOR CONTROL

Our assessment of the utility of predator control to benefit sharp-tailed grouse in Wisconsin also involved a more specific review of the available predator control literature pertaining to upland game birds. Predator control has not received much attention as a management tool for prairie grouse species, but it has been more commonly employed with other upland game birds. Results from individual studies were varied and equivocal. Overall, predator control has not been supported as a prudent technique when the goal is to increase upland game bird numbers despite frequent reports of increased nest survival.

Sharp-tailed Grouse. Only one study previously evaluated the effect of predator control on sharp-tailed grouse populations. Wiens (2007) monitored sharp-tailed grouse and shorebird nests on seven 36 mi^2 study areas in North Dakota where mammalian predators had been removed and four control areas with no predator removal. Professional trappers were used and financial incentives offered to maintain high removal rates of predators, yet nest survival for sharp-tailed grouse and shorebirds was the same between predator removal and control areas.

Attwater's Prairie Chicken. The Attwater's prairie-chicken (*Tumpanuchus cupido attwateri*) is a critically-endangered subspecies of the greater prairie-chicken, with a population of fewer than 100 individuals persisting on small isolated grasslands in coastal Texas. The National Fish and Wildlife Foundation used logic modeling to evaluate which conservation strategies and activities (including predator control) would be most likely to yield a secure prairie chicken

population. Predator control was ranked as the lowest priority option. Strategies that addressed habitat and genetic concerns were most likely to be effective (National Fish & Wildlife Foundation 2008).

Wild Turkey. Predator control has been used successfully to increase nest survival and poult production in wild turkey populations (Beasom 1974; Speake 1980). However, there is little evidence that predation regulates or limits turkey populations. Indeed, turkey populations across North America have increased and expanded their range despite predation as the major mortality factor for all sex and age classes except adult gobblers (Hughes et al. 2009). Hughes et al. (2009) suggested that predator control is not a cost-effective or publicly-acceptable strategy for wild turkeys. Additionally, Speake (1980) noted that, even when successful, costly predator control programs are likely to only realize short-term benefits for turkeys. For example, Beasom (1974) noted rapid predator recolonization of their south Texas study area each year immediately following the cessation of predator removal activities.

Bobwhite Quail. Given the popularity of quail hunting and the recent nationwide decline in bobwhite quail, predator removal has been explored repeatedly as a management option. Intensive predator control in south Texas did not benefit local populations of either bobwhite or scaled quail (Guthery & Beasom 1977). In addition, Palmer et al. (2005) noted that predator removal in North Carolina led to increased numbers of quail only if done in conjunction with habitat improvements. Carroll et al. (2007) suggested that managers interested in producing quail focus on the management of predation via habitat manipulation and not the direct removal of predators because the latter was ineffective, compromised biodiversity, and had little public support.

Understanding the Predator – Prey Relationship

It may seem counter-intuitive that the removal of predators from a an area does not necessarily lead to increases in prey survival or population size. Therefore, it is worth discussing some of the ecological underpinnings of these systems. This provides a baseline for many of the study results outlined above, details problems inherent with predator control when used as a tool to increase bird numbers, and illuminates the complexities in wildlife population dynamics.

Wildlife populations are regulated in complex ways, as multiple environmenal factors (e.g., weather, predators, disease, food availability) interact to determine levels of survival and reproduction that ultimately influence population size. Factors important in determining how individuals of a prey species survive between years may act in a compensatory fashion. That is, reduction in mortality during one portion of the life cycle (e.g., nest survival) brought about by controlling one mortality factor (e.g., predation) may be at least partially offset by increases in mortality due to another factor (e.g., food limitation) such that overall mortality (and, consequently, population size) remains unchanged. Such compensation has been well documented among bird species, and suggests there is a "doomed surplus" where individuals are removed from a population each year until the number supportable by the local habitat is reached. In this context, the specific mortality agent is not important, and reductions in one

agent will be offset by increases in others. Importantly, even if levels of predation are significant, control of predators will have no impact on subsequent breeding densities. Errington (1946) suggested that compensatory mortality keeps bobwhite quail populations at levels reflective of habitat quality, an idea consistent with the principle of carrying capacity.

A similar process may dampen response of wildife populations to predator control. Mortality and reproductive rates in birds and other wildlife species often vary according to the density of individuals within a population. As densities increase, survival and/or reproductive rates generally decrease. This density-dependence forces populations toward a density that can be supported by the available habitat. For example, overwinter mortality in red grouse was positively related to fall population size; when grouse densities were high in the fall, a large percentage died during the subsequent winter (Redpath and Thirgood 1997). This may in part explain why so few predator control studies report increases in subsequent breeding densities, despite increases in nest and post-fledging chick survival (Figure 1).

