THE VALUE OF FARM PROGRAMS FOR PROVIDING WINTER COVER AND FOOD FOR MINNESOTA PHEASANTS

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SUMMARY OF FINDINGS

The purpose of this study was to determine how much winter habitat is needed to sustain local populations of ring-necked pheasants (*Phasianus colchicus*) over a range of winter conditions. We estimated relative abundance of pheasant populations on 36 study areas using roadside surveys. In addition, we estimated amounts of winter cover, winter food, and reproductive cover on each study area by cover mapping to a Geographic Information System (GIS). During 2003-2006, pheasant population indices varied in association with weather and habitat. A preliminary evaluation indicated that mean pheasant indices were positively related to habitat abundance in most, but not all, regions. Four consecutive mild winters have hampered our ability to estimate winter habitat needs. Future work will include continued pheasant surveys for 1 additional year, improved estimates of habitat abundance, and more complex analysis of the association between pheasant indices and habitat parameters. Final products of this project will include GIS habitat models or maps that managers can use to target habitat development efforts where they may yield the greatest increase in pheasant numbers.

INTRODUCTION

Preferred winter habitat for ring-necked pheasants (*Phasianus colchicus*) in the Midwest includes grasslands, wetlands, woody cover, and a dependable source of food (primarily grain) near cover (Gates and Hale 1974, Trautman 1982, Perkins et al. 1997, Gabbert et al. 1999). However, emergent wetlands and woody habitats that are large enough to provide shelter during severe winters have been extensively removed from agricultural landscapes, and grasslands and grain stubble are inundated by snow during some years. During severe winters, pheasants without access to sufficient winter habitat are presumed to perish or emigrate to landscapes with adequate habitat. Birds that emigrate >3.2 km (2 miles) from their breeding range are unlikely to return (Gates and Hale 1974).

Almost 400,000 ha (1 million acres) of cropland in Minnesota's pheasant range are currently retired under the Conservation Reserve Program (CRP). Wetland restorations, woody habitats, and food plots are eligible cover practices in the CRP, but most appear inadequate in size, design, or location to meet pheasant habitat needs. Furthermore, small woody covers commonly established on CRP lands may reduce the quality of adjacent grass reproductive habitat without providing intended winter cover benefits.

Pheasants use grasslands for nesting and brood rearing, and we previously documented a strong relationship between grassland abundance and pheasant numbers (Haroldson et al. 2006). However, information is lacking on how much winter habitat is needed to sustain pheasant populations during mild, moderate, and severe winters. The purpose of this study is to quantify the relationship between amount of winter habitat and pheasant abundance over a range of winter conditions. Our objectives are to: 1) estimate pheasant abundance on study areas with different amounts of reproductive cover, winter cover, and winter food over a time period capturing a range of winter severities (≥5 years); 2) describe annual changes in availability of winter cover as a function of winter severity; and 3) quantify the association between mean pheasant abundance (over all years) and amount of reproductive cover, winter cover, and winter food.

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METHODS

We selected 36 study areas of contrasting land cover in Minnesota's core pheasant range to ensure a wide range of habitat configurations. Study areas averaged 23 km^2 (9 $miles^2$) in size, and were selected to vary in the amount of winter cover, winter food, and reproductive cover. We defined winter cover as cattail (*Typha spp.)* wetlands ≥4 ha (10 acres) in area (excluding open water), dense shrub swamps ≥4 ha (10 acres) in area, or planted woody shelterbelts ≥0.8 ha (2 acres) in area, ≥60 m (200 feet) wide, and containing ≥2 rows of conifers (Gates and Hale 1974, Berner 2001). Winter food was defined as grain food plots left unharvested throughout the winter and located ≤0.4 km (1/4 mile) from winter cover (Gates and Hale 1974). Reproductive cover included all undisturbed grass cover ≥6 m (20 feet) wide. To facilitate pheasant surveys, 9 study areas were selected in each of 4 regions located near Marshall, Windom, Glenwood, and Faribault, Minnesota (Figure 1).

We estimated amounts of winter cover, winter food, and reproductive cover on each study area by cover mapping to a GIS from recent aerial photographs. In addition, we mapped large habitat patches within a 3.2-km (2-mile) buffer around study area boundaries to assess the potential for immigration to and emigration from study areas. We used Farm Service Agency's GIS coverages of farm fields (Common Land Units) as base maps, and edited field boundaries to meet the habitat criteria of this project. Cover types were verified by ground-truthing all habitat patches visible from roads. Because cover mapping of cattail wetlands, shrub swamps, and undisturbed grasslands is still in progress, for this progress report we made preliminary estimates of the amounts of these habitats from GIS coverages of the National Wetlands Inventory (NWI), Wildlife Management Areas (WMAs), Waterfowl Production Areas (WPAs), and CRP enrollments. We recognize that not all cattail wetlands, shrub swamps, and undisturbed grasslands are included in these GIS coverages.

We plan to estimate availability of winter cover during moderate–severe winters using aerial surveys. When fallen or drifted snow has inundated small (4–6 ha [10–15 acre]) cattail wetlands for ≥2 weeks, a sample of winter cover patches on all affected study areas will be inspected by helicopter to determine 1) availability of any remaining cover within the patch, and 2) presence of pheasants within the patch.

We estimated relative abundance of pheasant populations on each study area using roadside surveys (Haroldson et al. 2006). Roadside surveys consisted of 16–19 km (10–12 mile) routes primarily on gravel roads (≤6 km [4 miles] of hard-surface road). Observers drove each route starting at sunrise at an approximate speed of 24 km/hour (15 miles/hour) and recorded the number, sex, and age of pheasants observed. Surveys were repeated 10 times on each study area during spring (20 April–20 May) and summer (20 July–20 August). Surveys were conducted on mornings meeting standardized weather criteria (cloud cover <60%, winds ≤16 km/hour [10 miles/hour], temperature ≥0^oC [32^oF], dew present) 1–2 hours before sunrise; however, surveys were completed even if conditions deteriorated after the initial weather check. We attempted to survey all study areas within a region on the same days, and observers were systematically rotated among study areas to reduce the effect of observer bias.

Observers carried Global Positioning System (GPS) receivers while conducting roadside surveys to record their time and position throughout each survey (track logs), and to record the location of observed pheasants (waypoints). We inspected all track logs for each observer to ensure that surveys were conducted at the correct time, location, and speed of travel.

For each study area and season, we calculated a population index (pheasants counted/route) from the total number of pheasants counted/total survey distance driven over all 10 repetitions. We standardized the index to pheasants/161 km (pheasants/100 miles) to adjust for variation in survey distance among study areas. We evaluated temporal trends in pheasant abundance by calculating mean percent change in population indices by region and in total. We interpreted trends as statistically significant when 95% confidence intervals of percent change did not include 0.

To evaluate the effect of habitat on pheasant abundance, we calculated a cover index for each study area:

CI = [(UG/Max)x4 + (WCwFP/Max)x4 + (WCwoFP/Max)x2 + (FP/Max)] / 11

where UG = undisturbed grass (% of study area)
WCwFP = winter cover near a food plot (number of patches)
WCwoFP = winter cover without a nearby food plot (number of patches)
FP = food plot (number of patches)
Max = maximum observed value among all 36 study areas.

