2004

Effects of spinning-wing decoys on flock behavior and hunting vulnerability of local and migrant mallards and other ducks in Minnesota

Michael L. Szymanski
Louisiana State University and Agricultural and Mechanical College

EFFECTS OF SPINNING-WING DECOYS ON FLOCK BEHAVIOR AND HUNTING VULNERABILITY OF LOCAL AND MIGRANT MALLARDS AND OTHER DUCKS IN MINNESOTA

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Science

in

The School of Renewable Natural Resources

by
Michael Lester Szymanski
B.S., University of North Dakota, 2001
May, 2004

Acknowledgements

I greatly appreciate the logistical support and funding provided by the Minnesota Department of Natural Resources. Specifically, I thank Jeff DiMatteo and his banding crews for providing feather samples in northern Minnesota and Jeff Lawrence for providing equipment and a vehicle. The USGS-Louisiana Cooperative Fish and Wildlife Research Unit also provided funding, equipment, and vehicles. I would like to express my utmost gratitude to my advisor, Dr. Alan D. Afton, for his patience, advice, and editing contributions. I also thank my committee members, Dr. James P. Geaghan and Dr. Vernon L. Wright, for providing helpful comments. I thank Kent and Laurel Brace for their generous hospitality while I was preparing feather samples in Saskatoon. Dr. Keith A. Hobson graciously allowed me to use his equipment to prepare feather samples, and provided expedited stable isotope analyses and helpful advice. Cabela's East Grand Forks, Minnesota provided spinning-wing decoys and chest-waders at reduced prices. I also thank managers of Sully's Hill National Game Preserve, Thief Lake WMA, and Whitewater WMA for providing housing. The USFWS (Regions 3, 4 and 6); managers of Detroit Lakes WMD, Devils Lake WMD, Fergus Falls WMD, Lake Andes WMD, Madison WMD, Morris WMD, Sand Lake WMD, Tamarac NWR and Upper Mississippi NFWR; and Minnesota Department of Natural Resources, North Dakota Game and Fish Department, South Dakota Department of Game, Fish and Parks, and Wisconsin Department of Natural Resources kindly issued scientific collection permits. I also thank Dr. Paul I. Padding and the 2003 Mississippi Flyway wingbee certified checkers for confirming ages of HY mallard wings. I thank Dr. C. D. Ankney, M. Anteau, S. Cordts, J. Lawrence, and D. Rave for reviewing an earlier draft of my thesis. I also thank J. Jonsson for allowing me to use his apartment between stints in the field. Additionally, M. Anteau, F. Bolduc, M. Engel, J. Jonsson, M. Kaller, T. Mason, and L.

Oligschlaeger provided friendship and support that made my experience at LSU unforgettable. I thank C. Garrett, N. P. Jerstad, and B. W. Meixell for their tireless efforts in contacting hunters and conducting experimental hunts, and J. Worms for his assistance with capture and collection of ducklings. Finally and most importantly, I would like to thank the many hunters who volunteered to participate in my experimental hunts.

Table of Contents

List of Tables

List of Figures

Abstract

Waterfowl managers in Minnesota and other states are concerned that increased kill rates associated with the use of spinning-wing decoys (SWDs) may negatively affect local breeding populations of mallards (*Anas platyrhynchos*). I conducted 219 experimental hunts to evaluate hunting vulnerability of mallards to SWDs during the 2002 duck-hunting season in Minnesota. Following experimental hunts, I asked volunteer hunters to complete post-hunt questionnaires to document their hunting experience, and their use and opinions of SWDs. Finally, I used stable isotope methodology to determine natal origins of HY mallards killed during experimental hunts. I found that mallard flocks (≥1 duck) were 2.91 times more likely to respond (i.e., approached within 40 m of hunters) when SWDs were turned 'ON'. Sizes of responding mallard flocks were 1.25 times larger, on average, when SWDs were turned 'ON' than 'OFF'. Mallards killed/hr/hunter/hunt averaged 4.71 times higher ($P < 0.05$) when SWDs were turned 'ON' than 'OFF'. More HY and AHY mallards were killed when SWDs were turned 'ON' than 'OFF'; however, AHYs were relatively less likely than were HYs to be killed with SWDs turned 'ON'. Based on my stable isotope analysis, more local and migrant HY mallards were killed by hunters when SWDs were turned 'ON' than 'OFF', but local HY mallards were not relatively more likely than were migrant HY mallards to be killed by hunters using SWDs in Minnesota. I found no evidence that SWDs reduced crippling nor allowed hunters to harvest relatively more drakes than hens. I estimated that if 46% and 79% of Minnesota hunters used SWDs in 2000 and 2002, respectively, Minnesota mallard harvest would increase by factors of 2. However, increasing use of SWDs may result in a partial re-distribution of annual mallard harvests if naïve ducks are harvested upon initial exposures to SWDs, and those ducks that survive migrations to wintering areas become habituated to SWDs, as suggested by my results. My study was confined to a

single hunting season in Minnesota, and thus, did not assess whether vulnerability of mallards to hunters using SWDs varies among years or geographically. A multi-year, flyway-wide study is needed to make stronger and more rigorous inferences regarding potential changes in annual harvest rates of mallards due to increasing use of SWDs by hunters in North America.

Chapter 1. Introduction

Electronic spinning-wing decoys (hereafter SWDs) are decoys that employ motors to spin some type of flat blade. The blade usually is painted white on one side and black on the other side. Simple designs are comprised of a single blade spinning between two posts (i.e., the original design), whereas others consist of a full body decoy, usually a mallard (*Anas platyrhychos*), mounted on a post with two rotating wings. The spinning blade is intended to mimic the flash of flapping duck wings and to attract ducks from long distances to within close gun range of hunters.

SWDs originated in California and currently are used throughout North America where legal. Presently, no federal regulations limit the use of SWDs in the United States. However, three states completely prohibit the use of SWDs: 1) Washington (Washington Department of Fish and Wildlife 2001), 2) Pennsylvania (Pennsylvania Game Commission 2001), and 3) Oregon (Oregon Fish and Wildlife Commission 2002). Additionally, use of SWDs has been prohibited until 30 November in California (California Fish and Game Commission 2001), and until the Saturday nearest 8 October on public waters in Minnesota (Minnesota Statutes 2002).

Field studies in California (Eadie et al. 2002), Missouri (Humburg et al. 2002), and Manitoba (Caswell and Caswell 2003) indicate that SWDs increase vulnerability of mallards and other ducks to hunters. Hunters killed 66% of their total mallard bags when using SWDs during experimental hunts in California (Eadie et al. 2002). In Missouri, hunters killed 1.28 more total ducks/hunting party when SWDs were turned 'ON' than 'OFF' (Humburg et al. 2002). However, neither of these studies had scientific collection permits to extend daily bag limits so that harvest opportunity was equal among sampling periods. Mallards were 1.9 and 6.3 times more likely to fly within 40 m of hunters when SWDs were turned 'ON' than 'OFF' during marsh and field experimental hunts in Manitoba, respectively (Caswell and Caswell 2003). Moreover, mallards killed/hunter/hr were 5.0 and 33.0 times higher in marsh and field experimental hunts, respectively, when SWDs were turned 'ON' than 'OFF' (Caswell and Caswell 2003).

The distance at which ducks are shot and the probability of crippling (ducks hit by shot but not retrieved) generally are correlated (Humburg et al. 1982, Hebert et al. 1984, Harvey et al. 1995). Thus, if SWDs attract ducks closer to hunters, crippling may be reduced. However, Eadie et al. (2002) reported that total numbers of ducks lost to crippling, within an experimental hunt, were higher when SWDs were turned 'ON' than 'OFF', but the proportions of ducks crippled (i.e., [total ducks hit by shot but not retrieved]/[total ducks hit by shot]) were similar when SWDs were turned 'ON' or 'OFF'. In contrast, Caswell and Caswell (2003) reported that mallard crippling rates were lower when SWDs were turned 'ON' than 'OFF'.

If SWDs attract ducks within close range, they might enable hunters to selectively harvest males over females. Humburg et al. (2002) reported that hunters killed 0.82 more drake mallards/hunting party when SWDs were turned 'ON' than 'OFF'. However, Eadie et al. (2002) reported that sex ratios among all ducks killed during experimental hunts were similar, regardless of SWD treatments.

Larger flocks of waterfowl generally are less vulnerable to hunting than are smaller flocks (Stott and Olson 1972, Lindberg and Malecki 1994). If SWDs increase the vulnerability of ducks to hunters (cf. Olsen and Afton 2000), then flock sizes of ducks responding to SWDs should be larger, on average, than those responding to traditional decoys. However, Eadie et al. (2002) reported that size of all responding flocks did not differ between SWD treatments.

Ducks in poor body condition generally are more vulnerable to hunters using decoys than are those in good condition (Greenwood et al. 1986, Dufour et al. 1993, Cox et al. 1998, Pace and Afton 1999, McCracken et al. 2000). Thus, if ducks are more vulnerable to hunters using SWDs (cf. Olsen and Afton 2000), body condition of ducks killed during experimental hunts should be higher, on average, when killed with SWDs turned 'ON' than 'OFF'.

Hatch-year (HY) ducks generally are more vulnerable to hunting than are after-hatch-year (AHY) ducks (Anderson 1975, Cox et al. 1998, Pace and Afton 1999). Thus, age ratios (HY/AHY) in the annual duck harvest could decrease if AHY ducks are more susceptible to hunters using SWDs. However, Caswell and Caswell (2003) reported that relative proportions of AHY and HY mallards killed did not differ between SWD treatments.

The perceived ability of SWDs to attract ducks from long distances has influenced hunter opinions concerning the use of SWDs. Some hunters may oppose the use of SWDs because they believe that SWDs overstep the ethical bounds of fair chase and increase harvest above acceptable levels. However, other hunters may strongly favor SWDs, believing the devices will attract ducks closer, thus, reducing crippling and enabling hunters to selectively harvest drakes over hens.

State-wide mail surveys of Minnesota duck hunters indicated that only 10% and 26% of hunters reported using SWDs in 2000 and 2002, respectively, which generally is much lower than that reported in other states during the same time periods (Fulton et al. 2002, Schroeder et al. 2003). Knowledge of current and future SWD utilization would be useful in modeling potential changes in annual harvest rates caused by hunters using SWDs.

The effectiveness of SWDs declined throughout the 1999-2000 hunting season in California (Eadie et al. 2002). Accordingly, the California Department of Fish and Game implemented a regulation to prohibit use of SWDs until 30 November (California Fish and Game Commission 2001). By postponing the use of SWDs, increased harvest may be shifted later in the season, thus potentially protecting local mallards (California Fish and Game Commission 2001). Knowledge of vulnerability to SWDs and timing of local mallard harvest would be useful in determining when and if SWDs should be restricted in Minnesota.

Natal origins of ducks harvested during fall can be determined from analysis of band recoveries and radio telemetry data. However, insufficient numbers of band recoveries generally are available to directly assess effectiveness of new hunting technologies, such as SWDs, or to make inferences about how they affect local populations. Thus, alternative methods are required to help delineate local and migrant ducks.

Migratory birds can be traced to their natal origins using stable isotopes from metabolically inert tissues such as feathers grown on breeding areas (Hobson and Clark 1992, Chamberlain et al. 1997, Hobson and Wassenaar 1997, Caccamise et. al 2000, Wassenaar and Hobson 2000, Hobson et al. 2001). Wassenaar and Hobson (2000) found that $\delta^{13}C$ and δD values determined natal origins of blackbirds with 80% accuracy (based on discriminant function analysis) compared to 64% accuracy with δD values alone. Therefore, accuracy may be improved by considering multiple isotope values (Hobson and Wassenaar 1997).

Isotopic values of $\delta^{13}C$ and $\delta^{15}N$ are determined at the vegetative base of the food web (Peterson and Fry 1987). Isotopic values of $\delta^{13}C$ generally are depleted (isotopically light compared to international standards) in forested areas as compared to grassland areas due to different photosynthetic pathways (C_3 in cooler, wetter climates; C_4 in warmer, drier climates; Lajtha and Michener 1994). Additionally, isotopic values of $\delta^{15}N$ are depleted in the forest web compared to the agricultural web due to nitrogen enrichment by fertilizer and animal waste nitrates on agricultural lands (Alexander et al. 1996, Hebert and Wassenaar 2001). Thus, $\delta^{13}C$ and $\delta^{15}N$ values may have useful east to west variability in central North America, given the forest to grassland transition from east to west in this region.

The potential east to west gradient provided by $\delta^{13}C$ and $\delta^{15}N$ values could be useful in determining natal origins of ducks that may migrate through Minnesota from states immediately to the east or west. Additionally, isotopic values for δD from precipitation provide a gradient of decreasing δD from southeast to northwest across North America (Chamberlain et al. 1997, Hobson and Wassenaar 1997). Therefore, using $\delta^{13}C$, $\delta^{15}N$ and δD values in a single predictive model may provide more accurate estimation of natal origins of longitudinal migrants.

Thesis Overview

In Chapter 2, I report results from a matched-pairs experimental study (cf. Olsen and Afton 2000, Caswell et al. 2003) to determine whether use of SWDs by hunters: 1) increases hunting vulnerability of mallards, 2) increases hunter selectivity and effectiveness, and 3) whether these response variables differ by time of season. In Chapter 3, I summarize results from a post-hunt questionnaire (cf. Olsen and Afton 1999) designed to determine prior hunting experience and use and opinions of SWDs of volunteers participating in experimental hunts. In Chapter 4, I use known isotope values from feathers of flightless mallard ducklings collected Minnesota, North Dakota, South Dakota, and Wisconsin to differentiate natal origins of HY mallards killed during experimental hunts in Minnesota. Additionally, I analyze band recoveries of HY and LOCAL ducks to determine whether harvest of Minnesota and migrant (i.e., banded elsewhere) mallards varied temporally during recent hunting seasons (1995-2001) and compare these results to those of my isotope analysis. Finally, I summarize my overall conclusions in Chapter 5.

Literature Cited

Alexander, S. A., K. A. Hobson, C. L. Gratto-Trevor, and A. W. Diamond. 1996. Conventional and isotopic determinations of shorebird diets at an island stopover: the importance of invertebrates and *Potamogeton pectinatus* tubers. Canadian Journal of Zoology 74: 1057-1068.

Anderson, D. R. 1975. Population ecology of the mallard: V. Temporal and geographic estimates of survival, recovery, and harvest rates. U. S. Fish and Wildlife Service Resource Publication 125.

Caccamise, D. F., L. M. Reed, P. M. Castelli, S. Wainright, T. C. Nichols. 2000. Distinguishing migratory and resident Canada geese using stable isotope analysis. Journal of Wildlife Management 64: 1084-1091.

California Fish and Game Commission. 2001. 2001-02 California waterfowl hunting regulations. Sacramento, California, USA.

Caswell, J. H., A. D. Afton, and F. D. Caswell. 2003. Vulnerability of non-target goose species to hunting with electronic snow goose calls. Wildlife Society Bulletin 31: *in press*.

Caswell, J. H., and F. D. Caswell. 2003. Vulnerability of mallards to hunting with a spinning-wing decoy in Manitoba. Wildlife Society Bulletin: *in review*.

Chamberlain, C. P., J. D. Blum, R. T. Holmes, X. Feng, T. W. Sherry, and G. R. Graves. 1997. The use of isotope tracers for identifying populations of migratory birds. Oecologia 109: 132-141.

Cox, R. R., Jr., A. D. Afton, and R. M. Pace, III. 1998. Survival of female northern pintails wintering in southwestern Louisiana. Journal of Wildlife Management 62: 1512-1521.

Dufour, K. W., C. D. Ankney, and P. J. Weatherhead. 1993. Condition and vulnerability to hunting among mallards staging at Lake St. Clair, Ontario. Journal of Wildlife Management 57: 209-215.

Eadie, J. M., T. G. Moore, and J. T. Ackerman. 2002. Experimental evaluation of the effect of a mechanical decoy (moto-duck) on hunting success and waterfowl response in California 1999-2000. Final report to the California Waterfowl Association. University of California, Davis, CA.

Fulton, D. C., J. Vlaming, J. S. Lawrence, and E. W. Price. 2002. The 2000 waterfowl hunting season in Minnesota: A study of hunters' opinions and activities. Final report to Minnesota Department of Natural Resources. USGS-Minnesota Cooperative Fish and Wildlife Research Unit, University of Minnesota, St. Paul, MN.

Greenwood, H., R. G. Clark, and P. J. Weatherhead. 1986. Condition bias of hunter-shot mallards *(Anas platyrhynchos)*. Canadian Journal of Zoology 64: 599-601.

Harvey, W. F., IV, L. J. Hindman, and W. E. Rhodes. 1995. Vulnerability of Canada geese to taxidermy-mounted decoys. Journal of Wildlife Management 59: 733-740.

Hebert, C. E., V. L. Wright, P. J. Zwank, J. D. Newsom, and R. L. Rhodes. 1984. Hunter performance using steel and lead loads for hunting ducks in coastal Louisiana. Journal of Wildlife Management 48: 388-398.

Hebert, C. E., and L. I. Wassenaar. 2001. Stable nitrogen isotopes in waterfowl feathers reveal long-term nitrification of agricultural landscapes. Environmental Science and Technology 35: 3482-3487.

Hobson, K. A., and R. G. Clark. 1992. Assessing avian diets using stable isotopes II: factors influencing diet tissue fractionation. Condor 94: 189-197.

Hobson, K. A., K. P. McFarland, L. I. Wassenaar, C. C. Rimmer, and J. E. Goetz. 2001. Linking breeding and wintering grounds of Bicknell's thrushes using stable isotope analysis of feathers. Auk 118: 16-23.

Hobson, K. A., and L. M. Wassenaar. 1997. Linking breeding and wintering grounds of neotropical migrant songbirds using stable hydrogen isotopic analysis of feathers. Oecologia 109: 142-148.

Humburg, D. D., S. L. Sheriff, P. H. Geissler, and T. Roster. 1982. Shotshell and shooter effectiveness: lead vs. steel shot for duck hunting. Wildlife Society Bulletin 10: 121-126.

Humburg, D. D., D. A. Graber and A. H. Raedeke. 2002. Missouri waterfowl status, 2002. Missouri Department of Conservation, Jefferson City, Missouri, USA.

Lajtha, K., and R. H. Michener, editors. 1994. Stable isotopes in ecology and environmental science. Blackwell, London, United Kingdom.

Lindberg, M. S., and R. A. Malecki. 1994. Hunting vulnerability of local and migrant Canada geese in Pennsylvania. Journal of Wildlife Management 58: 740-747.

McCracken, K. G., A. D. Afton, and M. S. Peters. 2000. Condition bias of hunter-shot ring-necked ducks exposed to lead. Journal of Wildlife Management 64: 584-590.

Minnesota Statutes 2002. 2002 Regular Session. Chapter 351-Senate File 2674. Section 20. Section 97B.811. Subdivision 4a. St. Paul, Minnesota, USA.

Olsen, R. E., and A. D. Afton. 1999. Goose hunter opinions concerning proposed management actions to reduce the mid-continent population of lesser snow geese. Wildlife Society Bulletin 27: 109-114.

Olsen, R. E., and A. D. Afton. 2000. Vulnerability of lesser snow geese to hunting with electronic calling devices. Journal of Wildlife Management 64: 983-993.

Oregon Fish and Wildlife Commission. 2002. Oregon Department of Fish and Wildlife news release, 11 October 2002. Salem, Oregon, USA.

Pace, R. M., III, and A. D. Afton. 1999. Direct recovery rates of lesser scaup banded in northwest Minnesota: sources of heterogeneity. Journal of Wildlife Management 63: 389-395.

Pennsylvania Game Commission. 2001. 2001-02 guide to migratory game bird hunting. Harrisburg, Pennsylvania, USA.

Peterson, B. J., and B. Fry. 1987. Stable isotopes in ecosystem studies. Annual Review of Ecological Systematics 18: 293-320.

Schroeder, S., D. C. Fulton, and J. S. Lawrence. 2003. The 2002 waterfowl hunting season in Minnesota: A study of hunters' opinions and activities. Preliminary report to Minnesota Department of Natural Resources. USGS-Minnesota Cooperative Fish and Wildlife Research Unit, University of Minnesota, St. Paul, MN.

Stott, R. S., and D. P. Olson. 1972. Differential vulnerability patterns among three species of sea ducks. Journal of Wildlife Management 36: 775-783.