Failure of predator control to bring about desired increases in survival may also be attributed to unpredictable consequences of removal activities. In many cases, intensive predator control efforts have been unable to significantly reduce predator populations due to low trapping success (Duebbert & Lokemoen 1980; Meckstroth & Miles 2005), inability to target important species (e.g., prohibition on raptor removal via the Migratory Bird Treaty Act), or rapid immigration of predators from the surrounding landscape (Guthery & Beasom 1977; Speake 1980). Predator control efforts may also alter predator community dynamics, with unpredictable consequences for the predator-prey system. For example, the removal of coyotes may actually depress nest survival of ground-nesting birds due to increased densities of fox, skunks, and other small mammalian predators (Sovada et al. 1995; Ritchie and Johnson 2009) through 'mesopredator release' (Crooks and Soulé 1999).

Predicting the demographic response by a specific bird population to predator removal is inherently difficult, and depends upon a suite of interacting factors.

OPTIONS FOR MITIGATING THE EFFECTS OF PREDATORS ON SHARP-TAILED GROUSE IN WISCONSIN

Two general options are available for mitigating predation on sharp-tailed grouse in Wisconsin: either manage predation via habitat manipulation or directly control predators via a predator removal program. The efficacy of each option is summarized below.

OPTION 1 - Predation Management via Habitat Management

Given the Plan's goal of increasing sharp-tailed grouse numbers in Wisconsin, it is instructive to examine historic population trends in order to infer factors responsible for population change. The sharp-tailed grouse population in Wisconsin has responded positively to large scale disturbance events, such as fire and clear-cutting, in the surrounding forest (Figure 2). Documented and dramatic increases in sharp-tailed grouse numbers over the past four decades normally followed major disturbances in the surrounding forest, and in the absence of predator control. These data provide *prima facie* support for the prevailing notion that the availability of

high-quality barrens habitat is the key to sustaining sharp-tailed grouse as a member of Wisconsin's wildlife community. Alternatively, while predation is certainly responsible for mortality of grouse, it likely does not limit population growth.

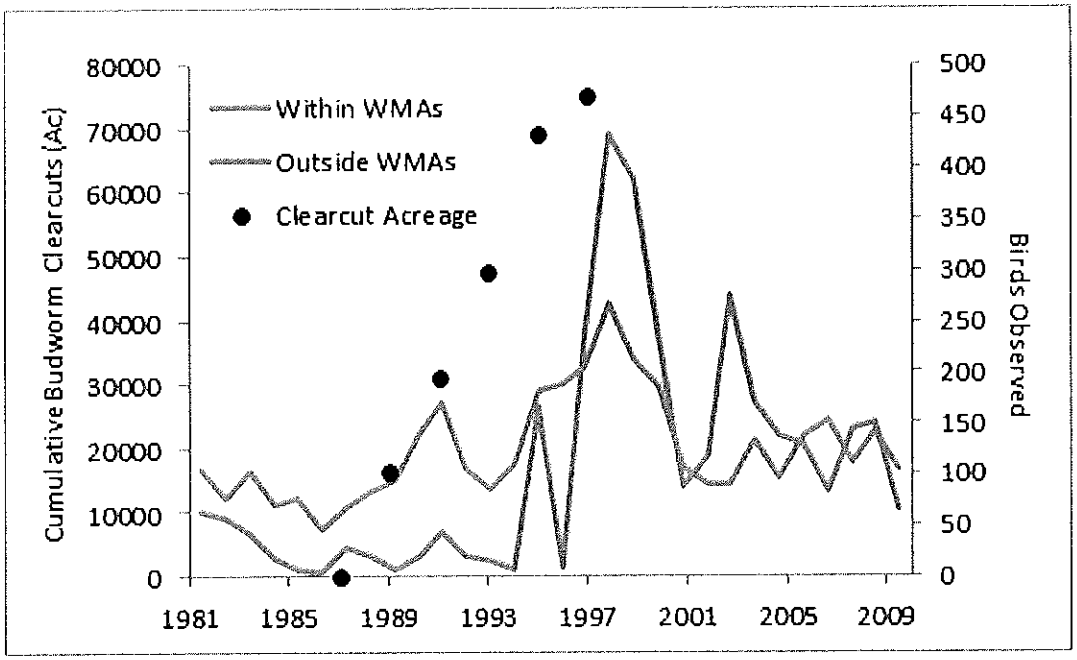

Figure 2. *Number of male sharp-tailed grouse in the Northwest Sands Ecological Region, 1981-2009, indicating the population response of birds within ond outside of Wildlife Management Areas (WMAs) to clearcuts following o large-scale budworm outbreok (graph prepared by Matt Reetz, UW-Madison).*