The cover index combined the effects of reproductive cover, winter cover, and winter food into a single weighted average (weight based on a preliminary estimate of relative importance). Potential values of cover index ranged from 0.0 (poorest habitat) to 1.0 (best habitat). We acknowledge that the cover index is an oversimplification, and we used it only to make simple, 2-dimentional plots for this early progress report. For each region, we evaluated the association of cover indices to pheasant population indices using simple linear regression.

RESULTS

We identified and mapped 321 patches of winter cover on the 36 study areas and surrounding 3.2-km (2-mile) buffers. Severity of winter weather was mild during all 4 winters (2002-2006) of this study. As a result, even the least robust patches of winter cover (e.g., 4-ha [10-acre] cattail wetlands) remained available to pheasants throughout the 4 winters of this study.

Spring 2006 Surveys

Observers completed all 360 scheduled surveys (10 repetitions on 36 study areas) during the spring 2006 season. Despite strong efforts by surveyors to select days that best met weather standards, weather conditions were not consistent among surveys, ranging from excellent (calm, clear sky, heavy dew) to poor (wind >16 km/hour [10 miles/hour], overcast sky, no dew, rain, or frost). Over all regions, 92% of the surveys were started with at least light dew present, which was greater than previous years (78-91%). Seventy-four percent of surveys were started under clear to partly cloudy skies (<60% cloud cover), 96% reported wind speeds <16 km/hour (10 miles/hour), and 98% of surveys were started on mornings with temperatures >0^{o}C (32^{o}F). Among regions, Glenwood experienced the least dew (16% of surveys started with no dew), whereas Faribault experienced the least cloud cover (only 7% of surveys started with cloud cover ≥60%).

Pheasants were observed on all 36 study areas during spring 2006, but abundance indices varied widely among areas from 32.5–474.5 pheasants observed per route (Table 1). Over all study areas, the mean pheasant index was 165.8 birds/route, a 69% increase (95% CI: 56–82%) from spring 2005 and the highest observed during the 4 years of this study (Table 2). Total pheasants/route varied among regions from 91.1 in the Faribault region to 234.3 in the Windom region (Table 2). Compared to 2005, total indices increased significantly in all regions, with the greatest increase in Marshall (101%; 95% CI: 76–126%) and the smallest increase in Windom (35%; 95% CI: 18–52%).

Hens were relatively abundant among study areas in spring 2006. The overall hen index averaged 97.5/route, a 95% increase (95% CI: 72–118%) from 2005 (Table 2). Among regions, the hen index ranged from 46.8/route in Faribault to 143.9/route near Windom. Hen indices increased significantly from 2005 in all regions, more than doubling in Faribault (132% increase; 95% CI: 56–208%) and Marshall (127% increase; 95% CI: 77–157%; Table 2). The observed hen:rooster ratio varied from 0.5 to 2.7 among study areas (Table 1). Fewer hens than roosters were observed on 1 study area in the Marshall region, 4 areas in Glenwood, and 4 areas in Faribault.

Summer 2006 Surveys

Observers completed all 360 scheduled surveys during the summer 2006 season. Weather conditions during the summer surveys ranged from excellent (calm, clear sky, heavy dew) to poor (light or no dew, overcast sky). Over all regions, 75% of the surveys were started with medium-heavy dew present, which was lower than 2005 (81%), 2004 (87%), and 2003 (81%). Large regional differences in dew conditions were observed this year, ranging from 90% of surveys with medium-heavy dew present in Marshall to only 62% in Windom and 66% in Glenwood. For all regions combined, 64% of the surveys were started under clear skies (<30% cloud cover), and 75% reported wind <6 km/hour (4 miles/hour). In comparison, 96% of the statewide August Roadside Surveys were started under medium-heavy dew conditions, 89% under clear skies, and 76% with winds <6 km/hour (4 miles/hour). The less desirable weather conditions reported in this study probably reflect the limited availability of 10 suitable survey days within the 31-day period.

Pheasants were observed on all 36 study areas during 2006, but abundance indices varied widely from 18.6–537.3 pheasants observed per route (Table 3). Over all study areas, the mean pheasant population index of 161.9 birds/route was not significantly different from 2005 (150.9 birds/route). Total pheasant indices varied among regions from 81.7 birds/route in the Faribault region to 280.9 birds/route in Marshall (Table 4). Compared to 2005, total indices increased significantly only in the Marshall region (Table 4).

The overall hen index (28.7 hens/route) was similar to last year (26.3 hens/route), and varied among regions from 12.2 in the Faribault region to 49.1 near Marshall (Table 4). Hen indices increased 60% (95% CI: 22–98%) in the Marshall region, but were not significantly higher than 2005 in the Glenwood, Faribault, or Windom regions (Table 4). In contrast, overall and regional cock indices increased significantly except in the Faribault region (Table 4). The observed hen:rooster ratio varied from 0.2 to 6.3 among study areas (Table 3), and averaged 1.8 overall. Fewer hens than roosters were observed on 2 study areas in the Glenwood and Faribault regions and 4 study areas in the Windom region.

The 2006 overall brood index (23.1 broods/route) was similar to 2005 (23.6 broods/route), with regional indices ranging from 11.4 in Faribault to 38.9 in Marshall (Table 4). Regional brood indices were also similar to 2005 (Table 4). Mean brood size averaged 4.8 chicks/brood overall, but varied among regions from 3.9 in Windom to 5.3 in Faribault. Mean brood size in 2006 increased 21% (95% CI: 1–41%) over that in 2005 in the Marshall region, was similar to 2005 in Glenwood and Faribault, and declined 12% (95% CI: -23 to -1%) in Windom (Table 4). On average, 27.9 broods were observed for every 100 hens counted during spring surveys, a 33% (95% CI: -45 to -21%) decrease from last year. This brood recruitment index (broods/100 spring hens) varied among regions from 18.7 in Windom to 35.9 in Marshall. Brood recruitment indices decreased significantly only in the Marshall (95% CI: -61 to -31%) and Faribault (95% CI: -61 to -31%) regions (Table 4).

Habitat Associations

The mean pheasant index (total pheasants/route averaged over summer 2003–2006) was significantly related to the cover index only in the Marshall region (Figure 2). Cover index explained 60% of the variation in pheasant indices in the Marshall region, 28% in Windom, 18% in Faribault, and 6% in Glenwood.

DISCUSSION

A high spring hen population in 2006 was expected given the relatively mild winter of 2005-2006 (the 5th consecutive mild winter), but the magnitude of the increase was greater than expected. Weather during the reproductive period was warmer and drier than average, conditions conducive for increased nest success and chick survival. However, brood size increased only in the Marshall region and the brood recruitment index (broods/100 spring hens) declined in 2006. Nevertheless, total pheasant indices remain high due to above-average carryover of adults from 2005 plus average chick recruitment in 2006.