Washington Department of Fish and Wildlife. 2001. 2001-02 Washington hunting regulations. Olympia, Washington, USA.

Wassenaar, L. M., and K. A. Hobson. 2000. Stable-carbon and hydrogen isotopes reveal breeding origins of red-winged blackbirds. Ecological Applications 10: 911-916.

Chapter 2. Effects of Spinning-wing Decoys on Flock Behavior and Hunting Vulnerability of Mallards in Minnesota

Introduction

Waterfowl managers in Minnesota and other states are concerned that local mallard (*Anas platyrhynchos*) breeding populations may be more vulnerable to hunters using spinning-wing decoys (hereafter SWDs) than are migrant ducks, and thus, that local breeding populations may be negatively affected by the use of SWDs. Successful nesting females and many hatch-year (HY) mallards are present on, or near, brood marshes at the beginning of the hunting season in Minnesota and may be especially vulnerable to hunters (Gilmer et al. 1977, Kirby et al. 1989). However, many hunters believe that SWDs increase hunter effectiveness by reducing crippling and enabling hunters to better select drakes over hens (see Chapter 1).

Field studies in California (Eadie et al. 2002), Missouri (Humburg et al. 2002), and Manitoba (Caswell and Caswell 2003) indicated that SWDs increase vulnerability of mallards to hunters. Eadie et al. (2002) reported that effectiveness of SWDs declined throughout the 1999-2000 hunting season in California because naïve and/or HY ducks were harvested early in the season and/or because SWD effectiveness was diluted later in the season when a larger proportion of hunters used them. Accordingly, SWDs subsequently were prohibited until 30 November in California (California Fish and Game Commission 2001). Similarly, use of SWDs on all public waters was restricted until the Saturday nearest 8 October in Minnesota beginning in 2002 (Minnesota Statutes 2002). Knowledge of the vulnerability of mallards to hunters using SWDs would be useful in determining if and when SWDs should be restricted in Minnesota. Accordingly, my general objectives were to quantify effects of SWDs on: 1) flock behavior of mallards, 2) hunter success and effectiveness, 3) harvest composition (by species, age, body condition, and sex), and 4) determine whether any of these effects differed between the first and second halves of the hunting season.

More specifically, I predicted that if mallards are more vulnerable to hunters using SWDs, then flock responses, sizes of responding flocks, and kill rates of mallards would be higher when SWDs were turned ‘ON’ than ‘OFF’ (cf. Olsen and Afton 2000, Caswell et al. 2003, Caswell and Caswell 2003). Similarly, I predicted that if ducks approached closer to hunters when SWDs were turned ‘ON’, then crippling rates and crippling proportions of mallards would be lower when SWDs were turned ‘ON’ than ‘OFF’.

Given that HY ducks generally are more vulnerable to hunters than are after-hatch-year (AHY) ducks (Anderson 1975, Cox et al. 1998, Pace and Afton 1999), I predicted that if mallards are more vulnerable to hunters using SWDs, then proportionally more AHY mallards would be killed with SWDs turned ‘ON’ than ‘OFF’. Body condition of ducks generally is inversely related to probability of harvest by hunters using decoys (Greenwood et al. 1986, Dufour et al. 1993, Cox et al. 1998, Pace and Afton 1999, McCracken and Afton 2000). Therefore, I predicted that if mallards are more vulnerable to hunters using SWDs, then body condition of mallards would be higher, on average, when killed with SWDs turned ‘ON’ than ‘OFF’ (cf. Olsen and Afton 2000). I also predicted that if SWDs enable hunters to better select drakes over hens, then proportionally more drakes would be killed when SWDs were turned ‘ON’ than ‘OFF’ based on hunter preference (Metz and Ankney 1991).

Finally, given conflicting results regarding temporal variation in vulnerability of ducks to SWDs (Eadie et al. 2002, Caswell and Caswell 2003), and restrictions of SWDs early in the hunting seasons in California and Minnesota, I examined whether vulnerability of mallards to SWDs was relatively greater during the first half of the season in Minnesota.

Study Area

I conducted experimental hunts in 17 Minnesota counties, from 28 September – 26 November 2002 (Figure 2.1). I selected counties to conduct experimental hunts based on mallard and total duck harvest from years 1995 – 2000 (see below), and reports from state and federal wildlife managers of areas where large concentrations of mallards were located during the 2002 hunting season. Specific counties (number of hunts) in which experimental hunts were conducted were: Becker (n = 20), Big Stone (n = 22), Clay (n = 1), Douglas (n = 4), Grant (n = 4), Houston (n = 15), Lac Qui Parle (n = 4), Marshall (n = 3), Otter Tail (n = 51), Pope (n = 29), Stearns (n = 3), Stevens (n = 2), Swift (n = 4), Todd (n = 2), Traverse (n = 8), Wabasha (n = 11), and Winona (n = 36).

Methods

Technician Training

I trained 3 research technicians and familiarized them with experimental hunt protocols in eastern North Dakota one week prior to the 2002 Minnesota duck season. I used ducks harvested in North Dakota to train technicians in aging and sexing techniques (Hochbaum 1942, Carney 1992) and recording morphometrics (Carney 1992, Dzubin and Cooch 1992). I terminated training when qualitative daily comparisons of flock observations and morphometrics recorded were accurate and similar among all observers. Accordingly, I assumed that observer bias did not influence my results.

Hunter Selection

I quantified mallard and total duck harvests in Minnesota by county and time period (7 to 10 day increments) using harvest data for years 1995-2000 (United States Fish and Wildlife Service [USFWS], unpublished harvest data). I then ranked (rank 1 = largest harvest) each

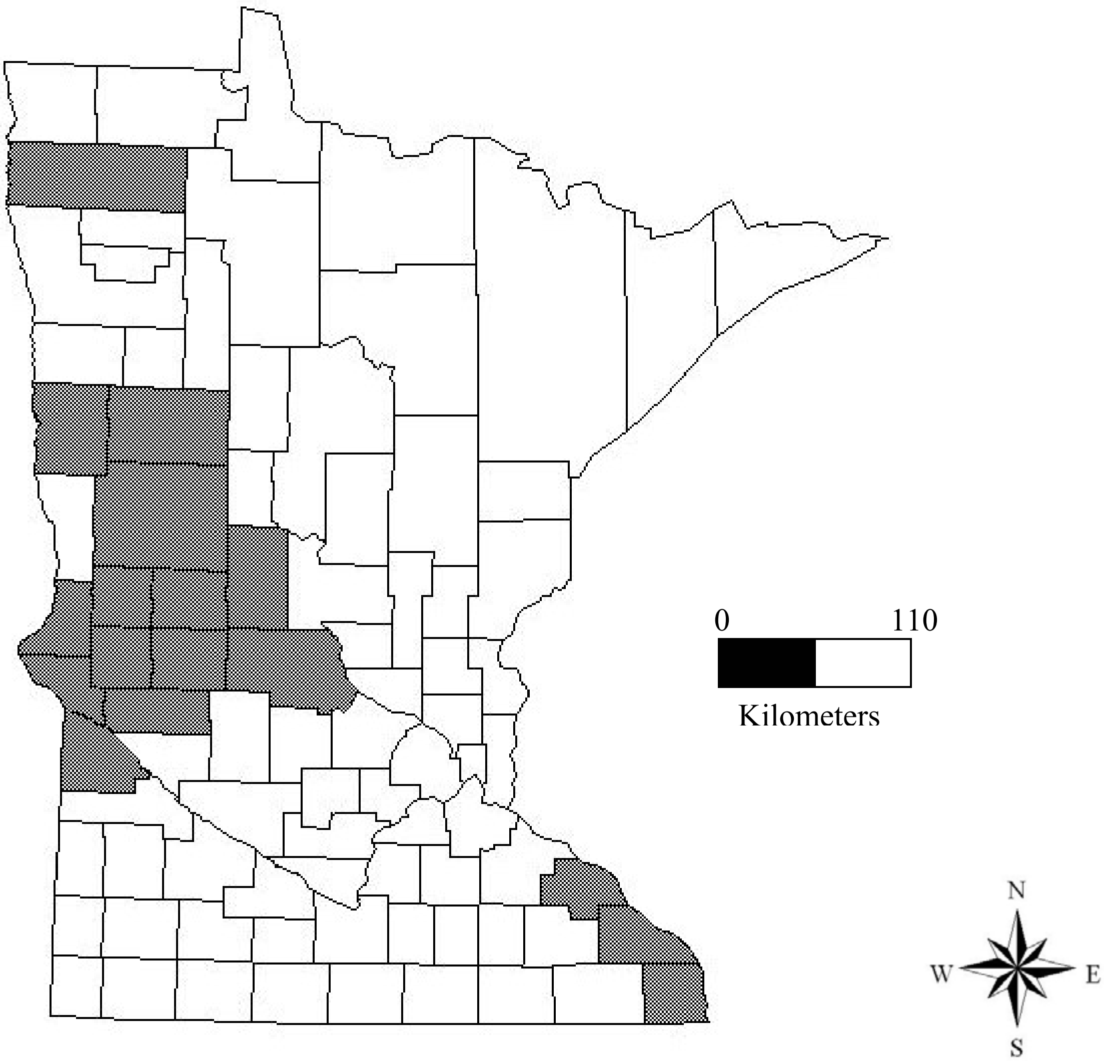


Figure 2.1. Locations of Minnesota counties (shaded) where experimental hunts were conducted, 28 September – 26 November 2002.

Minnesota county based on both mallard and total duck harvests within time periods to assign priority ranks ([mallard rank] + [total duck rank]; Appendix A). I subsequently contacted a random sample of hunters from the 2001 Minnesota Harvest Information Program (HIP) database (R. Lake, Minnesota Department of Natural Resources, unpublished HIP data) in those Minnesota counties that received highest priority ranks. I also directly contacted hunters encountered at boat landings, cafés, gas stations, public hunting areas, and sporting goods stores in these and nearby counties. Additionally, I posted informational flyers and handed out business cards to recruit hunters as volunteers; thus, some hunters contacted me directly to participate in experimental hunts.

Experimental Hunts

I compared 2 SWD treatments within each experimental hunt: 1) SWDs turned 'OFF' (control) and 2) SWDs turned 'ON' (experimental). I randomized the start order of SWD treatments for each experimental hunt, and alternated treatments during 15 min (minimum) sampling periods within each hunt (Olsen and Afton 2000, Caswell et al. 2003). I extended the duration of some sample periods so that flocks still under observation at the end of a period could be scored with regards to their response to decoy sets. Each experimental hunt consisted of 4 (minimum) to 10 (maximum) sampling periods (i.e., 2 to 5 pairs of control and experimental periods). Some hunts were limited to 4 sampling periods as per my scientific collecting permits (see below) and scheduling difficulties with volunteer hunters. I used 5 min buffer periods between sampling periods to ensure that ducks were not responding to stimuli from previous sampling periods and that all ducks killed during a sample period were retrieved and marked. Additionally, I did not allow calling or shooting during buffer periods. Ducks that responded to decoy sets during buffer periods were flushed and excluded from analysis.

I attempted to conduct experimental hunts everyday from 28 September – 26 November 2002 with a different group of 2 volunteer hunters for each hunt. However, due to logistical and scheduling difficulties, 1 to 4 hunters volunteered per hunt and a few hunters participated in multiple hunts. A total of 73 (33%), 106 (48%), 39 (18%) and 1 (<1%) of my experimental hunts were comprised of 1, 2, 3, and 4 volunteer hunters, respectively. A total of 326 hunters participated once, 36 hunters participated twice, and 5 hunters participated 3 times. I conducted experimental hunts twice a day (as could be scheduled) at locations that volunteer hunters had selected and were open to hunting. I asked volunteer hunters to select exact locations of their hunting blinds and decoys. I then placed 1 drake and 1 hen Mojo Mallard SWD (HuntWise, Bastrop, Louisiana, USA) within 15 m of hunters at locations and directions of their choice. I then began experimental hunts after volunteer hunters indicated that they were ready to begin hunting.

I prohibited hunters from altering decoy sets or blind placement after each experimental hunt began, and encouraged them to hunt as they typically would under ordinary hunting conditions. Furthermore, I asked hunters to follow all state and federal duck hunting regulations with exceptions provided by my Minnesota and USFWS scientific collecting permits. My permits allowed volunteer hunters under my supervision to: 1) hunt over SWDs during the period of prohibition in Minnesota (28 September – 5 October 2002) and 2) shoot up to 1 daily bag limit of ducks/hunter/15 min sampling period (i.e., 4 daily bag limits/hunter maximum); each hunter was allowed to retain only 1 daily bag limit at the conclusion of each day. Additionally, I was permitted to use remote controls to turn SWDs either ‘ON’ or ‘OFF’ for ensuing sample periods.

All flocks (≥ 1 duck) observed within 100 m of hunters were included in the experiment to determine flock responses to decoy sets (i.e., flew within 40 m; 'Yes' or 'No'; Appendix B). Additionally, I recorded: species composition, flock size, numbers of ducks killed by hunters (shot and retrieved), and numbers of ducks crippled by hunters (visibly hit by shot and not retrieved). I estimated distances from hunters to flocks using known distances from landmarks measured by Nikon Laser 400 rangefinders (Nikon Vision Company, Limited; Tokyo, Japan).

Following each experimental hunt, I determined age and sex of ducks killed using presence or absence of notched tail feathers, cloacal characteristics (Hochbaum 1942), and wing plumage (Carney 1992). I then recorded body mass using spring scales (±10 g) and the following morphometrics to index body size and estimate body condition: 1) notched-wing using a steel ruler (±1.0 mm); and 2) tarsus (±0.1 mm), 3) mid-toe (±0.1 mm), and 4) head length (±0.1 mm) using dial calipers (Dzubin and Cooch 1992). Ages and sexes of harvested mallards and other species (see Appendices C, D, E, and F) were confirmed later by certified checkers at the USFWS Mississippi Flyway wingbee and by myself, respectively.

Statistical Analysis

Flock Response.— I ran a mixed linear model analysis using a binomial error term and logit link function (GlimMix Macro; Littell et al. 1996) to test whether relative proportions of mallard flocks responding ([number of flocks approaching within 40 m]/[number of flocks observed within 100 m]/hunt) differed between SWD treatments (categorical; SWDs 'ON' or SWDs 'OFF'), time of season (categorical; early [days 1 – 30] or late [days 31 – 60]) and the 2-way interaction. I used backwards selection procedures to eliminate all non-significant ($P > 0.05$) terms from the full model, beginning with the 2-way interaction. I compared mallard flock responses during 132 hunts; 87 hunts lacked mallard flock observations for 1 of the SWD treatments, and thus, were excluded from analyses.

Sizes of Responding Flocks.— I ran a 2-way analysis of variance (ANOVA; PROC MIXED; Littell et al. 1996) to test whether sizes of responding mallard flocks differed between SWD treatments, time of season, and the 2-way interaction. I log-transformed flock size to meet assumptions of normality; least square means (95% CI) presented are back-transformed values. Model selection procedures were similar to those described for the analysis of flock response.

Kill Rates.— I ran a mixed linear model analysis using a poisson error term and log-linear link function (GlimMix Macro; Littell et al. 1996) to test whether mallard kill rates differed between SWD treatments, time of season, and the 2-way interaction. I calculated mallards killed/hr/hunter for each hunt with SWDs turned 'ON' and 'OFF'. Model selection procedures were similar to those described for the analysis of flock response.

Ages.— I used separate chi-square tests of independence (Agresti 1996) to determine whether numbers of AHY and HY mallards killed differed between SWD treatments and whether numbers of AHY and HY mallards killed differed by time of season. I used logistic regression analysis (PROC LOGISTIC; SAS Institute 1999) to determine whether relative proportions of AHY and HY mallards differed between SWD treatments, time of season, sexes, and all 2-way interactions. For analysis, I scored AHY mallards as "1" and HY mallards as "0". I used backwards selection procedures to eliminate all non-significant ($P > 0.05$) terms from the full model, beginning with the 2-way interactions.

Body Condition.— I indexed body size using principal component analysis (PROC PRINCOMP; SAS Institute 1999) of the correlation matrix of the 4 morphometrics taken from mallards killed during experimental hunts. I used first principal component (PC1) scores as a measure of body size for each individual (Alisauskas and Ankney 1987). PC1 explained 70% of the overall variation among morphometric variables, and all factor loadings were positive and ranged from 0.44 to 0.53. I then regressed (PROC REG; SAS Institute 1999) body mass on PC1, and adjusted each individual's mass for its size by adding the overall mean body mass of all mallards killed to the individual's residual from regression (Ankney and Afton 1988). I used size adjusted body mass of each duck as a measure of body condition (Dufour et al. 1993). I then used a 4-way ANOVA (PROC MIXED; Littell et al. 1996) to determine whether body condition of mallards differed between SWD treatments, time of season, age, sex, and all possible interactions. I used backwards selection procedures to eliminate non-significant ($P > 0.05$) terms from the full model, beginning with the 4-way interaction. I excluded 3 mallards from analysis because of extensive shot damage to morphometrics.

Sexes.— I used logistic regression analysis (PROC LOGISTIC; SAS Institute 1999) to determine whether relative proportions of male and female mallards killed differed between SWD treatments, time of season, ages, and all 2-way interactions. For analysis, I scored males as "1" and females as "0". Model selection procedures were similar to those described for the age analysis of mallards killed.

Crippling Rates and Proportions.— I ran a mixed linear model analysis using a poisson error term and log-linear link function (GlimMix Macro; Littell et al. 1996) to test whether mallard crippling rates differed between SWD treatments, time of season, and the 2-way interaction. I calculated mallards crippled/hr/hunter for each hunt with SWDs turned 'ON' and 'OFF'. Model selection procedures were similar to those described for the analysis of flock response.

I ran another mixed linear model analysis using a binomial error term and logit link function (GlimMix Macro; Littell et al. 1996) to test whether mallard crippling proportions ([total mallards crippled]/[total mallards hit by shot]/hunt) differed between SWD treatments, time of season, and the 2-way interaction. I compared mallard crippling proportions during 29 experimental hunts; 190 hunts lacked observations of mallards hit by shot for 1 of the SWD treatments, and thus, were excluded from analysis. Model selection procedures were similar to those described for the analysis of flock response. Finally, I determined type II error rates of my analysis of crippling proportions using power analysis (University of California, Los Angeles 2002).

Results

Hunter Selection

A total of 367 volunteer hunters participated in my SWD experimental hunts. I contacted 70 (19%) of these hunters randomly from HIP lists and 269 (73%) directly in the field; 28 (8%) hunters contacted me directly.

Experimental Hunts

I conducted 220 experimental hunts; however, 1 hunt was excluded from analysis because dense fog prevented accurate observations. I conducted equal numbers of SWD treatments during a total of 1556 sampling periods.

Flock Response.— A total of 386 (43%) and 158 (22%) mallard flocks approached within 40 m of hunters with SWDs turned 'ON' and 'OFF', respectively (Table 2.1). My final model indicated that mallard flock responses differed between SWD treatments. The odds ratio indicated that mallard flocks were 2.91 times more likely to respond when SWDs were turned 'ON' than 'OFF' ($F_{1, 131} = 37.48$, $P < 0.001$). However, flock response did not differ by time of

Table 2.1. Numbers of mallard flocks that were observed within 100 m and subsequently approached within 40 m (%) of hunters by time of season with SWDs turned ON and OFF, 28 September – 26 November 2002.

	ON		OFF		Total	
Season[a]	100 m	40 m	100 m	40 m	100 m	40 m
Early	372	177 (48%)	257	59 (23%)	629	236 (38%)
Late	530	209 (39%)	474	99 (21%)	1004	308 (31%)
Combined	902	386 (43%)	731	158 (22%)	1633	544 (33%)

[a] Early = 28 September – 27 October 2002; Late = 28 October – 26 November 2002.

season ($F_{1, 131} = 0.62$, $P = 0.437$), and the 2-way interaction also was not significant ($F_{1, 130} = 0.33$, $P = 0.569$).