OPTION 2 - Predation Management via Direct Predator Control

Predator control aimed at increasing adult survival would require targeting avian predators. However, due to restrictions imposed by the Migratory Bird Treaty Act, removal of raptors (e.g., hawks and owls) is not plausible. Conversations with staff from the U.S. Fish and Widlife Service Migratory Bird Permit Office suggest that a permit to remove raptors across an area as large as the Northwest Sands would not be granted. Permits to remove raptors have only been granted in very specific cases, generally to support efforts to conserve federally endanged species (e.g., removing owls near peregrine falcon rearing sites). A predator removal program that includes raptors is therefore not tenable.

Predator control to benefit sharp-tailed grouse in Wisconsin would therefore be restricted to the mammalian predator community (coyotes, badgers, red and gray fox, raccoons, weasels, ground squirrels, skunks). As discussed above, this predator group primarily impacts ground-nesting birds via predation on eggs. However, nest survival rates for sharp-tailed grouse in Wisconsin are already high (Figure 3), with recent estimates suggesting that 60–65% of nests

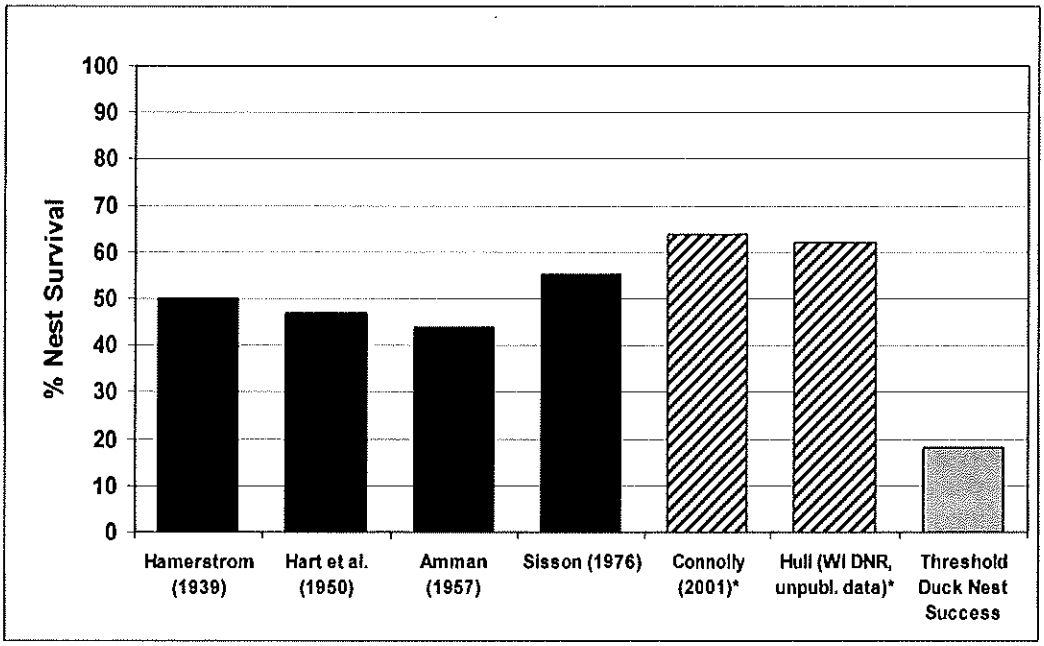

Figure 3. *Published nest survival rates for sharp-tailed grause in North America (solid bars), recent estimates from Wisconsin (hatched bars), and the threshold nest survival rate for ducks, above which nest survival is not believed to limit population growth.*