At this early stage in our evaluation, we cannot explain the weak association between summer pheasant indices and habitat abundance on the Glenwood and Faribault study areas (Figure 2). However, preliminary habitat estimates based on GIS coverages of the NWI, WMAs, WPAs, and CRP enrollments appear to have omitted much more winter and reproductive cover on the Glenwood and Faribault study areas than on Marshall and Windom study areas. Habitat estimates will be improved as we finish cover mapping the study areas. In addition, future analyses of pheasant-habitat associations will use multiple regression models that treat reproductive cover, winter cover, and winter food as independent predictor variables.

Our study design requires at least 1 severe winter to estimate pheasant winter cover needs. After 4 consecutive mild winters, we have observed relatively high, stable pheasant populations on all study areas. We expect pheasant populations to decline following a severe winter, with the largest declines on study areas with the least amount of winter cover. Unless the coming winter (2006-2007) is severe, we may not be able to fully accomplish Objective 1 of this study. Furthermore, the significant loss of CRP contracts expected during 2007-2009 will preclude an extension of this study.

We plan to continue to survey pheasant populations during spring and summer 2007. In addition, we will continue annual cover mapping of all 36 study areas. During the next moderate-severe winter, we will assess winter habitat availability in relation to snow depth and drifting. Finally, we will attempt to build a multiple regression model using data extracted from a previous pheasant habitat study (Haroldson et al. 2006).

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LITERATURE CITED

BERNER, A. H. 2001. Winterizing Minnesota's landscape for wildlife: providing food and cover for wintering pheasants and associated resident wildlife in Minnesota's farmlands. Minnesota Department of Natural Resources, Division of Fish and Wildlife, St. Paul.

GABBERT, A. E., A. P. LEIF, J. R. PURVIS, AND L. D. FLAKE. 1999. Survival and habitat use by ring-necked pheasants during two disparate winters in South Dakota. Journal of Wildlife Management 63:711–722.

GATES, J. M., AND J. B. HALE. 1974. Seasonal movement, winter habitat use, and population distribution of an east central Wisconsin pheasant population. Wisconsin Department of Natural Resources Technical Bulletin 76, Madison.

HAROLDSON, K. J., R. O. KIMMEL, M. R. RIGGS, AND A. H. BERNER. 2006. Association of ring-necked pheasant, gray partridge, and meadowlark abundance to CRP grasslands. Journal of Wildlife Management 70:1276–1284.

PERKINS, A. L., W. R. CLARK, T. Z. RILEY, AND P. A. VOHS. 1997. Effects of landscape and weather on winter survival of ring-necked pheasant hens. Journal of Wildlife Management 61:634–644.

TRAUTMAN, C. G. 1982. History, ecology and management of the ring-necked pheasant in South Dakota. South Dakota Department of Game, Fish and Parks Bulletin 7, Pierre.

Table 1. Pheasant population indices and sex ratios (female:male) after 10 repeated surveys (n) on 36 study areas in Minnesota, spring 2006.

			Birds/route[a]			
Region	Study area	n	Total	Cocks	Hens	F:M ratio
Marshall	1	10	226.6	71.1	155.5	2.2
	2	10	267.5	121.3	146.3	1.2
	3	10	340.8	137.9	202.9	1.5
	4	10	362.5	106.2	256.3	2.4
	5	10	104.2	46.7	57.5	1.2
	6	10	232.1	75.0	157.1	2.1
	7	10	155.5	42.3	113.2	2.7
	8	10	128.7	68.3	60.4	0.9
	9	10	85.1	35.1	50.0	1.4
Glenwood	10	10	79.0	35.0	44.0	1.3
	11	10	81.4	24.6	56.8	2.3
	12	10	169.1	98.6	70.5	0.7
	13	10	114.8	64.3	50.4	0.8
	14	10	158.8	60.5	98.2	1.6
	15	10	215.7	108.8	106.9	1.0
	16	10	96.2	53.3	42.9	0.8
	17	10	37.2	19.8	17.4	0.9
	18	10	184.3	77.5	106.8	1.4
Windom	19	10	474.5	148.9	325.5	2.2
	20	10	396.3	157.6	238.7	1.5
	21	10	173.7	58.4	115.3	2.0
	22	10	219.0	103.2	115.8	1.1
	23	10	357.4	148.5	208.9	1.4
	24	10	136.0	64.0	72.0	1.1
	25	10	129.0	46.3	82.7	1.8
	26	10	166.7	61.4	105.3	1.7
	27	10	56.5	26.1	30.4	1.2
Faribault	28	10	207.5	79.2	128.3	1.6
	29	10	65.2	37.0	28.2	0.8
	30	10	58.9	40.3	18.5	0.5
	31	10	125.5	70.6	54.9	0.8
	32	10	68.5	33.8	34.7	1.0
	33	10	79.3	36.6	42.7	1.2
	34	10	131.6	61.0	70.7	1.2
	35	10	50.4	26.5	23.9	0.9
	36	10	32.5	13.3	19.2	1.4

[a]Route length standardized to 161 km (100 miles).

Table 2. Regional trends (% change) in pheasant population indices on 36 study areas in Minnesota, spring 2003–2006.

Region	Group	n	Birds/route[a]				% change	
			2003	2004	2005	2006	2005-2006	95% CI
Marshall	Total pheasants	9	87.2	116.3	110.4	211.4	101	±25
	Cocks	9	43.1	47.4	47.7	78.2	72	±27
	Hens	9	44.1	68.9	62.7	133.2	127	±30
Glenwood	Total pheasants	9	100.9	113.0	84.5	126.3	67	±24
	Cocks	9	48.7	47.2	40.2	60.3	55	±22
	Hens	9	52.2	65.9	44.3	66.0	86	±41
Windom	Total pheasants	9	162.3	179.7	167.6	234.3	35	±17
	Cocks	9	69.4	75.8	65.0	90.5	37	±17
	Hens	9	92.9	103.9	102.6	143.9	36	±24
Faribault	Total pheasants	9	70.3	86.0	57.3	91.1	72	±37
	Cocks	9	37.1	47.1	33.5	44.3	44	±30
	Hens	9	33.2	38.8	23.8	46.8	132	±76
All	Total pheasants	36	105.2	123.8	104.9	165.8	69	±13
	Cocks	36	49.6	54.4	46.6	68.3	52	±11
	Hens	36	55.6	69.4	58.3	97.5	95	±23

[a]Route length standardized to 161 km (100 miles).

Table 3. Pheasant population indices and sex ratios (female:male) after 10 repeated surveys (n) on 36 study areas in Minnesota, summer 2006.