Size of Responding Flocks.— Size of responding mallard flocks ($n = 544$ total) ranged from 1 to 380 with a mean ± SE, median, and mode of 6.43 ± 0.93, 2, and 1 individuals, respectively. My final model indicated that size of responding mallard flocks differed between SWD treatments ($F_{1, 541} = 4.90$, $P = 0.027$) and time of season ($F_{1, 541} = 11.18$, $P = 0.001$); however, the 2-way interaction was not significant ($F_{1, 540} = 0.21$, $P = 0.645$). Responding mallard flocks averaged 1.25 times larger in size during periods when SWDs were turned 'ON' (log back-transformed LS Means, 95% CI = 2.63, 2.36 to 2.93) than 'OFF' (log back-transformed LS Means, 95% CI = 2.10, 1.77 to 2.28). Responding flocks averaged 1.37 times larger in size early (log back-transformed LS Means, 95% CI = 2.75, 2.37 to 3.18) than late in the season (log back-transformed LS Means, 95% CI = 2.01, 1.77 to 2.28).

Kill Rates.— Hunters killed a total of 221 mallards during experimental hunts for an average of 0.53 mallards/hunter/hunt. Only 21 (5%) hunters killed a daily bag limit during experimental hunts (i.e., 4 mallards, of which no more than 2 hens). Mallards comprised 43% of the total duck kill during experimental hunts, and 176 (80%) and 45 (20%) of these were killed with SWDs turned 'ON' and 'OFF', respectively (Table 2.2). My final model indicated that mallard kill rates differed between SWD treatments ($F_{1, 218} = 154.84$, $P < 0.001$). Kill rates averaged 4.71 times higher when SWDs were turned 'ON' (LS Means, 95% CI = 0.227, 0.176 to 0.293) than 'OFF' (LS Means, 95% CI = 0.048, 0.035 to 0.067). Kill rates did not differ by time of season ($F_{1, 218} = 1.20$, $P = 0.275$), and the 2-way interaction also was not significant ($F_{1, 217} = 1.22$, $P = 0.279$).

Table 2.2. Numbers (%) of mallards that were killed and crippled (hit and not retrieved) by time of season with SWDs turned ON and OFF, 28 September – 26 November 2002.

	Killed			Crippled		
Season[a]	ON	OFF	Total	ON	OFF	Total
Early	78 (76%)	24 (24%)	102 (46%)	39 (76%)	12 (24%)	51 (47%)
Late	98 (82%)	21 (18%)	119 (54%)	47 (82%)	10 (18%)	57 (53%)
Combined	176 (80%)	45 (20%)	221 (100%)	86 (80%)	22 (20%)	108 (100%)

[a] Season defined as in Table 2.1.

Ages.— A total of 61 (69%) and 28 (31%) AHY mallards were killed with SWDs turned 'ON' and 'OFF', respectively (Table 2.3). A total of 115 (87%) and 17 (13%) HY mallards were killed with SWDs turned 'ON' and 'OFF', respectively (Table 2.3). Both AHYs ($\chi^2 = 6.12$, $DF = 1$, $P < 0.025$) and HYs ($\chi^2 = 36.38$, $DF = 1$, $P < 0.001$) were more likely to be killed with SWDs turned 'ON' than 'OFF'. A total of 45 (51%) and 44 (49%) AHYs were killed during the first and second halves of the season, respectively (Table 2.3). A total of 57 (43%) and 75 (57%) HYs were killed during the first and second halves of the season, respectively (Table 2.3). Numbers of both AHYs ($\chi^2 = 0.005$, $DF = 1$, $P > 0.90$) and HYs ($\chi^2 = 1.23$, $DF = 1$, $P > 0.25$) killed did not differ between the first and second halves of the season.

The overall age ratio for mallards killed during experimental hunts was 1.48; age ratios were 1.89 and 0.61 with SWDs turned 'ON' and 'OFF', respectively (Table 2.3). My final model indicated that relative proportions of AHYs and HYs killed during experimental hunts differed between SWD treatments. The odds ratio indicated that, when compared to HYs, AHYs were relatively less likely to be killed with SWDs turned 'ON' than 'OFF' (Odds Ratio = 0.322; Wald $\chi^2 = 10.73$, $P = 0.001$). Relative proportions of AHYs and HYs killed did not differ between time of season (Wald $\chi^2 = 0.74$, $P = 0.391$) or sexes (Wald $\chi^2 = 0.02$, $P = 0.915$), and none of the 2-way interactions were significant (all Ps > 0.23).

Body Condition.— My final model indicated that body condition of mallards killed differed between ages ($F_{1, 216} = 11.39$, $P = 0.001$), but was similar between sexes ($F_{1, 213} = 1.65$, $P = 0.20$), SWD treatments ($F_{1, 214} = 1.90$, $P = 0.169$), and time of season ($F_{1, 215} = 3.75$, $P = 0.054$). Furthermore, none of the interactions were significant (i.e., all Ps > 0.09). Body condition of HY mallards (LS Means size adjusted body mass, 95% CI = 1159.69 g, 1143.56 to

Table 2.3. Numbers of HY, AHY, and age ratios (HY/AHY) of mallards that were killed by time of season with SWDs turned ON and OFF, 28 September – 26 November 2002.

	ON			OFF			Total		
Season[a]	HY	AHY	Age ratio	HY	AHY	Age ratio	HY	AHY	Age ratio
Early	49	29	1.69	8	16	0.50	57	45	1.27
Late	66	32	2.06	9	12	0.75	75	44	1.70
Combined	115	61	1.89	17	28	0.61	132	89	1.48

[a] Season defined as in Table 2.1.

1175.82) was lower, on average, than that of AHY mallards (LS Means size adjusted body mass, 95% CI = 1203.39 g, 1183.60 to 1223.18).

Sexes.— Relative proportions of male and females killed did not differ between SWD treatments (Wald $\chi^2 = 0.30$, $P = 0.581$), time of season (Wald $\chi^2 = 2.04$, $P = 0.152$), or ages (Wald $\chi^2 = 0.11$, $P = 0.741$), and none of the 2-way interactions were significant (all *P*s > 0.30). The overall sex ratio for mallards killed was 1.63.

Crippling Rates.— Overall, 86 (80%) and 22 (20%) mallards were crippled when SWDs were turned 'ON' and 'OFF', respectively (Table 2.2). My final model indicated that mallard crippling rates differed between SWD treatments ($F_{1, 218} = 130.30$, $P < 0.001$). Crippling rates averaged 5.22 times higher when SWDs were turned 'ON' (LS Means, 95% CI = 0.102, 0.077 to 0.135) than 'OFF' (LS Means, 95% CI = 0.02, 0.013 to 0.028). However, crippling rates did not differ by time of season ($F_{1, 218} = 0.37$, $P = 0.545$), and the 2-way interaction also was not significant ($F_{1, 217} = 0.20$, $P = 0.658$).

Crippling Proportions.— Overall, 262 (80%) and 67 (20%) mallards were hit by shot when SWDs were turned 'ON' and 'OFF', respectively; and of those, 86 (33%) and 22 (33%) were crippled when SWDs were turned 'ON' and 'OFF', respectively (Table 2.2). Overall, 33% of mallards hit by shot were crippled (Table 2.2). Mallard crippling proportions did not differ between SWD treatments ($F_{1, 28} = 0.76$, $P = 0.390$) or time of season ($F_{1, 28} = 0.29$, $P = 0.595$), and the 2-way interaction also was not significant ($F_{1, 27} = 0.64$, $P = 0.432$).

Discussion

Vulnerability of Mallards to Hunters Using SWDs

Waterfowl managers in Minnesota and other states are concerned that increased kill rates associated with the use of spinning-wing decoys (SWDs) may negatively affect local breeding populations of mallards. Hunters may have greater harvest opportunity if flocks of mallards are more likely to respond to decoy sets containing SWDs. My results generally support the hypothesis that mallards are more vulnerable to hunters using SWDs.

As predicted, I found that mallard flocks were more likely to respond to decoy sets when SWDs were turned 'ON' than 'OFF'. Additionally, I found that size of responding mallard flocks was 1.25 times larger when SWDs were turned 'ON' than 'OFF'.

Also as predicted, I found that mallard kill rates averaged 4.71 times higher when SWDs were turned 'ON' than 'OFF'. However, only 5% of volunteer hunters actually achieved daily mallard bag limits during experimental hunts. Furthermore, volunteer hunters, on average, killed only 0.53 mallards/hunter/hunt, despite the potential to exceed daily bag limits as allowed by my scientific collecting permits. Thus, despite increased kill rates, use of SWDs in Minnesota does not guarantee achievement of a daily bag limit of mallards. However, given the large differential in kill rates between SWD treatments and the large number of Minnesota waterfowl hunters, the percentage of hunters using SWDs could greatly influence mallard harvests in Minnesota.

HY ducks generally are more vulnerable to hunters than are AHY ducks (Anderson 1975, Cox et al. 1998, Pace and Afton 1999). I found that more AHY and HY mallards were killed when SWDs were turned 'ON' than 'OFF'; however, AHY mallards were relatively less likely than were HY mallards to be killed with SWDs turned 'ON'. Thus, HY mallards that survive their initial hunting season may learn to avoid hunters using SWDs in subsequent years.

My results were not consistent with the prediction that if mallards are more vulnerable to hunters using SWDs, then body condition of mallards would be higher when killed with SWDs were turned 'ON' than those when SWDs were turned 'OFF'. I found that body condition of mallards was similar between SWD treatments and differed only between ages. Given that relative vulnerability of mallards to SWDs also differed between ages, I expected that the age x treatment interaction to be important in describing variability in body condition of mallards. However, I found that neither the age x SWD treatment interaction nor SWD treatment main effects were significant (i.e., all *P*s > 0.05) in my body condition analysis. However, others have reported that waterfowl killed by hunters using electronic calls or SWDs were in better condition, on average, than were those killed by hunters using traditional hunting methods (Olsen and Afton 2000, Caswell and Caswell 2003).

Potential Effects of SWDs on Mallard Harvests in Minnesota

I modeled potential increases in mallard harvests for various percentages of Minnesota hunters using SWDs. My predictive model was based on: 1) observed kill rate differentials, 2) mallard harvests from HIP data for Minnesota in 2000 and 2002 (E. M. Martin and P. I. Padding, USFWS, unpublished report), and 3) estimated percentages of hunters using SWDs in Minnesota during 2000 and 2002 (Fulton et al. 2002, Schroeder et al. 2003). I first estimated mallard harvests in 2000 and 2002 without the use of SWDs (i.e., 197,740 and 141,705 mallards, respectively) and then estimated harvests, assuming a linear relationship, for various percentages of hunters using SWDs for those years. Based on my calculations, 47% and 79% of hunters using SWDs would be sufficient to double the 2000 and 2002 Minnesota mallard harvests, respectively (Figure 2.2).

Given the lack of information, and a desire to present a worst-case scenario, I made the assumption that the relationship between use of SWDs and increases in mallard harvests was linear. However, I suspect that subsequent research will detect a curvilinear relationship between these variables due to: 1) a possible negative relationship between mallard flock

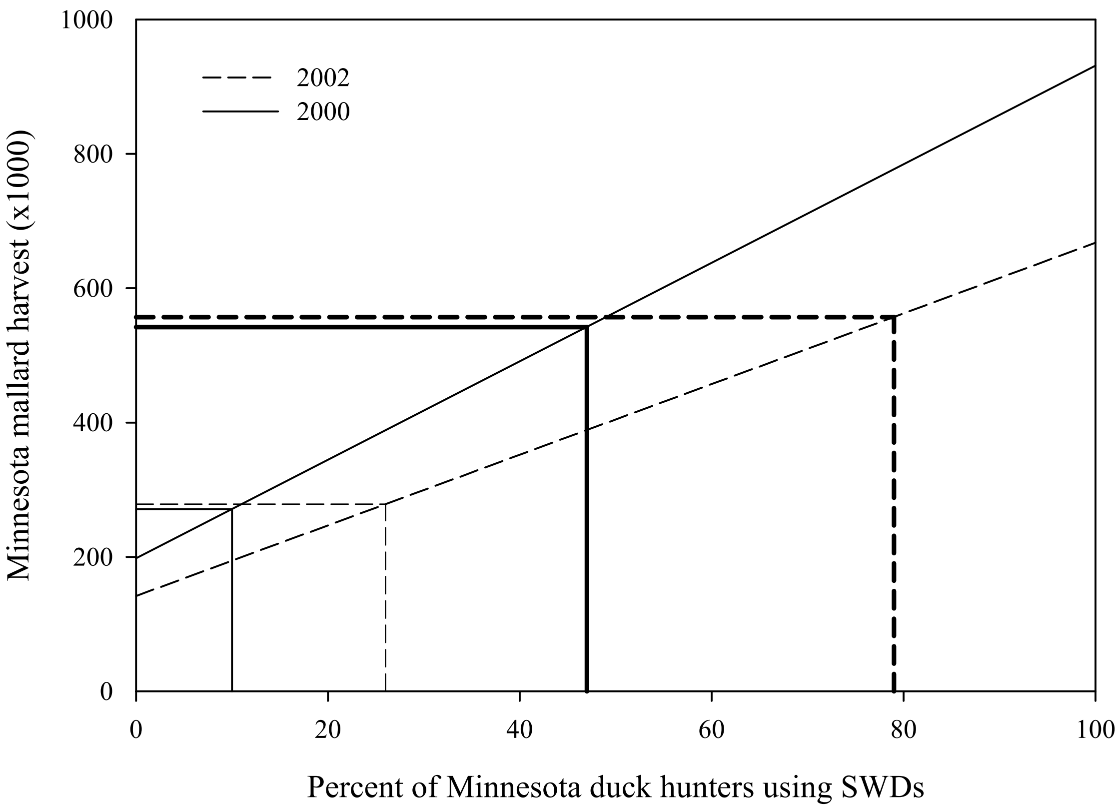


Figure 2.2. Predicted Minnesota mallard harvests with increasing use of SWDs by Minnesota duck hunters. Drop lines indicate observed Minnesota mallard harvests and percentages of hunters using SWDs in 2000 and 2002, and projected percentages of hunters using SWDs that would double harvest in those years (bold lines).

response and percentages of hunters using SWDs (cf. Eadie et al. 2002), and 2) a possible decline in the number of ducks available to harvest as use of SWDs increases. Consequently, my estimates of percentages of hunters using SWDs required to double Minnesota mallard harvests probably are biased low, and doubling of the harvest may not be achievable even if all duck hunters used SWDs in Minnesota.

Hunter Selectivity and Effectiveness Using SWDs

Hunters prefer to shoot drakes over hens (Metz and Ankney 1991) and many believe that SWDs enable them to better select drakes over hens by attracting ducks closer (see Chapter 1). In contrast to those beliefs, I found no evidence that drakes were relatively more likely than were hens to be killed by volunteer hunters in Minnesota when SWDs were turned 'ON'. Thus, I conclude that use of SWDs did not allow hunters to better select drakes over hens. Furthermore, many hunters believe that SWDs increase their effectiveness by decreasing crippling (see Chapter 1). I found that mallard crippling rates (cripples/hunter/hr/hunt) were higher when SWDs were turned 'ON' than 'OFF', which probably was related to the greater number of shooting opportunities available when SWDs were turned 'ON' than 'OFF'. In contrast, I found no evidence that mallard crippling proportions differed between SWD treatments. However, my analysis of crippling proportions was limited (power = 0.10) by a relatively small sample size of hunts ($n = 29$). Thus, I tentatively conclude that use of SWDs did not increase hunter effectiveness in Minnesota.

Caswell and Caswell (2003) reported that mallard crippling proportions were lower when SWDs were turned 'ON' than 'OFF' during experimental hunts in Manitoba. However, they did not analyze individual hunts as the experimental unit, and thus, different groups of hunters, possibly with different shooting abilities and/or hunting situations, may have greatly influenced their results.

Time of Season

Eadie et al. (2002) suggested that effectiveness of SWDs declined later in the hunting season because naïve ducks were harvested early in the season. Based on their results, the California Fish and Game Commission (2001) prohibited the use of SWDs until 30 November in California. In contrast, Caswell and Caswell (2003) and I did not detect seasonal differences in mallard kill rates by SWD treatments.

Local HY mallards frequently are located near their brooding areas at the beginning of the Minnesota hunting season and comprise a large proportion of the kill early in the season (Gilmer 1977, and Kirby et al. 1989). I found that numbers of HY mallards killed during the first and second halves of the season did not differ; however, it is unknown whether numbers of local HY mallards killed differed by time of season. My logistic regression analysis indicated that relative proportions of AHY and HY mallards killed when SWDs were turned 'ON' also were similar during the first half and second half of the season.

Management Implications

If mallard harvests were to increase in other states, as projected as a worst-case scenario in Minnesota, then the frequency of promulgation of restrictive regulatory packages probably would increase under Adaptive Harvest Management models (AHM; Williams and Johnson 1995). Increasing use of SWDs by duck hunters in Minnesota and other northern states could result in a partial re-distribution of annual mallard harvests if naïve ducks are harvested upon initial exposures to SWDs, and those ducks that survive migrations to southern wintering areas become habituated to SWDs (cf. Eadie et al. 2002). Indeed, my results suggest that AHY mallards have learned to avoid SWDs. However, my study was confined to a single hunting season in Minnesota, and thus, did not assess whether vulnerability of mallards to hunters using SWDs differs among years or geographically. A multi-year, flyway-wide study is needed to make stronger and more rigorous inferences regarding potential changes in annual harvest rates of mallards due to increasing use of SWDs by hunters in North America.

Literature Cited

Agresti, A. 1996. An introduction to categorical data analysis. John Wiley & Sons, New York, New York, USA.

Alisauskas, R. T., and C. D. Ankney. 1987. Age-related variation in the nutrient reserves of breeding American coots (*Fulica americana*). Canadian Journal of Zoology 65: 2417-2420.

Anderson, D. R. 1975. Population ecology of the mallard: V. Temporal and geographic estimates of survival, recovery, and harvest rates. U. S. Fish and Wildlife Service Resource Publication 125.

Ankney, C. D., and A. D. Afton. 1988. Bioenergetics of breeding northern shovelers: diet, nutrient reserves, clutch size, and incubation. Condor 90: 459-472.

California Fish and Game Commission. 2001. 2001-02 California waterfowl hunting regulations. Sacramento, California, USA.

Carney, S. M. 1992. Species, age, and sex identification of ducks using wing plumage. U.S. Department of the Interior, U.S. Fish and Wildlife Service. Washington, D.C., USA.

Caswell, J. H., A. D. Afton, and F. D. Caswell. 2003. Vulnerability of non-target goose species to hunting with electronic snow goose calls. Wildlife Society Bulletin 31: *in press*.

Caswell, J. H., and F. D. Caswell. 2003. Vulnerability of mallards to hunting with a spinning-wing decoy in Manitoba. Wildlife Society Bulletin: *in review*.

Cox, R. R., Jr., A. D. Afton, and R. M. Pace, III. 1998. Survival of female northern pintails wintering in southwestern Louisiana. Journal of Wildlife Management 62: 1512-1521.

Dufour, K. W., C. D. Ankney, and P. J. Weatherhead. 1993. Condition and vulnerability to hunting among mallards staging at Lake St. Clair, Ontario. Journal of Wildlife Management 57: 209-215.

Dzubin, A., and E. G. Cooch. 1992. Measurements of geese: general field methods. California Waterfowl Association, Sacramento, California, USA.

Eadie, J. M., T. G. Moore, and J. T. Ackerman. 2002. Experimental evaluation of the effect of a mechanical decoy (moto-duck) on hunting success and waterfowl response in California 1999-2000. Final report to the California Waterfowl Association. University of California, Davis, CA.

Fulton, D. C., J. Vlaming, J. S. Lawrence, and E. W. Price. 2002. The 2000 waterfowl hunting season in Minnesota: A study of hunters' opinions and activities. Final report to Minnesota Department of Natural Resources. USGS-Minnesota Cooperative Fish and Wildlife Research Unit, University of Minnesota, St. Paul, MN.

Gilmer, D. S., R. E. Kirby, I. J. Ball, and J. H. Reichmann. 1977. Post-breeding activities of mallards and wood ducks in north-central Minnesota. Journal of Wildlife Management 41: 345-359.

Greenwood, H., R. G. Clark, and P. J. Weatherhead. 1986. Condition bias of hunter-shot mallards *(Anas platyrhynchos)*. Canadian Journal of Zoology 64: 599-601.

Hochbaum, H. A. 1942. Sex and age determination in waterfowl by cloacal examination. Transactions of the North American Wildlife Conference 7: 299-307.

Humburg, D. D., D. A. Graber, and A. H. Raedeke. 2002. Missouri waterfowl status, 2002. Missouri Department of Conservation, Jefferson City, Missouri, USA.