hatch (S. Hull, WI DNR, pers. comm., Connolly 2001). This is in sharp contrast to low nest survival rates reported for ducks in the 1970s and 1980s (<10%; Greenwood 1986; Sargeant et al. 1995), where predator control was used successfully to increase nest survival above 18%. Above this threshold, nest survival is no longer limiting and population growth is possible (Figure 3). Duck nest survival has also been linked directly to the availability of quality nesting habitat (Horn et al. 2005). In areas with >30% grass cover, nest success is normally sufficient to allow population growth. It is only in landscapes that have been largely converted to agricultural production, where nesting cover is limited, that predators are able to significantly depress duck nest survival. Recent increases in duck nest success to ~30-40% (coincident with the establishment of large grassland blocks via the Conservation Reserve Program) led Delta Waterfowl, a strong historic advocate of predator control to increase duck numbers, to state "Trapping [of predators] simply isn't needed when background nest success is so high" (*Delta Waterfowl*, Summer 2011). In other words, with nest survival rates of 30% the growth of duck populations is not being limited by predation and, therefore, predator removal is not warranted. Similarly, with sharp-tailed grouse nest survival rates of 60–65%, there is reduced potential for mammalian predator control to contribute to the long-term goal of increasing sharp-tailed grouse numbers in Wisconsin. Connolly (2001) also found that nearly half of all nest mortality was due to raptor predation of the nesting hen, further reducing the likelihood that efforts to control mammalian predators would benefit sharp-tailed grouse.

Control of the mammalian predator community in the Northwest Sands Ecological Landscape is possible, and could include trapping outside of currently-established furbearer seasons, hunting with dogs, staff trappers, or incentive payments. However, it would: 1) entail significant costs, 2) require a larger scale than that of previously reported predator control studies (e.g.,

generally control areas have been ≤ 36mi^2 in size; the Northwest Sands Ecological Region is 1,875 mi^2), 3) be confounded by compensatory and density-dependent responses in grouse vital rates, 4) provide only short-term benefits, 5) produce significant opportunity costs (i.e., resources invested in predator control would necessarily be diverted from other management and/or research objectives), and 6) may not be acceptable to the public. These issues, combined with little potential for successful mammalian predator control to increase numbers of sharp-tailed grouse, suggest predator control is not a prudent strategy to help meet the population goals documented in the sharp-tailed grouse management plan.

RECOMMENDATION

Based on the extensive literature review summarized in this addendum and our communications with experts on the topic of predator management, it is the recommendation of the Department that predator management via habitat management (***OPTION 1***) will have the highest probability of helping to achieve long-term sharp-tailed grouse population and habitat goals. According to the above review, direct predator removal or control methods (***OPTION 2***) would be ineffective over the long-term at achieving the Sharp-tailed Grouse Plan goal of increasing sharp-tailed grouse populations in Wisconsin.

SHARP-TAILED GROUSE RESEARCH PRIORITIES – 2012 AND BEYOND

The recently-approved sharp-tailed grouse conservation and management plan identified a number of research and survey priorities as part of the overall implementation strategy that are currently being addressed. They include:

- Determine the minimum viable population size and estimate persistence of metapopulations under various scenarios utilizing a Population Viability Analysis that incorporates key vital rates. Determine which key vital rates have the largest impact on population growth.
- Conduct a cost:benefit analysis of specific management strategies and actions that will likely impact key vital rates and subsequently population growth.
- Revise and standardize current survey protocol. Continue monitoring at known lek locations in the state. Expand survey efforts on both public and private lands to identify new lek locations and evaluate their importance to the overall statewide population within the state. Make additional survey efforts in areas not previously or recently covered but with recent evidence of sharp-tailed grouse presence.

Several additional research questions have emerged from the ongoing sharp-tailed grouse research project collaboration between WDNR and UW-Madison. These include:

- Quantify how past landscape change such as large scale disturbance through clear-cutting or fire impacted persistence of grouse subpopulations to inform future management of the landscape.

- Quantify how future habitat management actions such as forest harvest outside of core properties impact specific sharp-tailed grouse demographics (nest success, adult and juvenile survival).
- Determine interchange and movement of birds between core managed properties such as the Namekagon Barrens and surrounding habitat. How quickly do birds colonize newly created habitat? Do colonizing birds come from core properties or do they come from other unknown smaller populations that already exist outside of core properties?
- Determine the relative contribution of sharp-tailed grouse subpopulations on core managed properties to the overall status of the statewide population.

These projects will help us further understand how management actions, including predator management as a function of habitat management, will impact sharp-tailed grouse vital rates. This will ultimately lead to prioritization of management actions identified in the overall plan that positively impact key vital rates and lead to overall population growth.

Literature Cited

Ammann, G. A. 1957. The prairie grouse of Michigan. Michigan Department of Conservation Game Division Technical Bulletin. Lansing, MI.

Beasom, S. L. 1974. Intensive short-term predator removal as a game management tool. Transactions of the North American Wildlife Conference 29:230-240.

Bergerud, A. T. and Gratson, M. W. 1988. Adaptive strategies and population ecology of northern grouse. University of Minnesota Press. Minneapolis, MN.

Carroll, J. P., Ellis-Felege, S. N., and Palmer, W. E. 2005. Impacts of predators on northern bobwhites in the southeast. Transactions of the 72nd North American Wildlife and Natural Resources Conference 72:246-257.