Region	Study area	n	Birds/route[a]			F:M ratio	Chicks/ route[a]	Broods/ route[a]	Chicks/ brood	Broods/100 Summer hens	Broods/100 Spring hens
			Total	Cocks	Hens						
Marshall	1	10	537.3	42.3	75.9	1.8	419.1	65.5	6.4	0.862	0.421
	2	10	421.7	46.7	64.2	1.4	310.8	52.5	5.9	0.818	0.359
	3	10	166.0	14.6	31.1	2.1	120.4	27.2	4.4	0.875	0.134
	4	10	313.0	18.5	61.5	3.3	233.0	51.0	4.6	0.829	0.199
	5	10	363.3	38.3	59.2	1.5	265.8	45.0	5.9	0.761	0.783
	6	10	267.9	18.9	53.8	2.9	195.3	35.8	5.4	0.667	0.228
	7	10	100.0	9.1	20.9	2.3	70.0	20.9	3.3	1.000	0.185
	8	10	253.5	35.1	50.0	1.4	168.3	38.6	4.4	0.772	0.639
	9	10	105.3	12.3	25.4	2.1	67.5	14.0	4.8	0.552	0.281
Glenwood	10	10	35.4	6.1	4.0	0.7	25.3	8.1	3.1	2.000	0.184
	11	10	152.1	7.2	22.5	3.1	122.3	19.5	6.3	0.868	0.344
	12	10	299.0	14.3	38.1	2.7	246.7	41.0	6.0	1.075	0.581
	13	10	107.8	7.8	23.5	3.0	76.5	15.7	4.9	0.667	0.310
	14	10	138.6	14.5	24.1	1.7	100.0	19.3	5.2	0.800	0.196
	15	10	197.2	28.2	35.6	1.3	133.3	33.3	4.0	0.935	0.312
	16	10	105.7	10.5	11.4	1.1	83.8	18.1	4.6	1.583	0.422
	17	10	24.8	5.0	4.1	0.8	15.7	2.5	6.3	0.600	0.143
	18	10	128.7	12.9	23.4	1.8	92.5	15.3	6.1	0.653	0.143
Windom	19	10	228.4	14.2	54.2	3.8	160.0	32.6	4.9	0.602	0.100
	20	10	172.0	19.7	43.5	2.2	108.8	28.0	3.9	0.643	0.117
	21	10	83.2	10.0	21.6	2.2	51.6	14.7	3.5	0.683	0.128
	22	10	151.6	28.0	40.6	1.5	83.0	21.7	3.8	0.533	0.187
	23	10	239.7	50.7	46.6	0.9	142.4	33.1	4.3	0.710	0.158
	24	10	76.0	27.5	14.5	0.5	34.0	11.0	3.1	0.759	0.153
	25	10	100.9	28.5	16.4	0.6	56.1	13.1	4.3	0.800	0.158
	26	10	281.6	41.2	52.6	1.3	187.7	44.7	4.2	0.850	0.425
	27	10	41.7	13.0	4.3	0.3	24.3	7.8	3.1	1.800	0.257
Faribault	28	10	127.4	9.0	20.3	2.3	98.1	18.9	5.2	0.930	0.147
	29	10	22.8	8.9	2.0	0.2	11.9	3.0	4.0	1.500	0.105
	30	10	77.4	6.5	11.3	1.8	59.7	11.3	5.3	1.000	0.609
	31	10	168.0	13.8	25.7	1.9	128.5	19.8	6.5	0.769	0.360
	32	10	77.5	6.8	16.7	2.5	54.1	11.7	4.6	0.703	0.338
	33	10	90.5	2.6	16.4	6.3	71.6	12.1	5.9	0.737	0.283
	34	10	118.4	11.0	11.8	1.1	95.6	18.4	5.2	1.556	0.261
	35	10	18.6	3.5	3.5	1.0	11.5	1.8	6.5	0.500	0.074
	36	10	35.0	8.3	2.5	0.3	24.2	5.8	4.1	2.333	0.304

[a]Route length standardized to 161 km (100 miles)

Table 4. Regional trends (% change) in pheasant population indices on 36 study areas in Minnesota, summer 2003–2006.

			Birds/route[a]				% change	
Region	Group	n	2003	2004	2005	2006	2005-2006	95% CI
Marshall	Total pheasants	9	142.6	114.9	190.5	280.9	54	±51
	Cocks		12.7	13.5	10.5	26.2	161	±107
	Hens		25.6	20.5	32.3	49.1	60	±38
	Broods		22.3	16.8	35.0	38.9	19	±34
	Chicks/brood		4.6	4.8	4.2	5.0	21	±20
	Broods/100 spring hens		59.9	29.8	77.2	35.9	–46	±15
Glenwood	Total pheasants	9	139.9	57.9	135.7	132.1	117	±189
	Cocks		9.2	8.3	8.0	11.8	73	±55
	Hens		23.5	12.3	20.7	20.8	8	±39
	Broods		20.2	8.3	17.2	19.2	30	±52
	Chicks/brood		5.0	4.1	6.1	5.2	–13	±19
	Broods/100 spring hens		44.7	14.7	42.8	29.3	–17	±38
Windom	Total pheasants	9	283.5	179.8	187.0	152.8	–5	±28
	Cocks		25.9	23.6	13.8	25.9	85	±43
	Hens		50.9	36.2	37.4	32.7	–5	±25
	Broods		36.2	24.2	29.4	23.0	–2	±36
	Chicks/brood		5.4	5.0	4.6	3.9	–12	±11
	Broods/100 spring hens		47.1	29.1	30.2	18.7	–20	±33
Faribault	Total pheasants	9	164.6	54.4	90.5	81.7	1	±32
	Cocks		9.5	13.0	8.0	7.8	4	±24
	Hens		23.6	13.1	14.8	12.2	–15	±24
	Broods		23.6	6.8	12.6	11.4	7	±36
	Chicks per brood		5.5	5.0	5.5	5.3	1	±18
	Broods/100 spring hens		85.4	18.6	71.0	27.6	–46	±15
All	Total pheasants	36	182.6	101.7	150.9	161.9	42	±46
	Cocks		14.3	14.6	10.1	17.9	81	±32
	Hens		30.9	20.5	26.3	28.7	12	±16
	Broods		25.6	14.0	23.6	23.1	13	±17
	Chicks/brood		5.1	4.7	5.1	4.8	–0	±8
	Broods/100 spring hens		59.3	23.1	55.3	27.9	–33	±12

[a]Route length standardized to 161 km (100 miles).