Kirby, R. E., L. M. Cowardin, and J. R. Tester. 1989. Premigrational movements and behavior of young mallards and wood ducks in north central Minnesota. U.S. Fish and Wildlife Service, Fish and Wildlife Research Report 5.

Littell, R. C., G. A. Milliken, W. W. Stroup, and R. D. Wolfinger. 1996. SAS system for mixed models. Cary, North Carolina, USA.

McCracken, K. G., A. D. Afton, and M. S. Peters. 2000. Condition bias of hunter-shot ring-necked ducks exposed to lead. Journal of Wildlife Management 64: 584-590.

Metz, K. J., and C. D. Ankney. 1991. Are brightly coloured male ducks selectively shot by duck hunters? Canadian Journal of Zoology 69: 279-282.

Minnesota Statutes 2002. 2002 Regular Session. Chapter 351-Senate File 2674. Section 20. Section 97B.811. Subdivision 4a. St. Paul, Minnesota, USA.

Olsen, R. E., and A. D. Afton. 2000. Vulnerability of lesser snow geese to hunting with electronic calling devices. Journal of Wildlife Management 64: 983-993.

Pace, R. M., III, and A. D. Afton. 1999. Direct recovery rates of lesser scaup banded in northwest Minnesota: sources of heterogeneity. Journal of Wildlife Management 63: 389-395.

SAS Institute. 1999. SAS/STAT user's guide, 8.02 edition. SAS Institute, Cary North Carolina, USA.

Schroeder, S., D. C. Fulton, and J. S. Lawrence. 2003. The 2002 waterfowl hunting season in Minnesota: A study of hunters' opinions and activities. Preliminary report to Minnesota Department of Natural Resources. USGS-Minnesota Cooperative Fish and Wildlife Research Unit, University of Minnesota, St. Paul, MN.

University of California, Los Angeles. 2002. Power calculator. Available online at: http://calculators.stat.ucla.edu/powercalc.

Williams, B. K., and F. A. Johnson. 1995. Adaptive management and the regulation of waterfowl harvests. Wildlife Society Bulletin 23: 430-436.

Chapter 3. Summary of Use and Opinions of Spinning-wing Decoys by Duck Hunters Participating in the Minnesota Study

Introduction

The perceived ability of spinning-wing decoys (hereafter SWDs) to attract ducks from long distances has influenced hunter opinions of the use of such technology. Some hunters believe that use of SWDs oversteps ethical bounds of "fair chase" and increases harvest above acceptable levels. Other hunters believe that SWDs attract ducks closer, and thus, are beneficial in reducing crippling and enabling selective harvest of drakes over hens. Moreover, hunters currently not using SWDs may choose to do so in the future based on opinions that SWDs increase hunter effectiveness and selectivity.

During the 2000 hunting season, only 10% of Minnesota waterfowl hunters used SWDs (Fulton et al. 2002). In 2002, use of SWDs increased to 26% of Minnesota hunters, but generally was lower than current estimates in other states (Schroeder et al. 2003). Knowledge of current and future SWD utilization, and factors that influence their use, would be useful in modeling potential changes in annual harvest rates due to hunter use of SWDs.

My objectives here were to: 1) summarize hunting experience and demographics, and use and opinions of SWDs by volunteer hunters participating in experimental duck hunts in Minnesota (see Chapter 2), 2) determine whether plans to use SWDs in the future vary among hunters with different opinions concerning the use of SWDs, and 3) compare selected responses from my post-hunt questionnaires to those of state-wide surveys conducted by Fulton et al. (2002) and Schroeder et al. (2003).

Specifically, I address two questions of management concern: 1) are hunters that believe SWDs enable them to reduce crippling or selectively shoot more drakes more likely to use

SWDs in the future, and 2) do hunters that believe SWDs violate "fair chase" ethics plan to use SWDs in the future?

Methods

Hunter Selection

I surveyed volunteer hunters that were selected and subsequently participated in experimental duck hunts in Minnesota, 28 September – 26 November 2002 (see Chapter 2). I initially quantified mallard and total duck harvests in Minnesota by county and time period (7 to 10 day increments) using harvest data for years 1995-2000 (United States Fish and Wildlife Service [USFWS], unpublished harvest data). I then ranked counties within time periods for mallard and total duck harvest to assign priority ranks (Appendix A). I subsequently contacted a random sample of hunters from the 2001 Minnesota HIP database (R. Lake, Minnesota Department of Natural Resources, unpublished HIP data) that resided in those counties with highest priority ranks. I also directly contacted hunters encountered at boat landings, cafés, gas stations, public hunting areas, and sporting goods stores in these and nearby counties. Additionally, I posted informational flyers and handed out business cards to recruit hunters as volunteers; thus, some hunters contacted me directly to participate in experimental hunts.

Following experimental hunts (see Chapter 2), I asked volunteer hunters to anonymously complete a 1-page questionnaire (cf. Olsen and Afton 1999). The questionnaire was designed to obtain information regarding prior duck hunting experience, hunter demographics, and use and opinions of SWDs (Appendix G).

Statistical Analysis

I estimated the mean ± SE, median, mode, and range for all continuous responses from post-hunt questionnaires (PROC UNIVARIATE, PROC MEANS; SAS Institute 1999).

Additionally, I summarized all categorical responses by table cell counts (PROC FREQ; SAS Institute 1999). I used chi-square tests of independence (Agresti 1996) to determine whether hunters, that believed SWDs enable them to reduce crippling, shoot more drakes, and/or violate "fair chase" ethics, were more likely to use SWDs in the future.

Results

Hunter Selection

A total of 367 volunteer hunters participated in my experimental hunts. I contacted 70 (19%) of these hunters randomly from HIP lists and 269 (73%) directly in the field; 28 (8%) hunters contacted me. I obtained 366 completed questionnaires following my experimental hunts; I forgot to provide a questionnaire to 1 hunter. Sample sizes varied slightly among questions because a few hunters (5 of 366) did not completely fill out their questionnaires.

Hunter Responses

Hunter Age and Gender.— Ages of volunteer hunters (n = 364) ranged from 12 to 77 years with a mean ± SE, median, and mode of 36.3 ± 0.7, 35, and 29, respectively. Volunteer hunters included 364 males and 2 females.

Years Duck Hunting.— Sixty-nine percent of hunters (n = 366) had 11 or more years duck hunting experience (Table 3.1). The categorical breakdown of previous years hunting (i.e., 1 = <3 years, 2 = 3 to 5 years, 3 = 5 to 10 years, 4 = 10 to 20 years, and 5 = >20 years) ranged from 1 to 5 with a mean ± SE, median, and mode of 3.9 ± 0.1, 4, and 5, respectively.

Days Spent Duck Hunting in Minnesota in 2001.— Sixty-eight percent of hunters (n = 364) indicated that they had duck hunted 11 or more days in Minnesota in 2001 (Table 3.1). The categorical breakdown of number of days hunting (i.e., 1 = <3 days, 2 = 3 to 5 days,

Table 3.1. Summary of numbers of volunteer hunters (%) by number of years spent duck hunting and by number of days spent duck hunting in Minnesota (MN) and other states and provinces in 2001.

Category[a]	Years hunting	Days in MN	Days in other
< 3	18 (5%)	39 (11%)	270 (74%)
3 – 5	45 (12%)	20 (5%)	35 (10%)
6 – 10	49 (13%)	59 (16%)	34 (9%)
11 – 20	88 (24%)	105 (29%)	15 (4%)
20 +	166 (45%)	141 (39%)	11 (3%)
Total	366 (100%)	364 (100%)	365 (100%)

[a] Years or days depending upon columns to the right.

3 = 5 to 10 days, 4 = 10 to 20 days, and 5 = >20 days) ranged from 1 to 5 with a mean ± SE, median, and mode of 3.8 ± 0.1, 4, and 5, respectively.

Days Spent Duck Hunting in Other States and Provinces in 2001.— Twenty-six percent of hunters (n = 365) reported that they had duck hunted more than 3 days in other states or provinces in 2001 (Table 3.1). The categorical breakdown of number of days hunting (i.e., 1 = <3 days, 2 = 3 to 5 days, 3 = 5 to 10 days, 4 = 10 to 20 days, and 5 = >20 days) ranged from 1 to 5 with a mean ± SE, median, and mode of 1.5 ± 0.1, 1, and 1, respectively.

Ownership of SWDs.— A total of 225 (61%) and 141 (39%) hunters (n = 366) responded yes and no, regarding whether they owned a SWD, respectively.

Percentage of Hunts that Hunters Used SWDs in 2001.— Overall, 170 (46%) hunters (n = 366) indicated that they used SWDs in 2001. A total of 196 (54%), 67 (18%), 21 (6%), 27 (7%), and 55 (15%) of hunters responded that they used SWDs in none, 1-25%, 26-50%, 51-75%, and ≥76% of their hunts in 2001, respectively. The categorical breakdown of percentages (i.e., 1 = 0%, 2 = 1-25%, 3 = 26- 50%, 4 = 51-75%, and 5 = ≥76%) ranged from 1 to 5 with a mean ± SE, median, and mode of 2.1 ± 0.1, 1, and 1, respectively.

Why Hunters Used SWDs.— Of those using SWDs in 2001, 107 (63%), 74 (44%), 58 (34%), 50 (29%), 45 (26%), and 17 (10%) responded that they used SWDs to improve harvest opportunity, just to try it, compete with other hunters, reduce crippling, shoot more drakes, and other reasons, respectively. Note that percentages do not sum to 100 because hunters were allowed to check more than 1 answer.

Plans to Use SWDs.— A total of 215 (59%), 118 (33%), and 33 (9%) hunters (n = 366) responded yes, undecided, and no, regarding their plans to use SWDs in future hunts, respectively (Tables 3.2 – 3.4).

Table 3.2. Summary of numbers (%) of volunteer hunters planning to use SWDs in the future and their opinions of whether using SWDs reduces crippling.

Plan to use SWDs	Believe using SWDs reduces crippling			
	No	Undecided	Yes	Total
Yes	30 (8%)	38 (10%)	147 (40%)	215 (59%)
Undecided	35 (10%)	45 (12%)	38 (10%)	118 (32%)
No	11 (3%)	19 (5%)	3 (1%)	33 (9%)
Total	76 (21%)	102 (28%)	188 (51%)	366 (100%)

Table 3.3. Summary of numbers (%) of volunteer hunters planning to use SWDs in the future and their opinions of whether using SWDs allow them to shoot more drakes.

Plan to use SWDs	Believe SWDs allow hunters to shoot more drakes			
	No	Undecided	Yes	Total
Yes	34 (9%)	73 (20%)	108 (30%)	215 (59%)
Undecided	22 (6%)	60 (16%)	36 (10%)	118 (32%)
No	8 (2%)	16 (4%)	9 (2%)	33 (9%)
Total	64 (18%)	149 (41%)	153 (42%)	366 (100%)

Table 3.4. Summary of numbers (%) of volunteer hunters that plan to use SWDs in the future and their opinions of whether using SWDs violates "fair chase" hunting ethics.

Plan to use SWDs	Believe SWDs violate "fair chase" ethics			
	No	Undecided	Yes	Total
Yes	169 (46%)	29 (8%)	17 (5%)	215 (59%)
Undecided	69 (19%)	36 (10%)	13 (4%)	118 (32%)
No	8 (2%)	7 (2%)	18 (5%)	33 (9%)
Total	246 (67%)	72 (20%)	48 (13%)	366 (100%)

Opinions that SWDs Reduce Crippling.— A total of 188 (51%), 102 (28%), and 76 (21%) hunters (n = 366) responded yes, undecided, and no regarding opinions that SWDs enable them to reduce crippling, respectively (Table 3.2).

Opinions that SWDs Enable Shooting More Drakes.— A total of 153 (42%), 149 (41%), and 64 (17%) hunters (n = 366) responded yes, undecided, and no regarding opinions that SWDs enable them to shoot more drakes, respectively (Table 3.3).

Opinions that SWDs Violate Fair Chase.— A total of 48 (13%), 72 (20%), and 246 (67%) hunters (n = 366) responded yes, undecided, and no regarding opinions that SWDs enable violate "fair chase" ethics, respectively (Table 3.4).

Opinions that SWDs Should be Banned.— A total of 37 (10%), 30 (8%), 63 (17%), and 236 (64%) hunters (n = 366) responded yes-entire season ban, yes-partial season ban, undecided, and no regarding opinions that use of SWDs should be prohibited, respectively.

Plans to Use SWDs and Hunter Opinions

Hunters that believed using SWDs enabled them to cripple fewer ducks (79%) were more likely to plan to use SWDs in the future (χ^2 = 113.48, DF = 1, P < 0.001; Table 3.2). Hunters that believed using SWDs enabled them to shoot more drakes (71%) also were more likely to plan to use SWDs in the future (χ^2 = 63.71, DF = 1, P < 0.001; Table 3.3). Hunters that believed SWDs violate "fair chase" ethics were equally likely to plan to use or not use SWDs in future hunts (χ^2 = 0.25, DF = 1, P > 0.50; Table 3.4).

Discussion

Most waterfowl hunters in Minnesota do not continue hunting after the first few weeks of the season (J. S. Lawrence, Minnesota Department of Natural Resources, personal communication). Fulton et al. (2002) reported that only half of their respondents hunted ducks more than 8 days during the 2000 season in Minnesota; the reported mean days hunted during the 2002 season was 9.7 days (Schroeder et al. 2003). Most volunteer hunters in my study had duck hunted at least 11 days in Minnesota in 2001. Furthermore, I found that 46% of hunters that participated in my study previously had used SWDs on at least one occasion in 2001, whereas Fulton et al. (2002) and Schroeder et al. (2003) estimated that 10% and 26% of randomly selected waterfowl hunters in Minnesota used SWDs in 2000 and 2002, respectively. They also reported that hunters with experience using SWDs hunted significantly more days and killed more ducks than those that had not used SWDs. Therefore, volunteer hunters in my study seemingly were more active and avid, and possibly more successful, than were those from a random, statewide sample of Minnesota hunters.

Most (64%) hunters in my study were opposed to any prohibition of SWDs in Minnesota. However, Schroeder et al. (2003) estimated that only 39.3 and 21.3 percent of hunters surveyed in 2002 were opposed to entire and existing prohibitions of SWDs in Minnesota, respectively. Thus, more active and avid hunters may be more likely to use and oppose prohibitions of SWDs.

Volunteer hunters generally became aware that flock responses and kill rates were higher when SWDs were turned 'ON' than 'OFF' in their respective experimental hunts (see Chapter 2). Thus, their opinions that SWDs increase hunter effectiveness may have been influenced by participation in my study. However, many volunteer hunters believed that SWDs reduce crippling and enable them to select drakes over hens, despite my findings otherwise (see Chapter 2). Accordingly, participation in my experimental hunts probably did not greatly influence volunteer hunters' opinions concerning effects of SWDs upon crippling of ducks, ability to select drakes over hens, or "fair chase" ethics. Hunters that believed SWDs reduce crippling (79%) and enable them to shoot more drakes (71%) were more likely to plan to use SWDs in the future.

Therefore, hunters that were undecided or planned to use SWDs based on these opinions alone may choose not to use SWDs in the future once my findings to the contrary become known. Similar numbers of volunteer hunters, that indicated that SWDs violate "fair chase" ethics, planned to use or not use SWDs in the future. In conclusion, SWDs generally were ethically acceptable among avid and active waterfowl hunters participating in my study because relatively few (9%) indicated that they would not use SWDs in the future.

Literature Cited

Agresti, A. 1996. An introduction to categorical data analysis. John Wiley & Sons, New York, New York, USA.

Fulton, D. C., J. Vlaming, J. S. Lawrence, and E. W. Price. 2002. The 2000 waterfowl hunting season in Minnesota: A study of hunters' opinions and activities. Final report to Minnesota Department of Natural Resources. USGS-Minnesota Cooperative Fish and Wildlife Research Unit, University of Minnesota, St. Paul, MN.

Olsen, R. E., and A. D. Afton. 1999. Goose hunter opinions concerning proposed management actions to reduce the mid-continent population of lesser snow geese. Wildlife Society Bulletin 27: 109-114.

SAS Institute. 1999. SAS/STAT user's guide, 8.02 edition. SAS Institute, Cary North Carolina, USA.

Schroeder, S., D. C. Fulton, and J. S. Lawrence. 2003. The 2002 waterfowl hunting season in Minnesota: A study of hunters' opinions and activities. Preliminary report to Minnesota Department of Natural Resources. USGS-Minnesota Cooperative Fish and Wildlife Research Unit, University of Minnesota, St. Paul, MN.

Chapter 4. Use of Stable Isotope Methodology to Determine Natal Origins of Hatch-year Mallards Harvested During Fall in Minnesota

Introduction

Waterfowl managers in Minnesota and other states are concerned that local mallards (*Anas platyrhynchos*) may be more vulnerable than are migrants to hunters using spinning-wing decoys (hereafter SWDs), and thus, that local breeding populations may be negatively affected by the use of SWDs. Successful nesting females and many local hatch-year (HY) mallards often are present on, or near, brood marshes at the beginning of the hunting season in Minnesota and may be especially vulnerable to hunters (Gilmer et al. 1977, Kirby et al. 1989). Consequently, Minnesota currently prohibits waterfowl hunting after 1600 hrs statewide and use of SWDs on public waters until the Saturday nearest 8 October (Minnesota Department of Natural Resources 2002, Minnesota Statutes 2002).

California also promulgated specific hunting regulations with goals of protecting local breeding populations of mallards from increased harvest early in the hunting season. The effectiveness of SWDs declined as the 1999-2000 hunting season progressed in California (Eadie et al. 2002). Accordingly, SWDs subsequently were prohibited until 30 November in California, despite no direct evidence that ducks shot early in the season using SWDs were of a local origin (California Fish and Game Commission 2001).

Natal origins of ducks harvested during fall can be determined from analysis of band recoveries and radio telemetry data. However, insufficient numbers of band recoveries generally are available to directly assess effectiveness of new hunting technologies, such as SWDs, or to make inferences about how they affect local populations. Thus, alternative methods are required to help delineate local and migrant ducks.

Stable isotope methodology has potential to delineate natal origins of HY ducks shot during fall hunting seasons using metabolically inert tissues (e.g., flight feathers) grown on breeding areas. Differences in photosynthetic pathways determine $\delta^{13}C$ values at the vegetative base of foodwebs (C_3 in cooler, wetter climates; C_4 in warmer, drier climates; Peterson and Fry 1987, Lajtha and Michener 1994). Thus, $\delta^{13}C$ values from forested areas generally are depleted (i.e., isotopically light as compared to international standards) as compared to grassland areas. Forest foodweb $\delta^{15}N$ values typically are more depleted than are those found in agricultural webs because fertilizer and animal waste nitrates unnaturally enrich agricultural lands with nitrogen (Alexander et al. 1996, Hebert and Wassenaar 2001). Moreover, $\delta^{13}C$ and $\delta^{15}N$ values may have useful east to west variability in central North America, given the transition from forests to grasslands from the east to west in this region. Additionally, δD values from precipitation provide a gradient of decreasing δD from southeast to northwest across North America (Chamberlain et al. 1997, Hobson and Wassenaar 1997).

My general objectives were to: 1) collect feathers from flightless mallard ducklings across Minnesota, North Dakota, South Dakota, and Wisconsin; 2) describe and use δD, $\delta^{13}C$ and $\delta^{15}N$ values from duckling feathers to differentiate natal origins of HY mallards that subsequently were killed during SWD experimental hunts in Minnesota, 3) determine whether Minnesota HY mallards are relatively more vulnerable to SWDs than are migrant HY mallards, 4) determine whether harvest of Minnesota and migrant HY mallards varied temporally during the 2002 Minnesota duck season, and 5) use band recoveries to determine whether harvest of banded HY + LOCAL (hereafter first-year [FY]) Minnesota and FY migrant mallards varied temporally during recent hunting seasons (1995-2001) and compare these results to those of my isotope analysis.

For analysis, I specifically address several questions important for management of local breeding populations of mallards in Minnesota: 1) do δD, $\delta^{13}C$ and $\delta^{15}N$ values from feathers of flightless mallard ducklings collected in Minnesota, North Dakota, South Dakota, and Wisconsin vary sufficiently to accurately classify natal origins of hunter-killed HY mallards in Minnesota, 2) are Minnesota HY mallards and Canadian HY mallards more likely to be killed with SWDs turned 'ON' than 'OFF' or between time periods similar to those imposed by regulatory dates to protect local mallards in California and Minnesota, 3) do proportions of FY mallard recoveries, both banded and recovered in Minnesota, differ between time periods similar to those imposed by regulatory dates to protect local mallards in California and Minnesota, and 4) are results from band recovery and stable isotope analyses similar with regard to these management questions?