Connelly, J. W., Gratson, M. W., and Reese, K. P. 1998. Sharp-tailed grouse. In: Poole, A., Stettenheim, P., and Gill, F., *eds*. The Birds of North America, No. 36. The Academy of Natural Sciences: Philadelphia; The American Ornithologists' Union. Washington, D.C.

Connolly, T. T. 2001. Reproductive ecology of sharp-tailed grouse in the pine barrens of northwestern Wisconsin. M. S. Thesis, University of Wisconsin-Stevens Point.

Cote, I. M. and Sutherland, W. J. 1996. The effectiveness of removing predators to protect bird populations. Conservation Biology 11:395-405

Crooks, K.R. and Soule', M.E. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. Nature 400:563–566.

Duebbert, H. F., and Lokemoen, J. T. 1980. High duck nesting success in a predator-reduced environment. Journal of Wildlife Management 44:428–37.

Errington, P. L. 1946. Predation and vertebrate populations. The Quarterly Review of Biology 21:144-177.

Greenwood, R. J. 1986. Influence of striped skunk removal on upland duck nest success in North Dakota. Wildlife Society Bulletin 14:6–11.

Guthery, F. S. and Beasom, S. L. 1977. Responses of game and nongame wildlife to predator control in south Texas. Journal of Range Management 30:404-409.

Hamerstrom, F. N. 1939. A study of Wisconsin prairie chicken and sharp-tailed grouse. Wilson Bulletin 51:105-119.

Hart, C. M., Lee, O. S., and Low, J. B. 1950. The sharp-tailed grouse in Utah: its life history, status, and management. Publication 3. Utah Department of Fish and Game, Salt Lake City, UT.

Horn, D. J., Phillips, M. L., Koford, R. R., Clark, W. R., Sovada, M. A., and Greenwood, R. J. 2005. Landscape composition, patch size, and distance to edges: interactions affecting duck reproductive success. Ecological Applications 15:1367-1376.

Hughes, T. W., Kennamer, J. E., Tapley, J. L., and Lehman, C. P. 2009. The impacts of predation on wild turkeys. Proceedings of the National Wild Turkey Symposium 9:117-126.

Meckstroth, A. M. and Miles, A. K. 2005. Predator removal and nesting waterbirds success at San Francisco Bay, California. Waterbirds 28:250-255.

National Fish and Wildlife Foundation, 2008. Business plan for Attwater's prairie chickens. 17pp.

Palmer, W. E., Wellendorf, S. D., Gillis, J. R., and Bromley, P. T. 2005. Effects of field borders and mesomammal reduction on bobwhite abundance on North Carolina farms. The Wildlife Society Bulletin 33:1398-1405.

Redpath, S. and Thirgood, S. 1997. Birds of prey and red grouse. HMSO Publications. London, UK.

Ritchie, E. G. and Johnson, C. N. 2009. Predator interactions, mesopredator release and biodiversity conservation. Ecology Letters 12:982-998.

Sargeant, A. B., Sovada, M. A., and Shaffer, T. L. 1995. Seasonal predator removal relative to hatch rate of duck nests in waterfowl production areas. Wildlife Society Bulletin 23:507-513.

Schroeder, M. A. 1994. Productivity and habitat use of Columbian sharp-tailed grouse in north-central Washington. Progress Report, Washington Department of Fish and Wildlife.

Schroeder, M. A. and Baydack, R. K. 2011. Predation and the management of prairie grouse. Wildlife Society Bulletin 29:24-32.

Sisson, L. 1976. The sharp-tailed grouse in Nebraska. Nebraska Game and Parks Commission. Lincoln, NE.

Smith, R. K., Pullin, A. S., Stewart, G. B., and Sutherland, W. J. 2010. Is predator control an effective strategy for enhancing bird populations? Environmenal Evidence: www.environmentalevidence.org/SR38.html.

Sovada, M. A., Sargeant, A. B., and Grier, J. W. 1995. Differential effects of coyotes and red foxes on duck nest success. Journal of Wildlife Management. 59:1–9.

Speake, D. W. 1980. Predation on wild turkeys in Alabama. Proceedings of the National Wild Turkey Symposium 4:86-101.

Ulliman, M. J. 1995. Winter habitat ecology of Columbian sharp-tailed grouse in southeastern Idaho. M. S. Thesis, University of Idaho, Moscow.

Wiens, D. 2007. Nest success and nest site selection of shorebirds in North Dakota. M. S. Thesis, Louisiana State University, Baton Rouge.