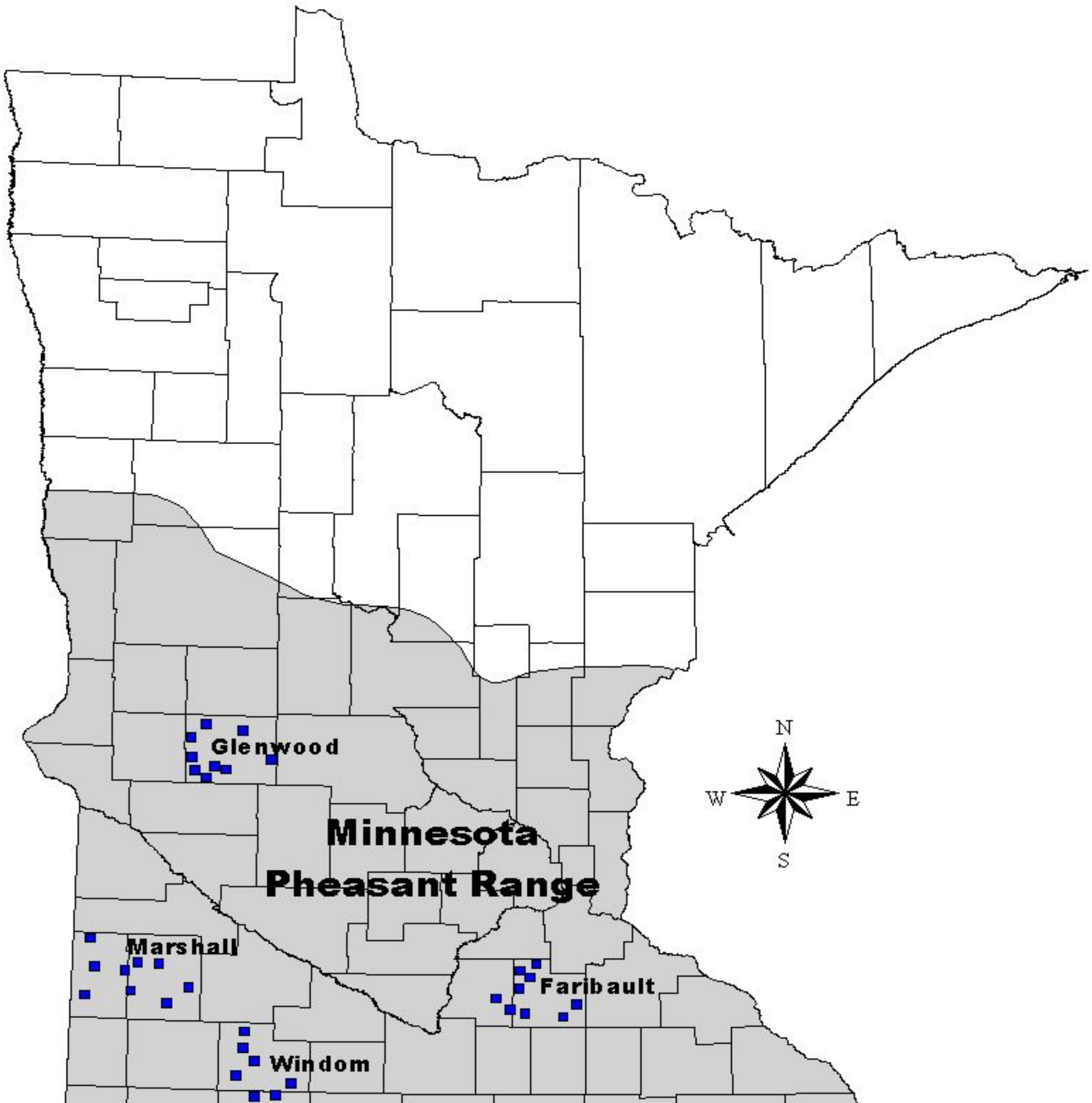

Figure 1. Locations of winter-habitat study areas within Minnesota's pheasant range, 2003-2006.

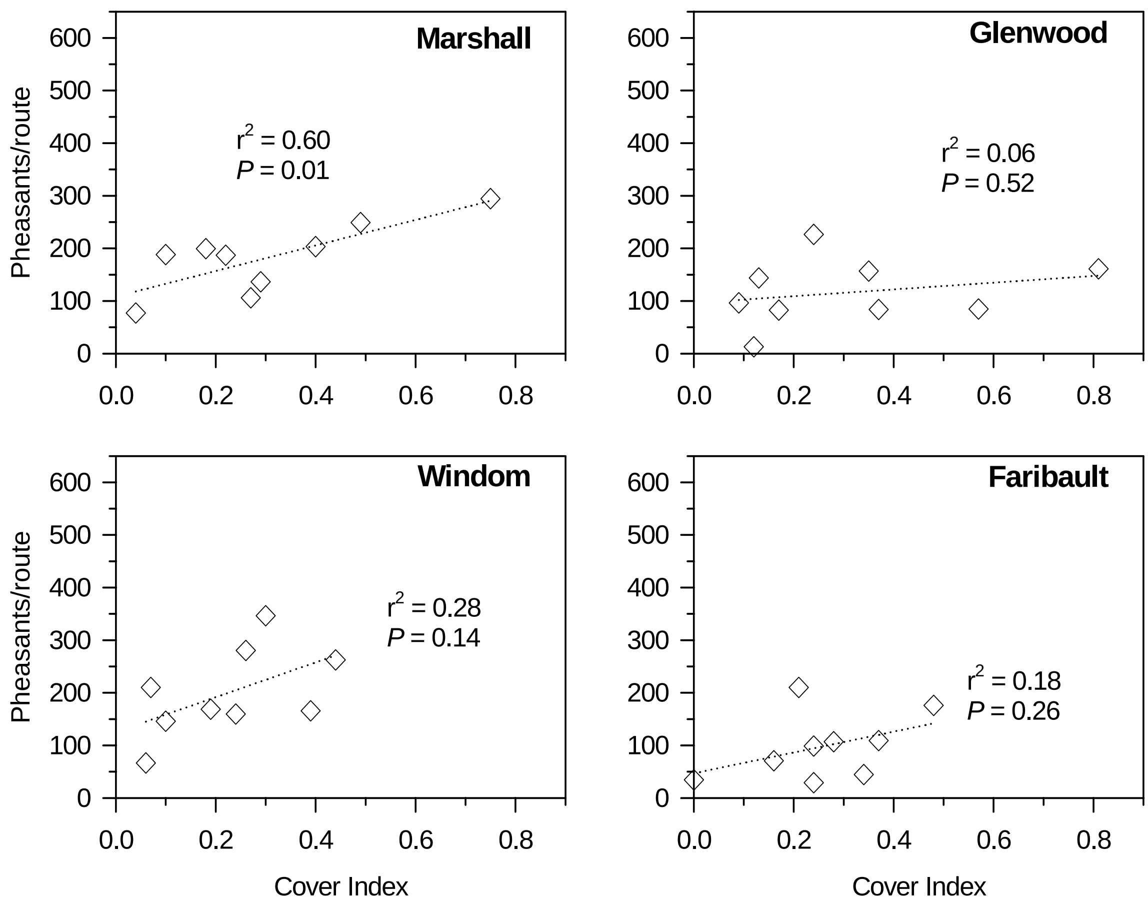

Figure 2. Relationship between relative pheasant abundance (pheasants counted/route) and amount of habitat (cover index) on 9 study areas in 4 regions in Minnesota during summer 2003-06. Route length was standardized to 161 km (100 miles).