Study Area

I visually analyzed Advanced Very High Resolution Radiometer (AVHRR) satellite data to approximate general land use and cover ecoregions across Minnesota, North Dakota, South Dakota and Wisconsin. I then selected 3 east to west transects to collect feather samples from flightless mallard ducklings (age classes 2b, 2c, and 3a; Gollop and Marshall 1954) during July – September 2002 (Figure 4.1). The transects traversed 5 land use and cover ecoregions: Agricultural, Agricultural/Forest, Agricultural/Grassland, Forest and Grassland (Figure 4.1).

Methods

Flightless Duckling Feathers

I collected the fourth secondary and tail feathers from 102 flightless mallard ducklings; 68 (67%) were shot, and 34 (33%) were captured and released (Table 4.1). I shot ducklings using a .22 rifle or a shotgun, or used night-lighting capture techniques (Bishop and Barratt 1969; Louisiana State University Animal Care and Use Committee Protocol #AE02-12).

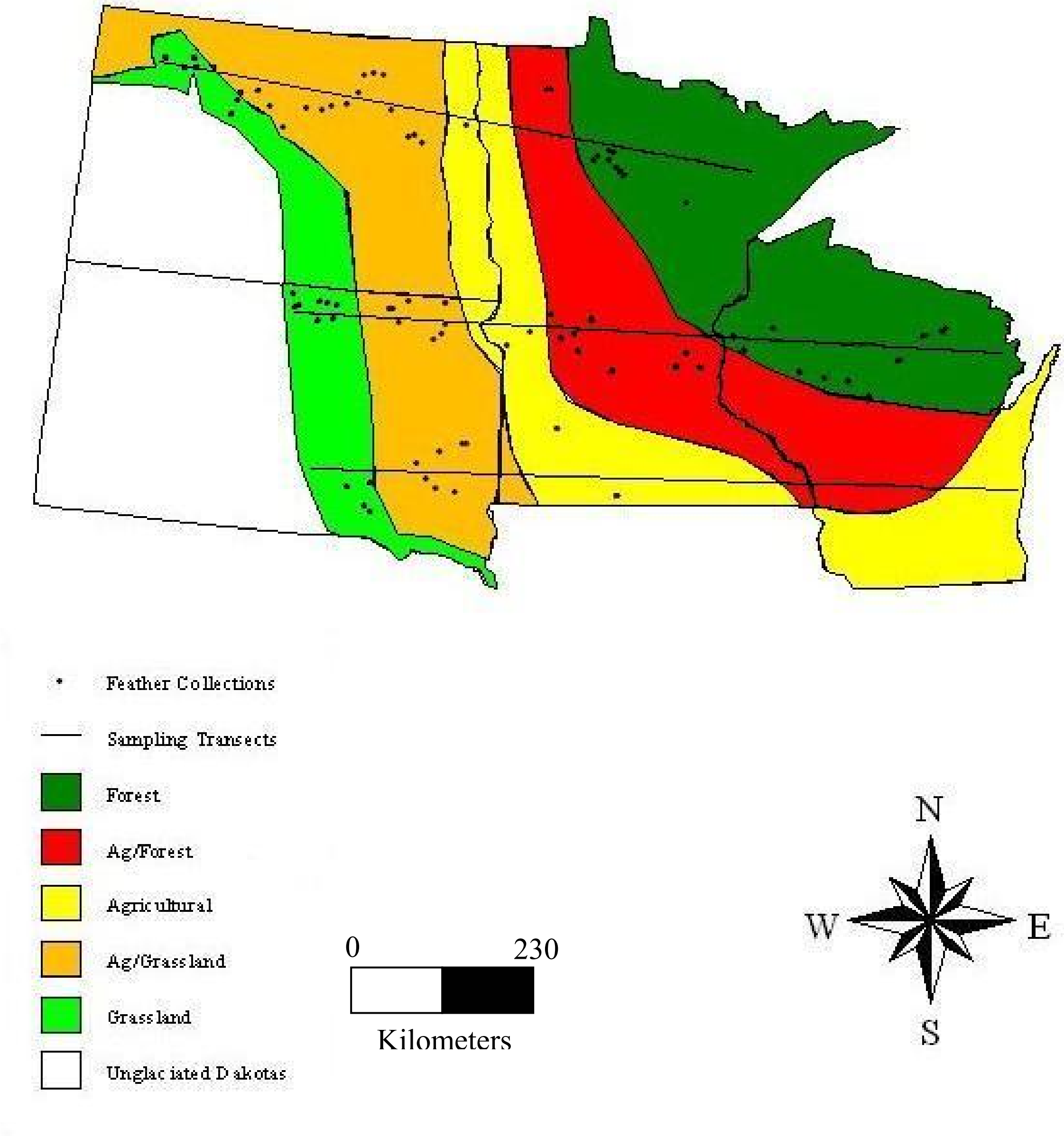


Figure 4.1. Map of ecoregions and locations where mallard duckling feathers were collected along transects traversing Minnesota, North Dakota, South Dakota, and Wisconsin, July – September 2002.

Table 4.1. Numbers (%) of flightless mallard ducklings collected or captured in Minnesota (MN), North Dakota (ND), South Dakota (SD), and Wisconsin (WI), July – September 2002.

State	Collected	Captured	Total
MN	9 (31%)	20 (69%)	29 (28%)
ND	24 (100%)	0 (0%)	24 (24%)
SD	27 (93%)	2 (7%)	29 (28%)
WI	8 (40%)	12 (60%)	20 (20%)
Total	68 (67%)	34 (33%)	102 (100%)

Hunter-shot Mallard Feathers

I collected the fourth secondary feather from all HY mallards killed during SWD experimental hunts in Minnesota, 28 September – 26 November 2002 (see Chapter 2). I determined ages of mallards using presence or absence of notched-tail feathers, cloacal examination (Hochbaum 1942), and wing characteristics (Carney 1992). Furthermore, certified wingbee checkers re-examined all wings from mallards killed during experimental hunts to confirm age classifications (HY or after-hatch-year [AHY]).

Stable Isotope Analysis

I cleaned feathers by rinsing them several times in a 2:1 chloroform:methanol solution and allowed them to air dry. I then cut samples from the upper third of secondary feathers and the lower half of tail feathers to represent similar periods of growth. I loaded feather samples into tin cups for $\delta^{15}N$ and $\delta^{13}C$ analysis and silver cups for δD analysis (see Hobson and Wassenaar 1997, Hobson 1999, Wassenaar and Hobson 2002 for a more complete description of stable isotope methods). I expressed all ratios in δ-notation as parts per thousand deviations from international standards. I used the exact same methods for analyses of hunter-shot HY mallard feather samples except that only fourth secondary feathers were analyzed.

Direct Recoveries of FY Mallards

I totaled direct recoveries of FY (banded as HY or LOCAL; Gustafson et al. 1997) mallards recovered in Minnesota separately by MN regulatory date (before or after the Saturday nearest 8 October) and by time of season (first or second half) during the 1995-2001 Minnesota duck hunting seasons. For analysis, I classified FY mallards that were banded and recovered in Minnesota as FY Minnesota mallards, and all other FY banded mallards recovered in Minnesota as FY migrant mallards. For this analysis, I assumed that HY mallards banded in Minnesota had natal origins in Minnesota, and that banding effort, reporting rate, and hunter effort were similar among years and geographic areas of interest.

Statistical Analysis

Isotopic, Latitudinal, and Longitudinal Relationships.— I used separate simple linear regression analyses (PROC REG; SAS Institute 1999) to describe relationships among $\delta^{13}C$, δD and $\delta^{15}N$ values of feathers and between isotope values and latitudes and longitudes of collection sites. I used a critical value of $\alpha = 0.05$ in all statistical analyses.

Analysis of Flightless Mallard Duckling Feathers by State.— I first classified samples by states (Minnesota, North Dakota, South Dakota, and Wisconsin) and ran 3 separate 1-way analyses of variance (ANOVA; PROC MIXED; Littell et al. 1996) to test whether $\delta^{13}C$, δD and $\delta^{15}N$ values differed among states. Following significant ANOVAs, I compared means with Tukey multiple comparisons tests using the PDMIX800 macro (Saxton 1998). I also used discriminant function analysis (DFA; PROC DISCRIM; SAS Institute 1999) to develop predictive models of natal origins of mallard ducklings based on different combinations of $\delta^{13}C$, δD and $\delta^{15}N$ values and subsequently determined models that most effectively predicted Minnesota natal origins of ducklings. Finally, I cross-validated the accuracy of each model by recalculating the discriminant function after removing each individual from the sample population and then re-classifying the individual with the newly calculated functions (PROC DISCRIM; SAS Institute 1999).

Natal Origins of HY Mallards Killed During SWD Experimental Hunts.— I grouped all hunter-shot HY mallard feathers that had δD values < -123.32 (minimum observed δD value of flightless duckling feathers from the USA) as having natal origins in Canada (hereafter Canadian HY mallards) based on the well-documented northwesterly trend of decreasing δD values

(Chamberlain et al. 1997, Hobson and Wassenaar 1997). I subsequently categorized natal origins of ducklings based on DFA classifications as Minnesota (DFA classification = Minnesota) or migrant HY mallards (all other DFA classifications plus those grouped as Canadian HY mallards).

Analysis of Minnesota HY Mallards by MN Regulatory Date.— I used separate chi-square tests of independence (Agresti 1996) to determine if numbers of hunter-shot Minnesota and migrant HY mallards differed between SWD treatments or by MN regulatory date. Additionally, I used logistic regression analysis (PROC LOGISTIC; SAS Institute 1999) to determine whether relative proportions of Minnesota and migrant HY mallards differed between SWD treatments (categorical; SWDs 'ON' or SWDs 'OFF'), MN regulatory date (categorical; before the Saturday nearest 8 October or after the Saturday nearest 8 October), and the 2-way interaction. For analysis, I scored Minnesota HY mallards as "1" and migrant HY mallards as "0". I used backwards selection procedures to eliminate all non-significant ($P > 0.05$) terms from the full model, beginning with the 2-way interaction.

Analysis of Minnesota HY Mallards by Time of Season.— I used separate chi-square tests of independence (Agresti 1996) to determine whether numbers of hunter-shot Minnesota and migrant HY mallards differed by time of season. Additionally, I used logistic regression analysis (PROC LOGISTIC; SAS Institute 1999) to determine whether relative proportions of Minnesota and migrant HY mallards killed differed between SWD treatments, time of season (categorical; first half or second half), and the 2-way interaction. For analysis, I scored Minnesota HY mallards as "1" and migrant HY mallards as "0". I used backwards selection procedures to eliminate all non-significant ($P > 0.05$) terms from the full model, beginning with the 2-way interaction.

Analysis of FY Mallard Band Recoveries by MN Regulatory Date.— I used separate chi-square tests of independence (Agresti 1996) to determine whether numbers of band recoveries of FY Minnesota and migrant mallards differed by MN regulatory date. Additionally, I used logistic regression analysis (PROC LOGISTIC; SAS Institute 1999) to determine whether relative proportions of band recoveries of FY Minnesota and migrant mallards differed between SWD treatments, MN regulatory date, and the 2-way interaction. For analysis, I scored FY Minnesota mallard recoveries as "1" and FY migrant mallard recoveries as "0". I used backwards selection procedures to eliminate all non-significant ($P > 0.05$) terms from the full model, beginning with the 2-way interaction.

Analysis of FY Mallard Band Recoveries by Time of Season.— I used separate chi-square tests of independence (Agresti 1996) to determine whether numbers of band recoveries of FY Minnesota and migrant mallards differed by time of season. Additionally, I used logistic regression analysis (PROC LOGISTIC; SAS Institute 1999) to determine whether relative proportions of band recoveries of FY Minnesota and migrant mallards differed between SWD treatments, time of season, and the 2-way interaction. For analysis, I scored FY Minnesota mallard recoveries as "1" and FY migrant mallard recoveries as "0". I used backwards selection procedures to eliminate all non-significant ($P > 0.05$) terms from the full model, beginning with the 2-way interaction.

Results

Flightless Duckling Feathers

Latitudinal, Longitudinal, and Isotopic Relationships.— Simple linear regression analyses indicated that $\delta^{13}C$ and δD values decreased with increasing latitude (Figures 4.2 and 4.3); $\delta^{15}N$ values were not significantly related to latitude ($n = 102$; $P = 0.409$; Figure 4.4).

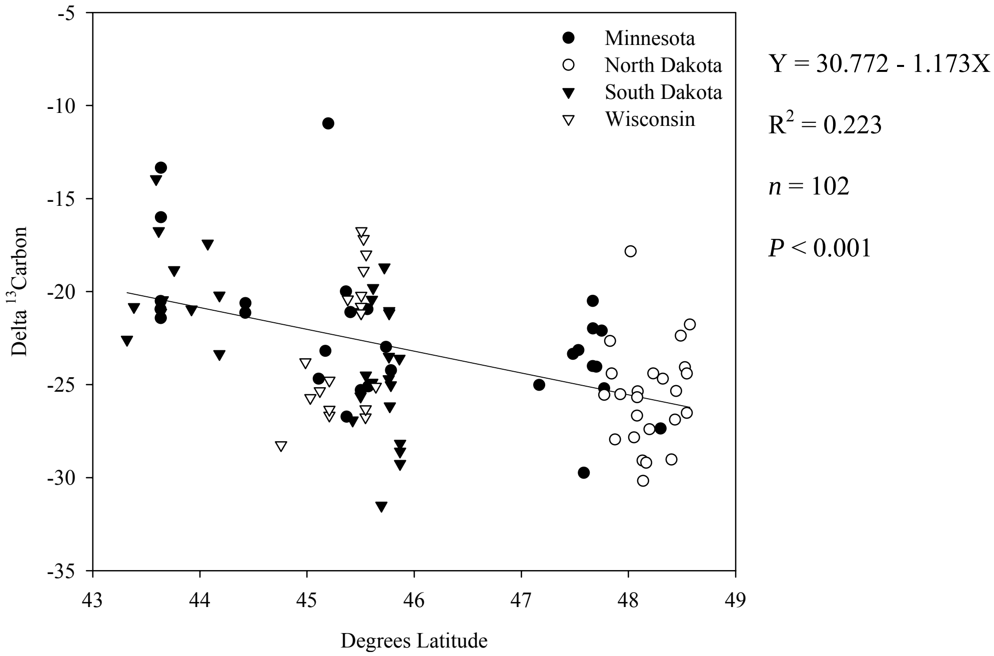


Figure 4.2. Relationship of feather $\delta^{13}C$ values to latitude for flightless mallard ducklings collected or captured in Minnesota, North Dakota, South Dakota, and Wisconsin, July – September 2002.

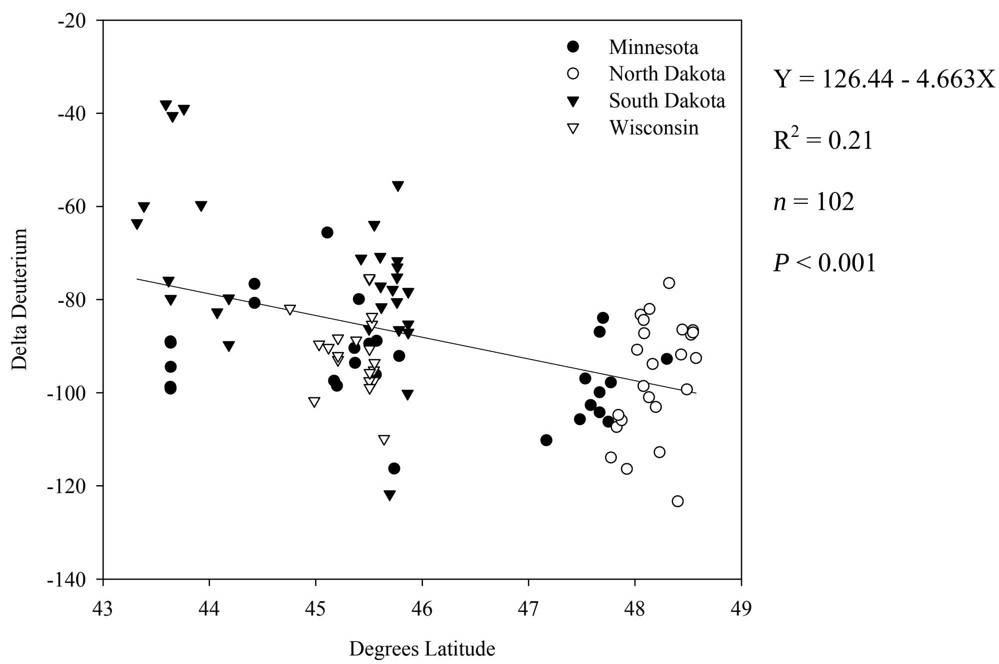


Figure 4.3. Relationship of feather δD values to latitude for flightless mallard ducklings collected or captured in Minnesota, North Dakota, South Dakota, and Wisconsin, July – September 2002.

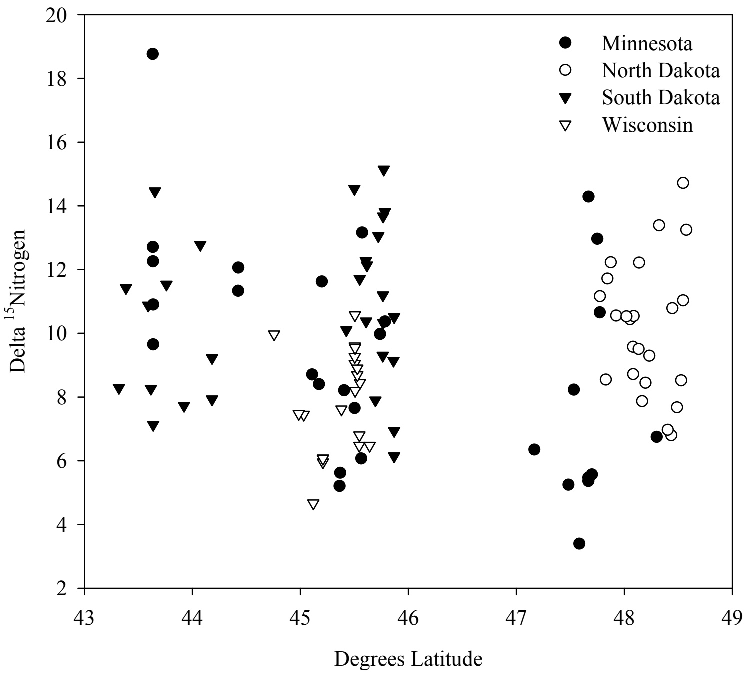


Figure 4.4. Relationship of feather $\delta^{15}N$ values to latitude for flightless mallard ducklings collected or captured in Minnesota, North Dakota, South Dakota, and Wisconsin, July – September 2002.

Simple linear regression analyses indicated an inverse relationship between $\delta^{13}C$ values and longitude (Figure 4.5), whereas $\delta^{15}N$ values increased with longitude (Figure 4.6); δD values were not significantly related to longitude (*n* = 102; *P* = 0.314; Figure 4.7). Three-dimensional graphs of each isotope value plotted by latitude and longitude are provided in Appendix H. Simple linear regression indicated significant, but weak, positive relationships between δD and $\delta^{13}C$ values, and between δD and $\delta^{15}N$ values, and between $\delta^{13}C$ and $\delta^{15}N$ values (Appendix I). A three-dimensional graph of isotope values is provided in Appendix J.

Comparison of Isotopes by State.— Separate ANOVAs indicated that isotope values differed among states ($\delta^{13}C$: $F_{3, 98} = 4.42$, $P = 0.006$; $\delta^{15}N$: $F_{3, 98} = 5.05$, $P = 0.003$; δD: $F_{3, 98} = 16.56$, $P < 0.001$). Mean comparison tests indicated that ducklings from North Dakota were more depleted of ^{13}C than were those from other states, whereas $\delta^{13}C$ values were similar for Minnesota, South Dakota, and Wisconsin (Table 4.2). Ducklings from South Dakota were less depleted of D than were those from other states, whereas δD values were similar for North Dakota, Minnesota, and Wisconsin (Table 4.2). Finally, ducklings from Wisconsin were less enriched in ^{15}N than were those from North Dakota and South Dakota, whereas $\delta^{15}N$ values were similar for North Dakota, Minnesota, and South Dakota (Table 4.2).

Using $\delta^{13}C$, δD and $\delta^{15}N$ as grouping variables, DFA correctly classified 31% of flightless mallard ducklings with natal origins in Minnesota and achieved 48% overall classification accuracy (Table 4.3). Using $\delta^{13}C$ and δD as grouping variables, DFA correctly classified 59% of mallard ducklings with natal origins in Minnesota and achieved 46% overall classification accuracy (Table 4.4). Other DFA models using various combinations of $\delta^{13}C$, δD and $\delta^{15}N$ had lower classification accuracy of both natal origins of Minnesota ducklings and all natal origins. Expected overall classification accuracy by random assignment was 25%, and

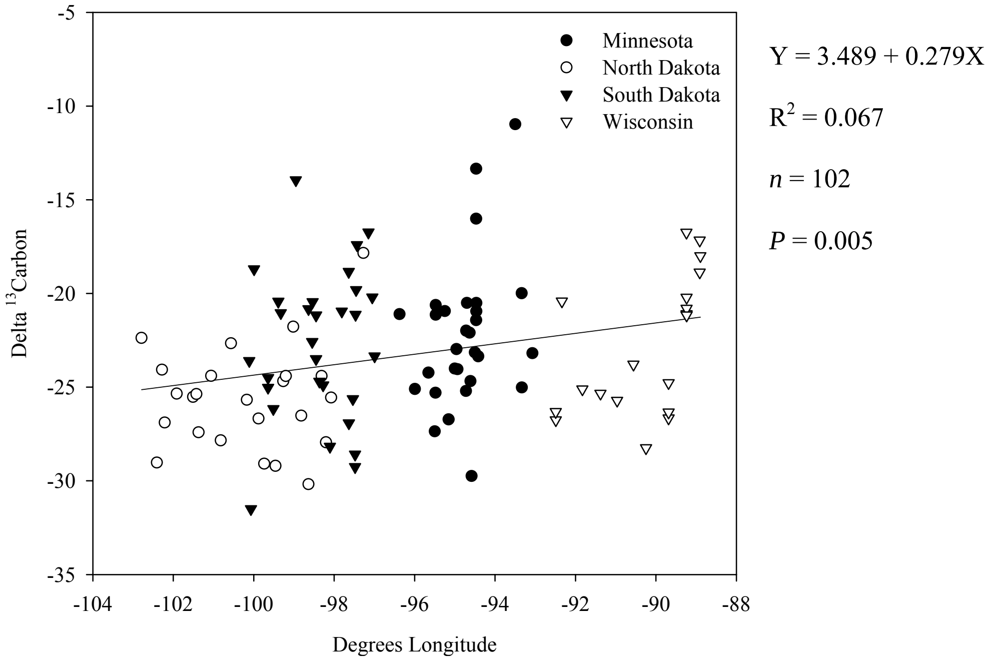


Figure 4.5. Relationship of feather δ^{13}C values to longitude for flightless mallard ducklings collected or captured in Minnesota, North Dakota, South Dakota, and Wisconsin, July – September 2002.

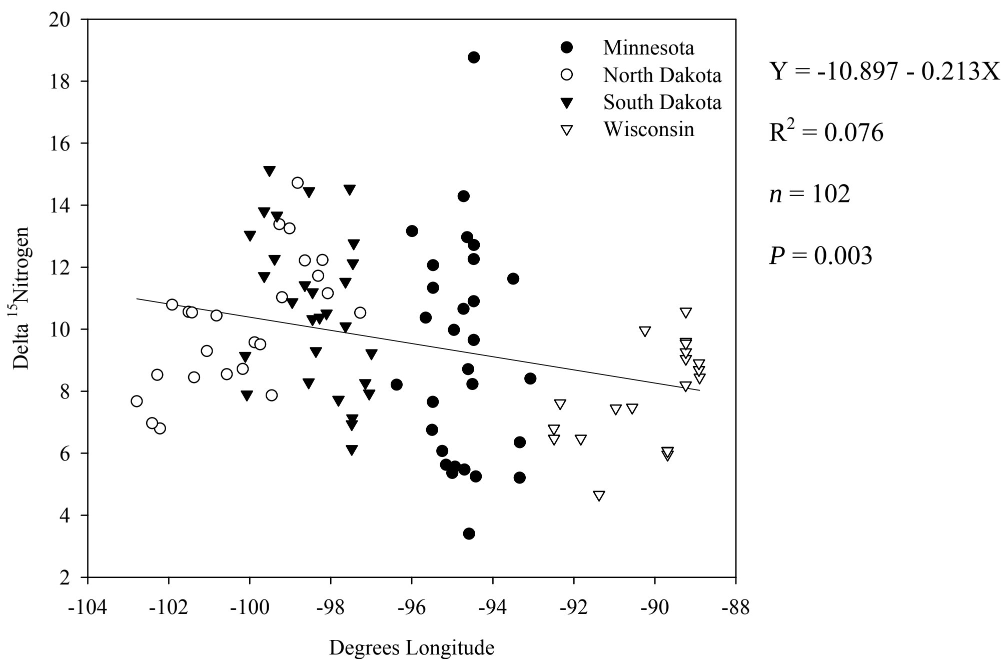


Figure 4.6. Relationship of feather δ^{15}N values to longitude for flightless mallard ducklings collected or captured in Minnesota, North Dakota, South Dakota, and Wisconsin, July – September 2002.

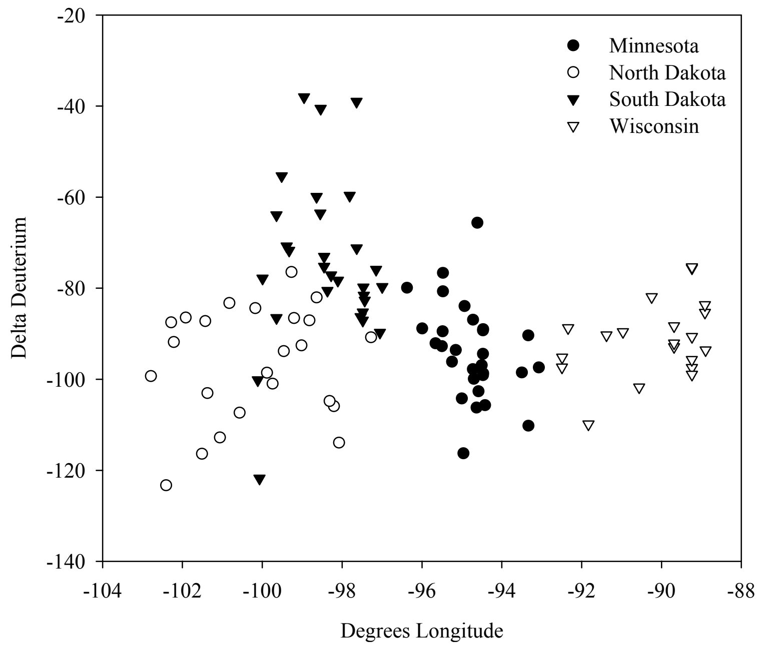


Figure 4.7. Relationship of feather δD values to longitude for flightless mallard ducklings collected or captured in Minnesota, North Dakota, South Dakota, and Wisconsin, July – September 2002.

Table 4.2. Mean $\delta^{13}C$, δD and $\delta^{15}N$ values (± SE) and range from flightless mallard duckling feathers collected in Minnesota (MN; $n = 29$), North Dakota (ND; $n = 24$), South Dakota (SD; $n = 29$), and Wisconsin (WI; $n = 20$), July – September 2002.[a]

	$\delta^{13}C$		δD		$\delta^{15}N$	
State	Mean ± SE	Range	Mean ± SE	Range	Mean ± SE	Range
MN	-22.27A ± 0.68	-29.75 – -10.97	-93.92B ± 2.42	-116.30 – -65.64	9.21AB ± 0.48	3.40 – 18.76
ND	-25.62B ± 0.74	-30.18 – -17.84	-96.52B ± 2.66	-123.32 – -76.76	10.19A ± 0.53	6.80 – 14.72
SD	-22.76A ± 0.68	-31.50 – -13.95	-74.22A ± 2.42	-121.76 – -38.04	10.62A ± 0.48	6.14 – 15.14
WI	-22.74A ± 0.81	-28.25 – -16.74	-91.22B ± 2.92	-109.87 – -75.36	7.87B ± 0.58	4.67 – 10.57

[a] Means with the same letters within a column are not significantly different ($P > 0.05$).

Table 4.3. Numbers (%) classified by DFA, using $\delta^{13}C$, δD and $\delta^{15}N$ as grouping variables, for flightless mallard duckling feather samples collected in Minnesota (MN), North Dakota (ND), South Dakota (SD) and Wisconsin (WI), July – September 2002.

	Numbers of observations (%) classified by state			
State	MN	ND	SD	WI
MN[a]	9 (31%)	6 (21%)	3 (10%)	11 (38%)
ND[b]	5 (21%)	15 (63%)	3 (10%)	1 (4%)
SD[c]	3 (10%)	4 (14%)	19 (66%)	3 (10%)
WI[d]	12 (60%)	0 (0%)	3 (15%)	5 (25%)
Total	29 (28%)	25 (25%)	28 (27%)	20 (19%)

[a] MN = $-60.140 - 1.73(\delta^{13}C) - 0.567(\delta D) + 2.823(\delta^{15}N)$
[b] ND = $-71.049 - 2.04(\delta^{13}C) - 0.573(\delta D) + 3.105(\delta^{15}N)$
[c] SD = $-55.173 - 1.919(\delta^{13}C) - 0.443(\delta D) + 2.946(\delta^{15}N)$
[d] WI = $-56.209 - 1.747(\delta^{13}C) - 0.538(\delta D) + 2.594(\delta^{15}N)$

Table 4.4. Numbers (%) classified by DFA, using $\delta^{13}C$ and δD as grouping variables, for flightless mallard duckling feather samples collected in Minnesota (MN), North Dakota (ND), South Dakota (SD) and Wisconsin (WI), July – September 2002.

	Numbers of observations (%) classified by state			
State	MN	ND	SD	WI
MN[a]	17 (59%)	7 (24%)	5 (17%)	0 (0%)
ND[b]	9 (38%)	11 (46%)	4 (17%)	0 (0%)
SD[c]	5 (17%)	5 (17%)	19 (66%)	0 (0%)
WI[d]	9 (45%)	8 (31%)	3 (15%)	0 (0%)
Total	40 (39%)	31 (30%)	31 (30%)	0 (0%)

[a] MN = $-36.436 - 1.233(\delta^{13}C) - 0.457(\delta D)$
[b] ND = $-42.378 - 1.492(\delta^{13}C) - 0.452(\delta D)$
[c] SD = $-29.356 - 1.398(\delta^{13}C) - 0.328(\delta D)$
[d] WI = $-36.196 - 1.289(\delta^{13}C) - 0.437(\delta D)$

28%, 24%, 28% and 20% for Minnesota, North Dakota, South Dakota and Wisconsin, respectively. Accordingly, I used the $\delta^{13}C$ – δD predictive model in subsequent analyses to classify natal origins of HY mallards killed during experimental hunts (see Chapter 2).

Hunter-shot HY Mallards

Determination of Natal Origins.— A total of 132 HY mallards were killed, and 33 (25%) of these HY mallards had δD values of < -123.31 and thus were grouped as Canadian HY mallards. My best DFA predictive model classified 35 (27%) HY mallards as having natal origins in Minnesota; thus, a total of 97 HY mallards were classified as migrants (Table 4.5).

Analysis by MN Regulatory Date.— A total of 19 (14%) and 113 (86%) HY mallards were killed before and after the MN regulatory date, respectively; and overall, 115 (87%) and 17 (13%) were killed with SWDs turned 'ON' and 'OFF', respectively (Table 4.6). Both Minnesota and migrant HY mallards were more likely to be killed with SWDs turned 'ON' than 'OFF' ($\chi^2 = 8.93$, $DF = 1$, $P < 0.01$ and $\chi^2 = 27.47$, $DF = 1$, $P < 0.001$, respectively) and after the MN regulatory date ($\chi^2 = 10.41$, $DF = 1$, $P < 0.001$ and $\chi^2 = 23.14$, $DF = 1$, $P < 0.001$, respectively). However, relative proportions of Minnesota and migrant HY mallards killed did not differ between SWD treatments (Wald $\chi^2 = 0.097$, $P = 0.755$), or by MN regulatory date (Wald $\chi^2 = 0.337$, $P = 0.562$), and the 2-way interaction also was not significant (Wald $\chi^2 = 0.004$, $P = 0.953$).

Given the moderate classification accuracy of my best DFA predictive model, I pooled (hereafter conservative pooled analysis) all HY mallards, not classified as Canadian HY mallards, as Minnesota HY mallards and re-ran the analysis as a worst-case scenario. For this analysis, 99 (75%) and 33 (25%) of HY mallards killed during experimental hunts were

Table 4.5. Mean $\delta^{13}C$, δD and $\delta^{15}N$ values (± SE), range and DFA natal origins of HY mallards killed during SWD experimental hunts during the 2002 Minnesota duck season.

	$\delta^{13}C$		δD		$\delta^{15}N$[c]	
Natal Origin[a]	Mean ± SE	Range	Mean ± SE	Range	Mean ± SE	Range
Canada[b]	-26.31 ± 0.67	-35.54 – -19.97	-149.47 ± 4.15	-241.08 – -123.37	7.85 ± 0.32	3.93 – 12.80
MN	-20.97 ± 0.53	-24.79 – -13.70	-100.25 ± 1.88	-123.31 – -80.86	9.53 ± 0.70	4.23 – 25.47
ND	-27.21 ± 0.26	-31.88 – -24.59	-101.59 ± 1.32	-123.11 – -87.68	8.07 ± 0.45	4.45 – 20.80
SD	-23.61 ± 1.04	-28.78 – -18.07	-76.11 ± 1.93	-83.46 – -62.42	8.52 ± 0.85	6.15 – 15.01

[a] n = 33, 35, 54, and 10 for Canada, Minnesota (MN), North Dakota (ND), and South Dakota (SD) classifications, respectively; DFA did not classify any HY mallards as from Wisconsin.

[b] Classifications for Canada are derived from a grouping based on δD values lower than minimum observed δD values of flightless mallard duckling feathers collected in the USA, those for states are based on DFA.

[c] $\delta^{15}N$ values were not used as a grouping variable in DFA, but are provided for descriptive purposes.

Table 4.6. Numbers (%) of Minnesota (MN), migrant (MIG), and Canadian (CDN) HY mallards killed with SWDs turned ON and OFF for 2 estimation models by MN regulatory date, 28 September – 26 November 2002.

Model	Classification	Date[c]	ON		OFF		Total	
DFA[a]	MN HY	Before	4	(25%)	0	(0%)	4	(3%)
	MIG HY	Before	12	(75%)	3	(100%)	15	(11%)
		Combined	16	(14%)	3	(18%)	19	(14%)
	MN HY	After	26	(26%)	5	(36%)	31	(24%)
	MIG HY	After	73	(74%)	9	(64%)	82	(62%)
		Combined	99	(86%)	14	(82%)	113	(86%)
	Total		115	(100%)	17	(100%)	132	(100%)
Pooled[b]	MN HY	Before	15	(94%)	3	(100%)	18	(14%)
	CDN HY	Before	1	(6%)	0	(0%)	1	(1%)
		Combined	16	(14%)	3	(18%)	19	(14%)
	MN HY	After	73	(74%)	8	(57%)	81	(61%)
	CDN HY	After	26	(26%)	6	(43%)	32	(24%)
		Combined	99	(86%)	14	(82%)	113	(86%)
	Total		115	(100%)	17	(100%)	132	(100%)

[a] Used $\delta^{13}C$ and δD to classify HY mallards that were not previously grouped as Canadian HY mallards.

[b] All HY mallards, that were not previously grouped as Canadian HY mallards, were pooled as Minnesota HY mallards.

[c] Before = hunts prior to 8 October 2002; After = hunts after 8 October 2002.

classified as Minnesota HY mallards and Canadian HY mallards, respectively (Table 4.6). Both Minnesota and Canadian HY mallards were more likely to be killed with SWDs turned ‘ON’ than ‘OFF’ (χ^2 = 29.94, *DF* = 1, *P* < 0.001 and χ^2 = 6.86, *DF* = 1, *P* < 0.01, respectively) and after the MN regulatory data (χ^2 = 20.05, *DF* = 1, *P* < 0.001 and χ^2 = 14.56, *DF* = 1, *P* < 0.001, respectively). However, relative proportions of Minnesota and Canadian HY mallards killed did not differ between SWD treatments (Wald χ^2 = 1.315, *P* = 0.252), or by MN regulatory date (Wald χ^2 = 3.51, *P* = 0.06), and the 2-way interaction also was not significant (Wald χ^2 = 0.003, *P* = 0.959).

Analysis by Time of Season.— A total of 57 (43%) and 75 (57%) HY mallards were killed during the first and second halves of the 2002 season, respectively (Table 4.7). Numbers of Minnesota and migrant HY mallards did not differ by time of season (χ^2 = 3.21, *DF* = 1, *P* > 0.05 and χ^2 = 0.05, *DF* = 1, *P* > 0.75, respectively). However, my final logistic regression model indicated that relative proportions of Minnesota and migrant HY mallards killed during experimental hunts differed by time of season, but not between SWD treatments (Wald χ^2 = 0.13, *P* = 0.72); the 2-way interaction also was not significant (Wald χ^2 = 0.548, *P* = 0.459). The odds ratio indicated that, when compared to migrant HY mallards, Minnesota HY mallards were relatively less likely to be killed during the first than second half of the season (Odds Ratio = 0.426; Wald χ^2 = 4.03, *P* = 0.045). For the conservative pooled analysis, numbers of Minnesota and Canadian HY mallards killed did not differ by time of season (χ^2 = 0.41, *DF* = 1, *P* > 0.50 and χ^2 = 1.23, *DF* = 1, *P* > 0.25, respectively). My final logistic regression model indicated that relative proportions of Minnesota and Canadian HY mallards killed also did not differ by time of season (Wald χ^2 = 0.895, *P* = 0.334); the 2-way interaction also was not significant (Wald χ^2 = 2.873, *P* = 0.09).

Table 4.7. Numbers (%) of Minnesota (MN), migrant (MIG), and Canadian (CDN) HY mallards killed with SWDs turned ON and OFF for 2 estimation models by time of season, 28 September – 26 November 2002.

Model	Classification	Season[c]	ON		OFF		Total	
DFA[a]	MN HY	Early	9	(18%)	1	(13%)	10	(8%)
	MIG HY	Early	40	(82%)	7	(87%)	47	(36%)
		Combined	49	(43%)	8	(47%)	57	(43%)
	MN HY	Late	21	(32%)	4	(44%)	25	(19%)
	MIG HY	Late	45	(68%)	5	(56%)	50	(38%)
		Combined	66	(57%)	9	(53%)	75	(57%)
	Total		115	(100%)	17	(100%)	132	(100%)
Pooled[b]	MN HY	Early	41	(84%)	4	(50%)	45	(34%)
	CDN HY	Early	8	(16%)	4	(50%)	12	(9%)
		Combined	49	(14%)	8	(18%)	57	(43%)
	MN HY	Late	47	(71%)	7	(78%)	54	(41%)
	CDN HY	Late	19	(29%)	2	(22%)	21	(16%)
		Combined	66	(86%)	9	(82%)	75	(57%)
	Total		115	(100%)	17	(100%)	132	(100%)

[a] Used $\delta^{13}C$ and δD to classify HY mallards that were not previously grouped as Canadian HY mallards.

[b] All HY mallards, that were not previously grouped as Canadian HY mallards, were pooled as Minnesota HY mallards.

[c] Early = 28 September – 27 October 2002; Late = 28 October – 26 November 2002.