SURVIVAL AND HABITAT USE OF EASTERN WILD TURKEYS TRANSPLANTED TO NORTHWESTERN MINNESOTA

Chad J. Parent, Brett J. Goodwin,[1] and Richard O. Kimmel

SUMMARY OF FINDINGS

Eastern wild turkeys (*Meleagris gallopavo sylvestris*) were not historically common in Minnesota. Public interest to restore extirpated populations to Minnesota generated an intensive trap-and-transplant program. Public demand for turkey populations is spreading northward, but our understanding of wild turkey ecology in northern habitat is inadequate. To address this, we released 59 female (radioed) and 19 male (not radioed) wild turkeys at two study areas in Red Lake and Pennington Counties, MN, USA. Locations were obtained on female turkeys 3-4 days/week in the winter (1 January 2006 to 31 March 2006) and 1-2 days/week the rest of the year (non-winter). We estimated survival, habitat use, home range, and productivity based on data in 2006. Overall survival was 22% (annual), 38% (winter), and 59% (non-winter). Cropland habitat had the most turkey locations (55%) followed by deciduous forests of oak, aspen, and white birch (27%), marsh (9%) and grassland (9%). Turkeys tended to stay close to farmsteads and rural residences with 65% of locations in Pennington County and 75% in Red Lake County found within 400 m of a farmstead. Twelve turkeys at the 2 study areas were located enough (≥ 20 locations) for home range analyses. We found that annual core home ranges were small compared to similar research: 168 ± 179 ha (mean ± SD) for Pennington County and 119 ± 58 ha (mean ± SD) for Red Lake County. Seven turkeys attempted to nest with 4 having successful clutches.

INTRODUCTION

In Minnesota, eastern wild turkeys were historically restricted to the southern part of the state with persistence of these populations dependent on winter severity (Leopold 1931). Public interest in northward expansion of turkeys in Minnesota has led to the establishment of sustainable populations as far north as Mahnomen and Norman counties in the northwest, and the St. Croix River valley south of Duluth (Figure 1).

Physiologically, turkeys should be able to survive in northern Minnesota if food is available (Haroldson 1996, Haroldson et al. 1998, Coup and Pekins 1999). Prince and Gray (1986) suggest that hens are capable of surviving 8 days without food. This is particularly important in northern Minnesota, as snowfall can cover food sources for extended periods. Snowfall deeper than 30 cm has been observed to abate turkey movement and make food hard for turkeys to find (Austin and DeGraff 1975). Finally, snowfall can also effect reproduction. Porter (1983) attributed severe winter conditions in southeastern Minnesota to reduced hatching success. It is unknown if translocated turkey populations are self-sustaining in northern Minnesota. The objectives of this study are to examine wild turkey survival, habitat use, and productivity during the first year following release in northern Minnesota.

METHODS

During winter 2006, Minnesota Department of Natural Resources (MNDNR) captured 59 female and 19 male wild turkeys using cannon nets at sites in southeastern Minnesota. The turkeys were weighed, aged (juvenile or adult), and leg-banded. Female turkeys were equipped with a backpack style radio-transmitter (95 - 104 g, 40 cm whip antenna) with a battery life of

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approximately 3 years and a movement (mortality) sensitive switch (Advanced Telemetry Systems-ATS, Isanti, MN, USA). Males were not radioed because of their higher resilience to severe weather (Gray and Prince 1988). Within 2 days of capture, turkeys were transported to study areas in Red Lake County and Pennington County, MN and released. Both study areas are located in the Aspen Parkland Ecological Classification System subsection (MNDNR 2006). The landscape is composed of lacustrine plain and historic beach ridges formed by Glacial Lake Agassiz (MNDNR 2006). Based on level III GAP land cover classification data, both study areas were approximately 82% cropland with the remaining 18% of the study areas composed of nearly equal amounts of grassland, oak forest, aspen or white birch forests, and marshes (Table 2).

Monitoring of Turkeys

Radioed birds were monitored 3-4 times/week during winter and 1-2 times/week during non-winter. Winter was defined as 1 January through 31 March (Kassube 2006). Wild turkeys were located via triangulation from roads using ≥3 azimuths acquired within 15 minutes (Hubbard 1999). Attempts to keep triangulation angles within 45 to 135 degrees were carried out whenever possible. Due to the lack of roads at the Red Lake study area, this was not always feasible.

Mortality date was assumed to be the midpoint of the last known date the turkey was alive and the date of the first mortality signal. During the nesting season a mortality signal was assumed to be an incubating hen; a follow up was conducted 30 days from the original mortality signal or when the hen left the nesting site. Efforts were made to retrieve the radio and examine the bird as soon as was possible after a mortality signal. Upon recovering the radio and dead bird, an investigation to determine the probable cause of mortality was conducted, i.e. feathers, hair, tracks, carcass condition, marks on radio (Thogmartin and Schaeffer 2000). If a turkey carcass was recovered we examined crop contents.

Survival

We calculated annual (1 January through 31 December), winter (1 January through 31 March), and non-winter (1 April through 31 December) survival rates. Hens that died < 7 days post-release were censored from the analyses because of potential trapping stress or transmitter harness complications (Vangilder 1996, Miller et al. 1998). To investigate impacts of weather conditions on mortality rates, weather data were extracted from the Minnesota Climatology Working Group (MCWG 2006) weather stations. For the Red Lake County study area the weather station was located in the same township as the release site. For the Pennington County study area the weather station is located in a neighboring township.

Habitat Use

Triangulation data were converted to spatial data using Location Of A Signal (LOAS, Ecological Software Solutions). Habitat associated with each individual turkey location from 2006 (n=321) was determined from level III GAP land cover data downloaded from the MDNR Data Deli (deli.dnr.state.mn.us). These associations provide an estimate of turkey habitat use. As we had no *a priori* study area, we used the turkey locations most distant from the release sites (9 km) to determine the extent of our two study areas. Study areas were the area contained in a 9 km radius circle around the release point (26,890 ha each). From the study area, we calculated habitat availability, which was compared to our estimate of habitat use. To estimate farmstead use, we counted turkey locations that fell within 400 m of a farmstead or rural residence.

Home Range

Locations from LOAS were examined in BIOTAS (Ecological Software Solutions) to estimate turkey home ranges at the two study areas. Home ranges were estimated from the complete year's locations and also from seasonal (winter, non-winter) subsets of the locations. A fixed kernel was applied to the locations and yielded 95, 75, and 50 percent confidence regions. Only turkeys with ≥20 locations were considered for analysis. Twelve turkeys were included in home range analyses, with 6 turkeys at each study area.

Productivity

To prevent disturbance of nesting females, mortality signals during the nesting season were treated as nesting attempts. The number of poults per hen were estimated from personal observations and reports by landowners of young turkeys in the field after poults had fledged.

RESULTS

Survival

In 2006, 14 of 59 (23.7%) hens were censored from the study due to early mortality, which reduced the sample size to 45 hens. In 2006, 6 turkeys at the Pennington County study area and 4 turkeys at the Red Lake County study area survived into the next year (2007). Annual survival was 27% and 17% respectively at each study site and 22% overall (Table 1). Overall winter survival was 38%, 36% at the Pennington County study area and 39% at the Red Lake County study area (Table 1). Overall non-winter survival was 59%; 75% at the Pennington County study area and 44% at the Red Lake County study area (Table 1). Mortality at both study areas increased with snowfall and low temperatures (Figure 2). Substantial snowmelt and warming occurred in April with a concurrent decrease in mortality. Scavenging prevented us from identifying some mortalities. Sources of mortality were attributed to avian (6%) or mammalian (22%) predation, vehicle collision (2%), severe weather (4%), and unknown (66%).