Direct Recoveries of FY Mallards

Analysis by MN Regulatory Date.— A total of 406 (44%) and 519 (56%) direct recoveries of FY mallards were reported before and after the MN regulatory date in the years 1995-2001, respectively; and of those, 336 (83%) and 345 (66%) were FY mallards banded in Minnesota, respectively. Numbers of FY Minnesota banded mallards recovered before and after the MN regulatory date did not differ ($\chi^2 = 0.06$, $DF = 1$, $P > 0.75$). However, more FY migrant banded mallards were recovered in Minnesota after the MN regulatory date during the 1995-2001 seasons ($\chi^2 = 22.16$, $DF = 1$, $P < 0.001$). My final logistic regression model indicated that relative proportions of FY Minnesota and migrant mallard band recoveries differed by MN regulatory date. The odds ratio indicated that, when compared to FY migrant banded mallards, FY Minnesota banded mallards were 2.42 times more likely to be recovered before than after the MN regulatory date (Wald $\chi^2 = 30.17$, $P < 0.001$).

Analysis by Time of Season.— A total of 742 (80%) and 183 (20%) direct recoveries of FY mallards were reported during the first and second halves of the 1995-2001 seasons, respectively; and of those, 596 (80%) and 85 (46%) were FY mallards banded in Minnesota, respectively. Both Minnesota FY and migrant FY banded mallards were more likely to be recovered during the first half of the 1995-2001 seasons in Minnesota ($\chi^2 = 191.72$, $DF = 1$, $P < 0.001$ and $\chi^2 = 4.72$, $DF = 1$, $P < 0.05$, respectively). My final logistic regression model indicated that relative proportions of FY Minnesota and migrant mallard band recoveries differed by time of season. The odds ratio indicated that, when compared to FY migrant banded mallards, FY Minnesota banded mallards were 4.71 times more likely to be recovered during the first than second halves of the 1995-2001 seasons (Wald $\chi^2 = 78.67$, $P < 0.001$).

Discussion

Determination of Natal Origins

Based on the well-documented inverse relationship of δD to latitude (Chamberlain et al. 1997, Hobson and Wassenaar 1997), I grouped all hunter-shot HY mallards with δD values < -123.31 (minimum observed δD value of flightless mallard ducklings in the USA) as Canadian HY mallards. I then used the best DFA predictive model to classify natal origins of remaining hunter-shot HY mallards for subsequent analyses; however, this DFA model correctly classified only 59% of those feather samples. This moderate accuracy occurred because feathers of flightless mallard ducklings from Minnesota had intermediate mean values for $\delta^{13}C$, δD and $\delta^{15}N$ compared to those from North Dakota, South Dakota, and Wisconsin. Accordingly, I pooled all hunter-shot HY mallards that were not classified as Canadian HY mallards, as Minnesota HY mallards and ran worst-case scenario analyses to provide conservative estimates of effect sizes.

Analysis of SWD Treatments

I found that more HY mallards were killed with SWDs turned 'ON' than 'OFF', regardless of natal origin. Additionally, results of both logistic regression analyses (i.e., DFA and conservative pooled) suggest that Minnesota HY mallards were not relatively more likely than were migrant or Canadian HY mallards to be killed by hunters using SWDs.

Analysis of Temporal Variation

DFA.— California and Minnesota have implemented regulatory measures designed to reduce the harvest of local mallards based on assumptions that migrant ducks arrive later, and thus, alleviate harvest pressure from local ducks later in the season. I found that more Minnesota and migrant HY mallards were killed after than before the Saturday nearest 8 October 2002. Additionally, Minnesota HY mallards were not relatively more likely than were migrant HY mallards to be killed before the MN regulatory period in 2002. Finally, I found that numbers of hunter-shot HY mallards did not differ between the first and second halves of the 2002 season, regardless of natal origin. However, Minnesota HY mallards were relatively less likely than were migrant HY mallards to be killed during the first half of the 2002 season. My best DFA predictive model classified only 27% of hunter-shot HY mallards as from Minnesota, whereas, 75% of FY mallard band recoveries in Minnesota were Minnesota FY banded mallards. Therefore, given this difference and the moderate classification accuracy of DFA using $\delta^{13}C$ and δD, these results should be viewed with caution.

Conservative Pooled Analysis.— Results from my conservative pooled analysis indicated that more Minnesota and Canadian HY mallards were after than before the Saturday nearest 8 October 2002. Additionally, relative proportions of Minnesota and Canadian HY mallards killed did not differ before or after the MN regulatory date. Numbers of hunter-shot Minnesota HY mallards did not differ between the first and second halves of the 2002 season. Finally, relative proportions of Minnesota and Canadian HY mallards killed did not differ between the first and second halves of the 2002 season. The proportion of hunter-shot HY mallards classified as Minnesota HY mallards in my conservative pooled analysis was similar to that of FY Minnesota banded mallards recovered in Minnesota (74% vs. 75%) from the 1995-2001 seasons.

Common dogma states that mallards present on upper-Midwest breeding areas at the beginning of the hunting season are locally reared birds and that migrants from Canada arrive later in the season. However, my results indicate that numbers of Canadian HY mallards killed in Minnesota in 2002 were similar between the first and second halves of the season. Therefore, Canadian HY mallards may not always arrive later in the season to alleviate harvest pressure from locally reared Minnesota mallards.

Band Recovery Analysis.— I conducted experimental hunts during a single hunting season in Minnesota, and thus, my results based on stable isotope analysis may not be representative of longer-term averages. Therefore, I analyzed Minnesota band recoveries for FY mallards in recent years (1995-2001) to determine whether results based on stable isotope analysis and band recoveries were similar. For this analysis, I specifically assumed that HY mallards banded in Minnesota originated within the state. However, young mallards capable of flight (i.e., HY mallards) banded prior to the hunting season are of unknown origin. Thus, some HY mallards banded in Minnesota, especially northwestern Minnesota where large staging areas are located, probably originated elsewhere.

I found that numbers of FY Minnesota mallard recoveries did not differ before or after the Saturday nearest 8 October, but more FY migrant banded mallards were recovered after that date. Additionally, based on my logistic regression analysis, FY Minnesota banded mallards were 2.42 times more likely than were migrant FY banded mallards to be recovered before the Saturday nearest 8 October during the 1995-2001 seasons in Minnesota. A regulation that closes hunting at 1600 hrs before the Saturday nearest October 8 in Minnesota (Minnesota Department of Natural Resources 2002) may have confounded these relative proportions, and thus, perhaps more FY Minnesota banded mallards would have been recovered before the Saturday nearest 8 October had such restrictions not been in place. I found that both Minnesota and migrant FY banded mallards were more likely to be recovered during the first halves of the 1995-2001 seasons. Additionally, based on my logistic regression analysis, FY Minnesota banded mallards were 4.71 times more likely than were migrant FY banded mallards to be recovered during the first halves of those seasons in Minnesota.

Management Implications

I found that stable isotope methodology was only moderately accurate in classifying natal origins of mallards along an east to west gradient in upper-Midwest states. However, stable isotope methodology provides useful information regarding natal origins of migratory birds along a north to south gradient.

Based on stable isotope analysis, both Minnesota and migrant HY mallards were more likely to be killed by hunters using SWDs in 2002. However, I found no evidence that Minnesota HY mallards were relatively more vulnerable than were migrant HY mallards to SWDs. More Minnesota HY mallards were killed after than before the Saturday nearest 8 October, but numbers of Minnesota HY mallards killed did not differ between the first and second halves of the 2002 season in Minnesota. Additionally, Minnesota HY mallards were not relatively more likely than were migrant (or Canadian in my conservative pooled analysis) HY mallards to be killed before the Saturday nearest 8 October or during the first half of the season in 2002. However, my results from analysis of FY mallard band recoveries in Minnesota from 1995-2001 suggest that FY Minnesota banded mallards were relatively more likely than were FY migrant banded mallards to be recovered before the Saturday nearest 8 October and during the first half of the season.

Literature Cited

Agresti, A. 1996. An introduction to categorical data analysis. John Wiley & Sons, New York, New York, USA.

Alexander, S. A., K. A. Hobson, C. L. Gratto-Trevor, and A. W. Diamond. 1996. Conventional and isotopic determinations of shorebird diets at an island stopover: the importance of invertebrates and *Potamogeton pectinatus* tubers. Canadian Journal of Zoology 74: 1057-1068.

Bishop, R. A., and R. Barratt. 1969. Capturing waterfowl in Iowa by night-lighting. Journal of Wildlife Management 33: 956-960.

California Fish and Game Commission. 2001. 2001-02 California waterfowl hunting regulations. Sacramento, California, USA.

Carney, S. M. 1992. Species, age, and sex identification of ducks using wing plumage. U.S. Department of the Interior, U.S. Fish and Wildlife Service. Washington, D.C., USA.

Chamberlain, C. P., J. D. Blum, R. T. Holmes, X. Feng, T. W. Sherry, and G. R. Graves. 1997. The use of isotope tracers for identifying populations of migratory birds. Oecologia 109: 132-141.

Eadie, J. M., T. G. Moore, and J. T. Ackerman. 2002. Experimental evaluation of the effect of a mechanical decoy (moto-duck) on hunting success and waterfowl response in California 1999-2000. Final report to the California Waterfowl Association. University of California, Davis, CA.

Gilmer, D. S., R. E. Kirby, I. J. Ball, and J. H. Reichmann. 1977. Post-breeding activities of mallards and wood ducks in north-central Minnesota. Journal of Wildlife Management 41: 345-359.

Gollop, J. B., and W. H. Marshall. 1954. A guide for aging duck broods in the field. Mississippi Flyway Council Technical Section.

Gustafson, M. E., J. Hildenbrand, and L. Metras. 1997. The North American bird banding manual (electronic version). Version 1.0. Available online at: http://www.pwrc.usgs.gov/BBL/manual/manual.htm

Hebert, C. E., and L. I. Wassenaar. 2001. Stable nitrogen isotopes in waterfowl feathers reveal long-term nitrification of agricultural landscapes. Environmental Science and Technology 35: 3482-3487.

Hobson, K. A., and L. M. Wassenaar. 1997. Linking breeding and wintering grounds of neotropical migrant songbirds using stable hydrogen isotopic analysis of feathers. Oecologia 109: 142-148.

Hobson, K. A. 1999. Stable-carbon and nitrogen isotope ratios of songbird feathers grown in two terrestrial biomes: Implications for evaluating trophic relationships and breeding origins. Condor 101: 799-805.

Hochbaum, H. A. 1942. Sex and age determination in waterfowl by cloacal examination. Transactions of the North American Wildlife Conference 7: 299-307.

Kirby, R. E., L. M. Cowardin, and J. R. Tester. 1989. Premigrational movements and behavior of young mallards and wood ducks in north central Minnesota. U.S. Fish and Wildlife Service, Fish and Wildlife Research Report 5.

Lajtha, K., and R. H. Michener, editors. 1994. Stable isotopes in ecology and environmental science. Blackwell, London, United Kingdom.

Littell, R. C., G. A. Milliken, W. W. Stroup, and R. D. Wolfinger. 1996. SAS system for mixed models. Cary, North Carolina, USA.

Minnesota Department of Natural Resources. 2002. 2002 Waterfowl hunting regulations (supplement). St. Paul, Minnesota, USA.

Minnesota Statutes 2002. 2002 Regular Session. Chapter 351-Senate File 2674. Section 20. Section 97B.811. Subdivision 4a. St. Paul, Minnesota, USA.

Peterson, B. J., and B. Fry. 1987. Stable isotopes in ecosystem studies. Annual Review of Ecological Systematics 18: 293-320.

SAS Institute. 1999. SAS/STAT user's guide, 8.02 edition. SAS Institute, Cary North Carolina, USA.

Saxton, A. M. 1998. A macro for converting mean separation output to letter groupings in Proc Mixed, p. 1243-1246. *In* Proceedings of the 23rd annual SAS Users Group International Conference. SAS Institute, Cary, North Carolina, USA.

Wassenaar, L. M., and K. A. Hobson. 2002. Comparative equilibration and online technique for determination of non-exchangeable hydrogen of keratins for use in animal migration studies. Isotopes Environmental Health Studies 39: 1-7.

Chapter 5. Conclusion

Vulnerability of Ducks to Hunters Using SWDs

My results generally support the hypothesis that mallards are more vulnerable to hunters using SWDs in Minnesota. Moreover, my results based on stable isotope analysis indicated that both Minnesota and migrant HY mallards were more likely to be killed when hunters used SWDs. However, relative proportions of Minnesota and migrant HY mallards killed did not differ by SWD treatment.

I estimated that 46% and 79% of hunters using SWDs would be sufficient to double the 2000 and 2002 Minnesota mallard harvests. Given the lack of information and a desire to present a worst-case scenario, I assumed that the relationship between increases in mallard harvests and percentages of hunters using SWDs in Minnesota was linear. However, this relationship probably is curvilinear for several reasons (see Chapter 2).

If mallard harvests were to increase in other states, as projected as a worst-case scenario in Minnesota, then the frequency of promulgation of restrictive regulatory packages probably would increase under AHM models. However, increasing use of SWDs by hunters could result in a partial re-distribution of annual mallard harvests if naïve ducks are harvested upon initial exposures to SWDs, and those ducks that survive migrations to southern wintering areas become habituated to SWDs (c.f. Eadie et al. 2002). My study was confined to a single hunting season in Minnesota, and thus, did not assess whether vulnerability of mallards to hunters using SWDs differs geographically within and among years. Therefore, a multi-year, flyway-wide study is needed to make stronger inferences regarding potential changes in annual harvest rates of mallards to increasing use of SWDs by hunters.

Hunter Effectiveness and Opinions Concerning SWDs

Many Minnesota hunters that planned to use SWDs in the future also believed that SWDs reduce crippling or enabled them to selectively shoot more drakes. However, I found no evidence that use of SWDs reduced crippling or enabled hunters to better select drakes over hens. Therefore, hunters that were undecided or planned to use SWDs based on opinions regarding hunter effectiveness may choose not to use SWDs in the future once my findings to the contrary become known.

Utility of Stable Isotopes

My best DFA model correctly classified only 59% of feather samples from flightless mallard ducklings in Minnesota. This moderate accuracy occurred because duckling feathers from Minnesota had intermediate mean values for $\delta^{13}C$, δD and $\delta^{15}N$ compared to those from North Dakota, South Dakota, and Wisconsin. Therefore, my results suggest that stable isotope methodology is only moderately accurate in classifying natal origins of mallards along an east to west gradient in upper-Midwest states. However, stable isotope methodology provides useful information regarding natal origins of migratory birds along a north to south gradient.

Temporal Effects

I found that flock responses and kill rates of mallards did not differ by time of season. Additionally, I found that size of responding mallard flocks was greater during the first half of the season. Based on stable isotope analysis, more Minnesota HY mallards were after than before the Saturday nearest 8 October, but numbers of Minnesota HY mallards killed did not differ between the first and second halves of the 2002 season in Minnesota. Additionally, Minnesota HY mallards were not relatively more likely than were migrant (or Canadian in my conservative pooled analysis) HY mallards to be killed before the Saturday nearest 8 October or during the first half of the season in 2002. However, my results from analysis of FY mallard band recoveries in Minnesota from 1995-2001 suggest that FY Minnesota banded mallards were relatively more likely than were FY migrant banded mallards to be recovered before the Saturday nearest 8 October and during the first half of the season. Therefore, my results based on stable isotope analysis may not be representative of long-term temporal variation in harvest of local HY mallards in Minnesota, or alternately, assumptions that I made concerning banding data were grossly violated in my analysis.

Literature Cited

Eadie, J. M., T. G. Moore, and J. T. Ackerman. 2002. Experimental evaluation of the effect of a mechanical decoy (moto-duck) on hunting success and waterfowl response in California 1999-2000. Final report to the California Waterfowl Association. University of California, Davis, CA.

Fulton, D. C., J. Vlaming, J. S. Lawrence, and E. W. Price. 2002. The 2000 waterfowl hunting season in Minnesota: A study of hunters' opinions and activities. Final report to Minnesota Department of Natural Resources. USGS-Minnesota Cooperative Fish and Wildlife Research Unit, University of Minnesota, St. Paul, MN.

Schroeder, S., D. C. Fulton, and J. S. Lawrence. 2003. The 2002 waterfowl hunting season in Minnesota: A study of hunters' opinions and activities. Preliminary report to Minnesota Department of Natural Resources. USGS-Minnesota Cooperative Fish and Wildlife Research Unit, University of Minnesota, St. Paul, MN.

Appedix A. Top Ranking Minnesota Counties for Mallard and Total Duck Harvests by Time Period for Years 1995 – 2000

Time period	County	Mallard rank	Total duck rank	Priority rank[a]
9/28-10/07	Pope	1	3	1
9/28-10/07	Becker	2	2	2
9/28-10/07	Cass	3	4	4
9/28-10/07	St. Louis	4	-[b]	-
9/28-10/07	Otter Tail	5	1	3
10/08-10/14	Becker	1	1	1
10/08-10/14	Pope	2	2	2
10/08-10/14	Clay	3	-	-
10/08-10/14	Stearns	4	9	5
10/08-10/14	Big Stone	5	-	-
10/08-10/14	Martin	6	7	6
10/08-10/14	Otter Tail	6	2	3
10/15-10/21	Becker	1	1	1
10/15-10/21	Otter Tail	2	2	2
10/15-10/21	Clay	3	-	-
10/15-10/21	Martin	4	-	-
10/15-10/21	Pope	4	3	3
10/22-10/28	Becker	1	1	1
10/22-10/28	Big Stone	2	6	2

Appendix A continued on next page.

Appendix A continued.

10/22-10/28	Winona	3	6	3
10/29-11/04	Winona	1	5	1
10/29-11/04	Houston	2	6	3
10/29-11/04	Dakota	3	8	4
10/29-11/04	Otter Tail	4	2	2
11/05-11/11	Winona	1	3	1
11/05-11/11	Hennepin[c]	2	8	4
11/05-11/11	Houston	3	6	2
11/05-11/11	Traverse	4	-	-
11/05-11/11	Dakota	5	-	-
11/05-11/11	Le Suer	6	-	-
11/05-11/11	Pope[d]	6	4	3

[a] Higher priority was given to counties with highest mallard harvests when ranks were tied within a time period.

[b] Dash denotes counties that did not rank in the top 10 for total duck harvest during specific time periods and subsequently were not given a priority rank.

[c] Hennepin county was excluded because of difficulty in conducting experimental hunts in this highly-populated county.

[d] All hunts after 10 November were conducted in Houston, Wabasha, and Winona counties due to poor hunting conditions elsewhere.

Appendix B. Numbers of Duck Flocks Observed Within 100 m and that Subsequently Approached Within 40 m (%) of Hunters by Species with SWDs Turned ON and OFF, 28 September – 26 November 2002

	ON		OFF	
Species[a]	100 m	40 m	100 m	40 m
AGWT	59	44 (75%)	66	36 (55%)
AMWI	41	23 (56%)	28	13 (46%)
BUFF	32	14 (44%)	42	17 (40%)
BWTE	79	59 (75%)	77	46 (60%)
CANV	27	19 (70%)	16	5 (31%)
COGO	35	10 (29%)	49	8 (16%)
COME	4	3 (75%)	8	3 (38%)
GADW	90	54 (60%)	65	26 (40%)
GRSC	2	1 (50%)	2	2 (100%)
HOME	11	8 (73%)	11	8 (73%)
LESC	82	47 (57%)	84	39 (46%)
MALL	902	386 (43%)	731	158 (22%)
MIXED[b]	34	22 (65%)	21	7 (33%)
NOPI	28	15 (54%)	21	4 (19%)
NSHO	24	13 (54%)	11	7 (64%)
REDH	42	32 (76%)	45	19 (42%)
RNDU	200	108 (54%)	190	82 (43%)

Appendix B continued on next page.

Appendix B continued.

RUDU	3	1	(33%)	3	2	(67%)
WODU	80	33	(41%)	81	33	(41%)
Total	1775	892	(50%)	1551	515	(33%)

[a] See Appendix F for a list of species abbreviations and common and scientific names approved by the American Ornithologists' Union (AOU).
[b] Flocks consisting of multiple species.

Appendix C. Total Numbers of Ducks Killed (%) and Crippled (Hit and Not Retrieved) by Species with SWDs Turned ON and OFF During Experimental Hunts in Minnesota, 28 September – 26 November 2002

	Killed					Crippled				
Species[a]	ON		OFF		Total	ON		OFF		Total
AGWT	20	(74%)	7	(26%)	27	4	(50%)	4	(50%)	8
AMWI	16	(84%)	3	(16%)	19	4	(80%)	1	(20%)	5
BUFF	4	(57%)	3	(43%)	7	1	(50%)	1	(50%)	2
BWTE	18	(62%)	11	(38%)	29	4	(100%)	0	(0%)	4
CANV	1	(33%)	2	(67%)	3	2	(100%)	0	(0%)	2
COGO	2	(67%)	1	(33%)	3	1	(50%)	1	(50%)	2
COME	1	(33%)	2	(67%)	3	0	(0%)	0	(0%)	0
GADW	33	(79%)	9	(21%)	42	8	(80%)	2	(20%)	10
GRSC	0	(0%)	2	(100%)	2	0	(0%)	0	(0%)	0
HOME	1	(100%)	0	(0%)	1	2	(33%)	1	(67%)	3
LESC	16	(53%)	14	(47%)	30	6	(40%)	9	(60%)	15
MALL	176	(80%)	45	(20%)	221	86	(80%)	22	(20%)	108
MIXED[b]	-	-	-	-	-	2	(100%)	0	(0%)	2
NOPI	19	(91%)	2	(9%)	21	1	(50%)	1	(50%)	2
NSHO	5	(56%)	4	(44%)	9	1	(100%)	0	(0%)	1
REDH	15	(60%)	10	(40%)	25	7	(100%)	0	(0%)	7
RNDU	31	(52%)	29	(48%)	60	17	(94%)	1	(6%)	18

Appendix C continued on next page.

Appendix C continued.

WODU	4	(50%)	4	(50%)	8	4	(57%)	3	(43%)	7
Total	362	(71%)	148	(29%)	510	121	(58%)	87	(42%)	208

[a] See Appendix F for a list of species abbreviations and common and scientific names approved by the American Ornithologists' Union (AOU).

[b] Flocks consisting of multiple species.

Appendix D. Numbers of HY, AHY, and Age Ratios (HY/AHY) of Ducks Killed by Species with SWDs Turned ON and OFF, 28 September – 26 November 2002

	ON			OFF			Total		
Species[a]	HY	AHY	Age ratio	HY	AHY	Age ratio	HY	AHY	Age ratio
AGWT	15	5	3.00	7	0	-	22	5	4.40
AMWI	16	0	-	3	0	-	19	0	-
BUFF	4	0	-	1	2	0.50	5	2	2.50
BWTE	11	7	1.57	8	3	2.67	19	10	1.90
CANV	0	1	0.00	1	1	1.00	1	2	0.50
COGO	1	1	1.00	0	1	0.00	1	2	0.50
COME	1	0	-	0	2	0.00	1	2	0.50
GADW	21	12	1.75	7	2	3.50	28	14	2.00
GRSC	0	0	-	2	0	-	2	0	-
HOME	0	1	0.00	0	0	-	0	1	0.00
LESC	7	9	0.78	5	9	0.56	12	18	0.67
MALL	115	61	1.89	17	28	0.61	132	89	1.48
NOPI	18	1	18.00	2	0	-	20	1	20.00
NSHO	5	0	-	4	0	-	9	0	-
REDH	5	10	0.50	2	8	0.25	7	18	0.39
RNDU	15	16	0.94	16	13	1.23	31	29	1.07
WODU	2	2	1.00	3	1	3.00	5	3	1.67
Total	236	126	1.87	78	70	1.11	314	196	1.60

[a] See Appendix F for a list of species abbreviations and common and scientific names approved by the American Ornithologists' Union (AOU).

Appendix E. Numbers of Male, Female and Sex Ratios (Male/Female) of Ducks Killed by Species with SWDs Turned ON and OFF, 28 September – 26 November 2002

	ON			OFF			Total		
Species[a]	Male	Female	Sex ratio	Male	Female	Sex ratio	Male	Female	Sex ratio
AGWT	7	13	0.54	3	4	0.75	10	17	0.59
AMWI	14	2	7.00	1	2	0.50	15	4	3.75
BUFF	1	3	0.33	2	1	2.00	3	4	0.75
BWTE	5	13	0.38	5	6	0.83	10	19	0.53
CANV	0	1	0.00	2	0	-	2	1	2.00
COGO	0	2	0.00	1	0	-	1	2	0.50
COME	1	0	-	2	0	-	3	0	-
GADW	22	11	2.00	5	4	1.25	27	15	1.80
GRSC	0	0	-	2	0	-	2	0	-
HOME	1	0	-	0	0	-	1	0	-
LESC	9	7	1.29	10	4	2.50	19	11	1.73
MALL	111	65	1.71	26	19	1.37	137	84	1.63
NOPI	12	7	1.71	1	1	1.00	13	8	1.63
NSHO	2	3	0.67	3	1	3.00	5	4	1.25
REDH	10	5	2.00	6	4	1.50	16	9	1.78
RNDU	16	15	1.07	23	6	3.83	39	21	1.86
WODU	3	1	3.00	2	2	1.00	5	3	1.67
Total	214	148	1.45	94	54	1.74	308	202	1.53

[a] See Appendix F for a list of species abbreviations and common and scientific names approved by the American Ornithologists' Union (AOU).

Appendix F. Species Abbreviations and Common and Scientific Names of Ducks Observed and Killed in Minnesota, 28 September – 26 November 2002[a]

Abbreviation	Common name	Scientific name
AGWT	American green-winged teal	(*Anas crecca*)
AMWI	American widgeon	(*Anas americana*)
BUFF	Bufflehead	(*Bucephala albeola*)
BWTE	Blue-winged teal	(*Anas discors*)
CANV	Canvasback	(*Aythya valisineria*)
COGO	Common goldeneye	(*Bucephala clangula*)
COME	Common merganser	(*Mergus merganser*)
GADW	Gadwall	(*Anas strepera*)
GRSC	Greater scaup	(*Aythya marila*)
HOME	Hooded merganser	(*Lophodytes cucullatus*)
LESC	Lesser scaup	(*Aythya affinis*)
MALL	Mallard	(*Anas platyrhynchos*)
NOPI	Northern pintail	(*Anas acuta*)
NSHO	Northern shoveler	(*Anas clypeata*)
REDH	Redhead	(*Aythya americana*)
RNDU	Ring-necked duck	(*Aythya collaris*)
RUDU	Ruddy duck	(*Oxyura jamaicensis*)
WODU	Wood duck	(*Aix sponsa*)

[a] As approved by the American Ornithologists' Union (AOU).

Appendix G. Post Hunt Questionnaire

(Please fill out or circle the following)
Date __________ Age ______ Gender M F

(Please check the answer that most applies to you.)

1) How many years have you been duck hunting?
( ) <3 ( ) 3-5 ( ) 6-10 ( ) 11-20 ( ) >20

2) How many days did you duck hunt in Minnesota last hunting season?
( ) <3 ( ) 3-5 ( ) 6-10 ( ) 11-20 ( ) >20

3) How many days did you duck hunt in other states or provinces last hunting season?
( ) <3 ( ) 3-5 ( ) 6-10 ( ) 11-20 ( ) >20

4) Do you own a spinning-wing decoy?
( ) Yes ( ) No

5) During last hunting season, what percent of hunts did you use a spinning-wing decoy?
( ) 0%( ) 1-25% ( ) 26-50% ( ) 51-75% ( ) ≥76%

6) Why did you use a spinning-wing decoy? (Check all that apply, if other; please explain on the line provided. If you have not used one, skip this question.)
( ) To be able to compete with other hunters ( ) Just wanted to try it
( ) To reduce crippling ( ) To shoot more drakes
( ) To improve harvest opportunity ( ) Other
____

7) Do you plan to use a spinning-wing decoy in the future?
( ) Yes ( ) No ( ) Undecided

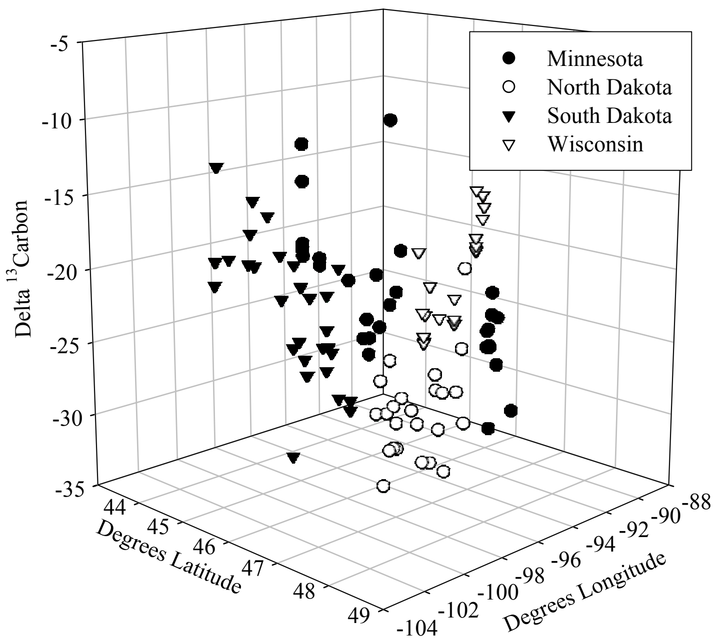
8) Do you believe that spinning-wing decoys allow you to shoot more drakes?
( ) Yes ( ) No ( ) Undecided

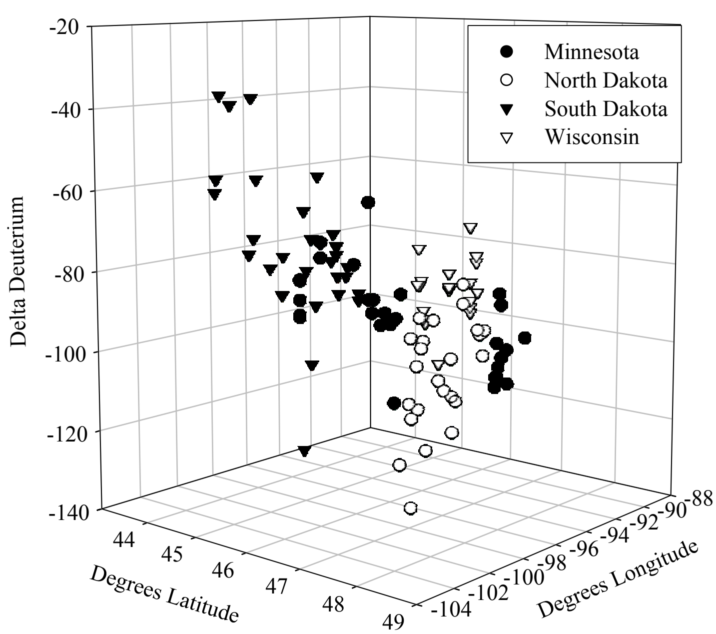
9) Do you believe that spinning-wing decoys allow you to reduce crippling of ducks?
( ) Yes ( ) No ( ) Undecided

10) Do you feel that spinning-wing decoys violate fair chase?
( ) Yes ( ) No ( ) Undecided

11) Do you believe that spinning-wing decoys should be banned?
( ) Yes, the entire season ( ) No
( ) Yes, part of the season ( ) Undecided

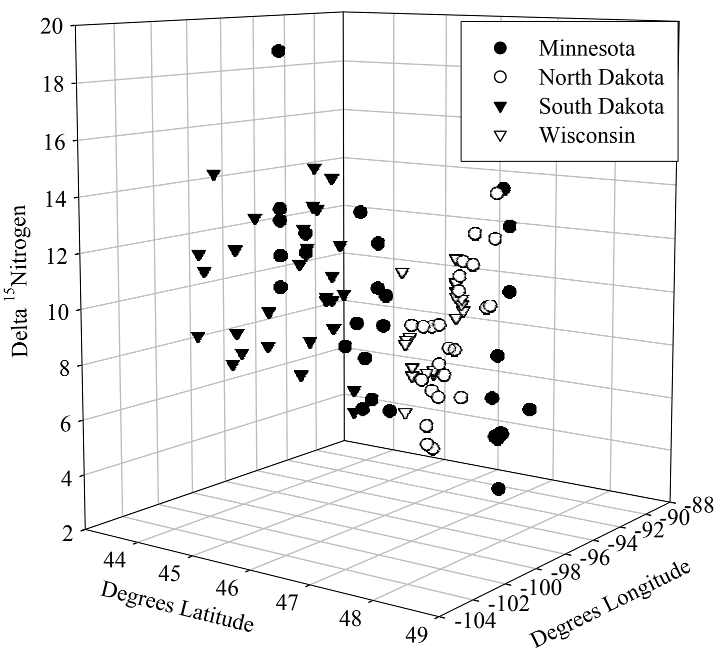
Appendix H. Distribution of Feather $\delta^{13}C$, δD and $\delta^{15}N$ Values by Latitude and Longitude from Flightless Mallard Ducklings Collected in Minnesota, North Dakota, South Dakota, and Wisconsin, July – September 2002



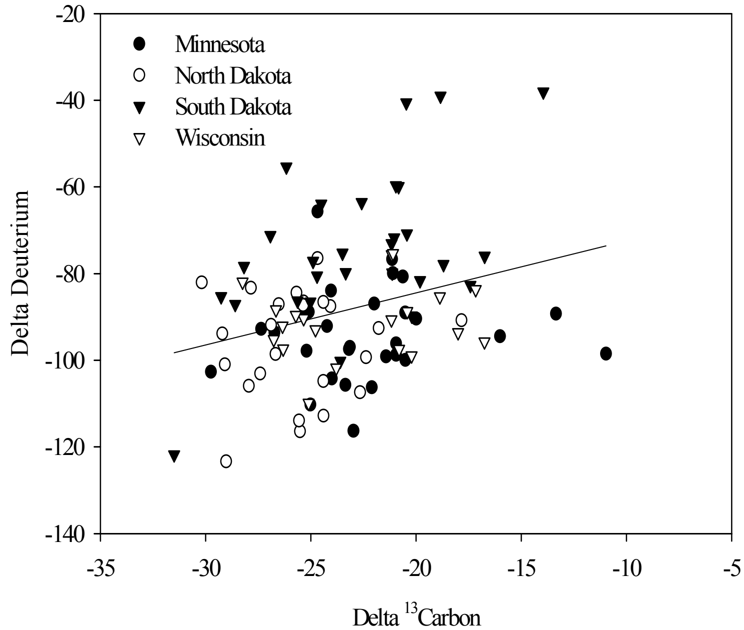


Appendix H continued on next page.

Appendix H continued.



Appendix I. Simple Linear Relationships of $\delta^{13}C$, δD and $\delta^{15}N$ Values from Flightless Mallard Ducklings Collected in Minnesota, North Dakota, South Dakota, and Wisconsin, July – September 2002

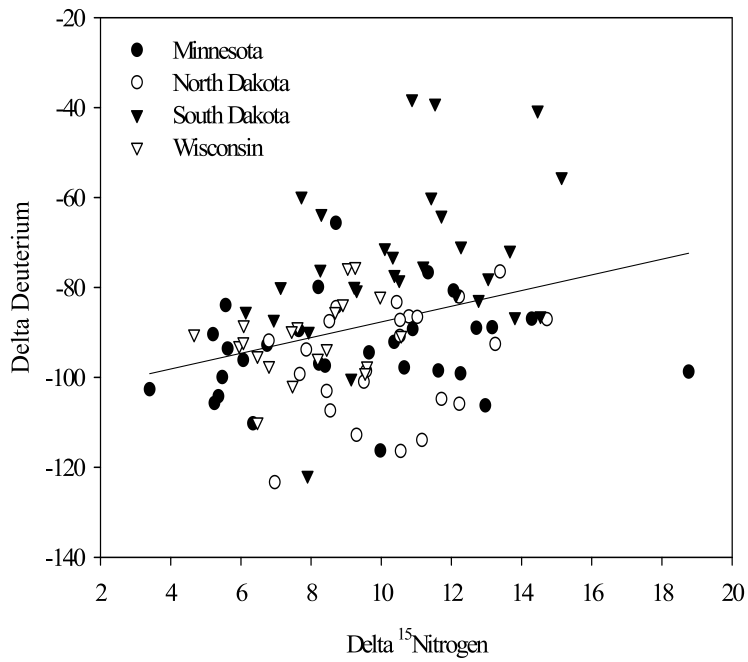


Y = 60.439 + 1.201X

$R^2 = 0.075$

n = 102

P = 0.003



Y = 105.09 + 1.743X

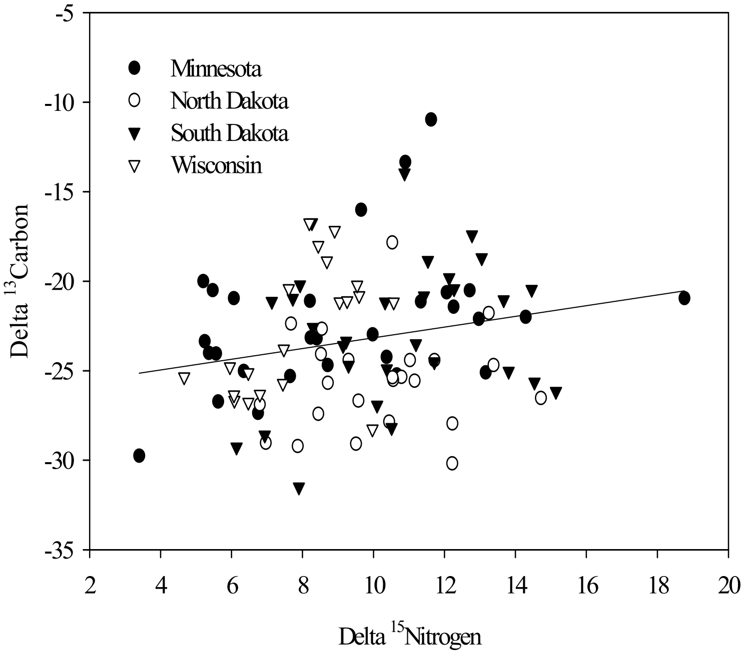
$R^2 = 0.084$

n = 102

P = 0.002

Appendix I continued on next page.

Appendix I continued.



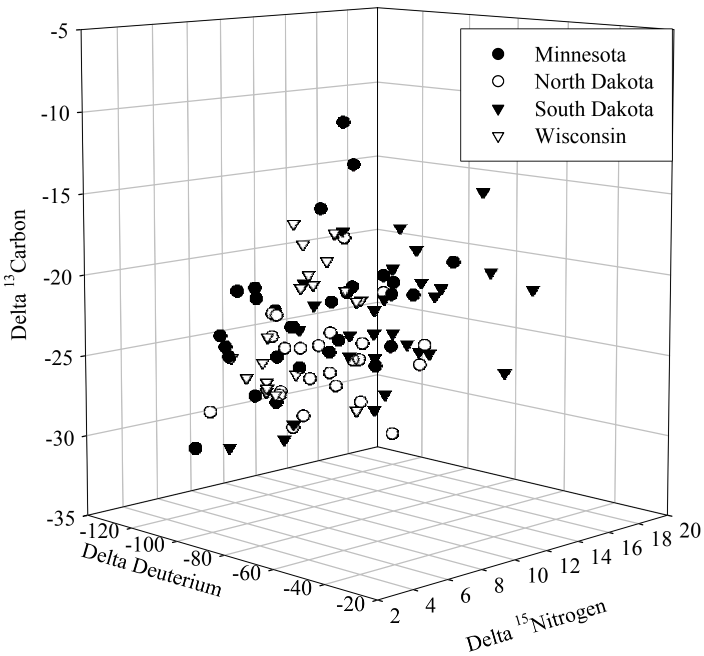
Y = 26.154 + 0.299X

$R^2 = 0.037$

$n = 102$

$P = 0.029$

Appendix J. Joint Distributions of Feather $\delta^{13}C$, δD, and $\delta^{15}N$ Values from Flightless Mallard Ducklings Collected in Minnesota, North Dakota, South Dakota, and Wisconsin, July – September 2002



Vita

Michael Lester Szymanski was born 9 December 1979, to James Paul Szymanski and Marian Lucille Szymanski in Grand Forks, North Dakota. Mike received his high school diploma from Minot High School in 1998 and earned his Bachelor of Science degree majoring in fisheries and wildlife biology with a minor in geography (emphasis in Geographical Information Systems) from the University of North Dakota in December 2001. Mike worked summers for the United States Fish and Wildlife Service at Audubon NWR/WMD and the rest of the year at the University of North Dakota while achieving his undergraduate degree. Mike enrolled to pursue a Master of Science degree in wildlife at Louisiana State University in January 2002.