Habitat Use

Turkeys were found most often in cropland, followed by oak forests, marsh, aspen and birch forests, and grassland (Table 2). Turkeys were found in cropland in 52.6% of locations. Cropland made up 82.3% of the study area. In contrast, 33% of locations were in oak and marsh habitats, which make up only 6% of the study areas.

Sixty-five percent of the locations at the Pennington County study area and 75% of the locations at the Red Lake County study area were located within 400 m of farmsteads and rural residences. Farmsteads and rural residences, along with a 400 m buffer, comprise 261 ha (0.9% of study area) of the Pennington County study area and 729 ha (2.7% of study area) of the Red Lake County study area.

Home Range

Core home range (50% confidence region; Gitzen et al. 2006) in Pennington County was 168 ha ± 179 (mean ± St. Dev) for the whole year, 136 ha ± 92 during the winter, and 316 ha ± 420 during the non-winter period (Table 3). Home ranges increased 180 ha during non-winter periods, and were at their peak size during this period.

Core home range in Red Lake County was 119 ha ± 58 annually, 118 ± 133 during the winter, and 120 ± 133 during non-winter periods (Table 4). Home range increased 2 ha during the non-winter period.

Productivity

During 2006, 5 adults and 2 juveniles nested (4 hens at the Red Lake County study area and 3 at the Pennington County study area). We assume hatching occurred between 19 June 2006 and 29 June 2006. Of the hens that nested, 57% (4/7) appeared to have been successful. Our observations indicate that 13 poults were hatched at the Pennington County study area and 9 at Red Lake County study area.

DISCUSSION

Survival

Severe winter conditions can reduce wild turkey survival (Wunz and Hayden 1975, Porter et al. 1983, Haroldson et al. 1998). In 2006, we assume that handling stress and unfamiliarity with surroundings contributed to winter mortality observed in this study. Winter mortality was linked to weather conditions; as temperature increased and snow cover decreased, turkey mortality declined (Figure 2). An increase in survival during spring is not common, but changes in survival rates between winter and spring have been reported to be negligible (Porter 1988, Roberts et al 1995, Wright et al 1996). However, in Ontario, Nguyen et al (2003) observed increased survival during the spring. Non-winter mortality was predominately due to predation. Scavenged carcasses indicated mortality was likely due to avian or mammalian predators.

Nguyen et al (2003) observed 28% survival during the first year of a release in Ontario. Kane (2003) observed 22% annual survival in central Minnesota during the first year of a release coinciding with mild winter conditions. Our estimates of survival were similar with 22% annual survival, which may in part be due to 2006 having a mild winter. It remains to be seen what survival rates will be like during a winter with colder temperatures and more snow remaining on the ground for longer periods.

Habitat Use

Most turkey locations occurred in croplands. However, it is unclear if turkeys are selecting croplands or simply moving through them because they are so abundant on the landscape. During winter, it is unlikely that cropland was a preferred habitat since snow depth was >30 cm (MCWG 2006) at both study areas. At this snow depth, unless snow was blown from fields, turkey movements would be slowed and it would be difficult for turkeys to find food left on the ground (Austin and DeGraff 1975). Finally, interpretation of the location data as an indicator of turkey habitat selection is complicated by turkey flocking behavior, since data might be inflated because each member of the flock would be counted in a particular habitat type.

At the Pennington County study area, oak forest and marsh habitats emerge as important habitat types. This conclusion is based on the large proportion of locations in these habitat types compared to the low percent of the study area that are oak forest or marsh. We expected turkeys to use oak forest because acorns are an important food source (Palmer et al 1969). Based on incidental observations, acorns were abundant in 2006. We suspect that turkeys may have used marsh habitat as cover from predators and nesting habitat (e.g., Lazarus and Porter 1985).

At the Red Lake County study area, grassland and marsh habitat locations were used by turkeys. We suggest turkeys may have selected these habitats for nesting or for food. Grasslands consisting of alfalfa and grains were used by turkeys in Wisconsin (Paisley and Kubisiak 1994). Lazarus and Porter (1985) identified mesic plant communities (i.e. marsh) as nesting sites by turkeys in southern Minnesota. Marsh habitat was used for nesting by 1 turkey at the Red Lake study area.

In this study, hen turkeys used farmsteads and rural residences at a high rate; especially considering that farmsteads made up a small proportion of the 2 study areas. Most farmsteads in the study areas have ranching or agriculture, which could provide a consistent source of food. Crop contents from turkeys during winter (n = 6) included corn, suggesting some possible feeding on stored grains. Crop depredation by wild turkeys is a concern when they use farmstead habitats (Paisley and Kubisiak 1994). Public acceptance of future wild turkey releases in northern Minnesota will likely be influenced by farmstead use by turkeys.

Home Range

While a number of studies have estimated turkey home range size (e.g., Lewis 1963, Porter 1977, Brown 1980) most are conducted in areas quite different from northern Minnesota. Studies in Minnesota include Porter (1978, 1980) in southeastern Minnesota and McMahon and Johnson (1980, 1982) in east-central Minnesota. All except Porter (1978) reported home ranges larger than those we observed. Porter (1980) and McMahon and Johnson (1980, 1981) reported larger mean home range sizes (year long mean home range of 100 ha, winter mean home range of 750 ha, and winter mean home range of 596 ha respectively). Only Porter (1978) reported smaller mean home range sizes (100 ha). An explanation for the differences could be our use of kernel estimators, while the other studies used Minimum Convex Polygon. Minimum Convex Polygon estimates are known to be larger than kernel estimates (Aebischer et al 1993). Additionally, both our study areas have a higher concentration of agriculture or ranching landuse than the other studies. We have shown that turkeys tend to be found near farmsteads likely due to availability of food or shelter. As a result, turkeys would not need to move far between food and shelter resulting in smaller home ranges.

Nesting and Recruitment

Nesting success in our study was lower than Porter (1978). Because our turkeys were released between January and March, it is possible that an unfamiliarity of the area could result in fewer nesting attempts.

LITERATURE CITED

Austin, D.E. and L.W. DeGraff. 1975. Winter survival of wild turkeys in the southern Adirondacks. National Wild Turkey Symposium 3:55-60.

Aebischer, N.J., P.A. Robertson, and R.E. Kenward. 1993. Compositional Analysis of Habitat Use From Animal Radio-Tracking Data. Ecology 74(5): 1313-1325.

Brown, E.K. 1980. Home range and movements of wild turkeys – a review. National Wild Turkey Symposium 4:251-261.

Coup, R.N., and P. J. Pekins. 1999. Field metabolic rate of wild turkeys in winter. Canadian Journal of Zoology 77:1075-1082.

Gitzen, R.A. J.J. Millspaugh, and B.J. Kernohan. 2006. Bandwidth selection for fixed-kernel analysis of animal utilization distributions. Journal of Wildlife Management 70(5):1334-1344.

Gray, B.T. and H.H. Prince. 1988. Basal metabolism and energetic costs of thermoregulation in wild turkeys. Journal of Wildlife Management 52(1):133-137.

Haroldson, K. 1996. Energy requirements for winter survival of wild turkeys. National Wild Turkey Symposium 7:9-14.

_________. et al. 1998. Effect of winter temperature on wild turkey metabolism. Journal of Wildlife Management 62(1):299-305.

Hubbard, M.W., D.L. Garner, and E.E. Klaas. 1999. Factors influencing wild turkey hen survival in southcentral Iowa. Journal of Wildlife Management 63:731-738.

Kane, D.F. 2003. Winter survival of eastern wild turkeys (*Meleagris gallopavo silvestris*) translocated north of their ancestral range in Minnesota. Master's Thesis, St. Cloud State University, St. Cloud, Minnesota, USA

Kassube, C.M. 2006. Annual survival and productivity of wild turkey hens transplanted north of their ancestral range in central Minnesota. Master's Thesis, St. Cloud State University, St. Cloud, Minnesota, USA.

Lazarus, J.E. and W.F. Porter. 1985. Nest habitat selection by wild turkeys in Minnesota. National Wild Turkey Symposium 5:67-81.

Leopold, A. 1931. Game survey of the north central states. American Game Association, Washington D.C.

McMahon, G. L. and R. N. Johnson. 1980. Introduction of the wild turkey into the Carlos Avery Wildlife Management Area. National Wild Turkey Symposium 4:32-44.

MCWG.2005 Sept 1. Minnesota Climatology Working Group Home Page climate.umn.edu. Accessed 2006 June.

MNDNR. 2006. Tomorrow's Habitat for the Wild and Rare: An Action Plan for Minnesota Wildlife, Comprehensive Wildlife Conservation Strategy. Division of Ecological Services, Minnesota Department of Natural Resources, St. Paul.

Nguyen, L.P., J. Hamr, and G.H. Parker. 2003. Survival and reproduction of wild turkey hens in central Ontario. Wilson Bulletin 115(2):131-139.

Paisley, R. N. and J.F. Kubisiak. 1994. Food habits of wild turkeys in southwestern Wisconsin. Wisconsin Department of Natural Resources. Research Management Findings No. 37.

Palmer, W.L., K.L. Palmer, and D.A. Whitcomb. 1969. Food habits of Michigan wild turkeys. Michigan Department of Natural Resources, Research and Developmental Report No. 193.

Porter, W. F. 1977. Utilization of agricultural habitats by wild turkeys in southeastern Minnesota. International Congress of Game Biologists 13:319-323.

________. 1978. The ecology and behavior of the wild turkey (*Meleagris gallopavo*) in southeastern Minnesota. Ph.D. Dissertation, University of Minnesota, St. Paul, Minnesota. 122pp.

________. 1980. An evaluation of wild turkey brood habitat in southeastern Minnesota. National Wild Turkey Symposium 4:203-212.

________, G.C. Nelson, and K. Mattson. 1983. Effects of winter conditions on reproduction in a northern wild turkey population. Journal of Wildlife Management 47(2):281-290.

Roberts, S.D., J.M. Coffey, and W.F. Porter. 1995. Survival and reproduction of female wild turkeys in New York. Journal of Wildlife Management 59(3):437-447.

Vangilder, L. D. 1996. Survival and cause-specific mortality of wild turkeys in the Missouri Ozarks. National Wild Turkey Symposium 7:21-31.

Wunz, G.A. and A.H. Hayden. 1975. Winter mortality and supplemental feeding of turkeys in Pennsylvania. National Wild Turkey Symposium 3:61-69.

Wright, R.G., R.N. Paisley, and J.F. Kubisiak. 1996. Survival of wild turkey hens in southwestern Wisconsin. Journal of Wildlife Management 60(2):313-320.

Table 1. Annual and seasonal survival of wild turkeys at the Red Lake County and Pennington County study areas, Minnesota, 19 January 2006 through 30 October 2006.

	Annual	Winter[1]	Non-Winter[2]
Pennington	(6/22) 27%	(8/22) 36%	(6/8) 75%
Red Lake	(4/23) 17%	(9/23) 39%	(4/9) 44%
Overall	(10/45) 22%	(17/45) 38%	(10/17) 59%

[1] 1 January – 31 March
[2] 1 April – 31 December

Table 2. Proportion of habitat types used by wild turkeys, Minnesota, 2006.

	Pennington County		Red Lake County	
Habitat type	Percent of study area	Percent of loc. in habitat	Percent of study area	Percent of loc. in habitat
Cropland	82.3	52.6	81.9	56.2
Grassland	5.9	6.1	5.9	23.1
Aspen or White Birch	4.3	7.6	2.7	3.1
Oak	3.3	17.7	4.2	5.8
Marsh	2.9	15.2	2.5	11.6
Lowland Shrub	0.8	0	0.1	0
Upland Shrub	0.6	0	0.6	0
Aquatic	0.4	0	0	0
Black Ash	0.3	0.74	0.2	0
Developed	0	0	1.5	0

Table 3. Fixed-kernel home ranges (hectares) for wild turkeys on the Pennington County study area, with 50, 75, and 95% confidence regions for 6 turkeys with ≥ 20 locations, Minnesota, 2006.

	50%		75%		95%	
	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev
Annual	168	179	511	543	1268	1258
Winter	136	92	295	182	695	368
Non-Winter	316	420	731	909	1564	1800

Table 4. Fixed-kernel home ranges (hectares) for wild turkeys on the Red Lake County study area, with 50, 75, and 95% confidence regions for 6 turkeys with ≥ 20 locations, Minnesota, 2006.

	50%		75%		95%	
	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev
Annual	119	58	257	206	941	682
Winter	118	133	256	291	912	1028
Non-Winter	120	133	381	457	1139	1287

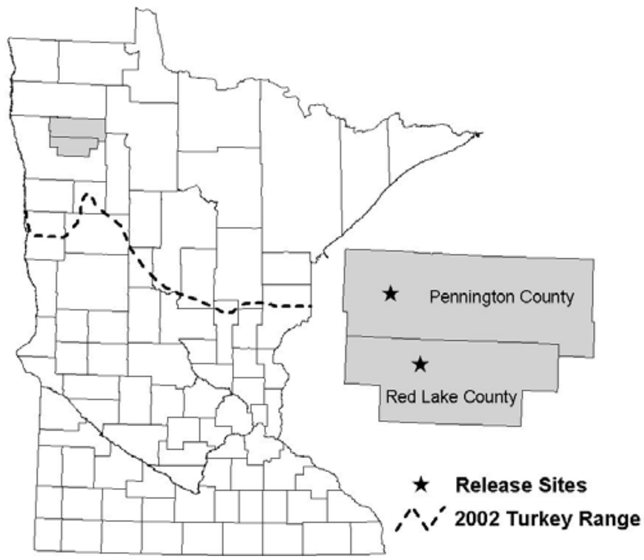

Figure 1. Wild turkey release sites (study areas) in Red Lake and Pennington County, Minnesota in 2006 and the northern range of turkeys in Minnesota in 2002.

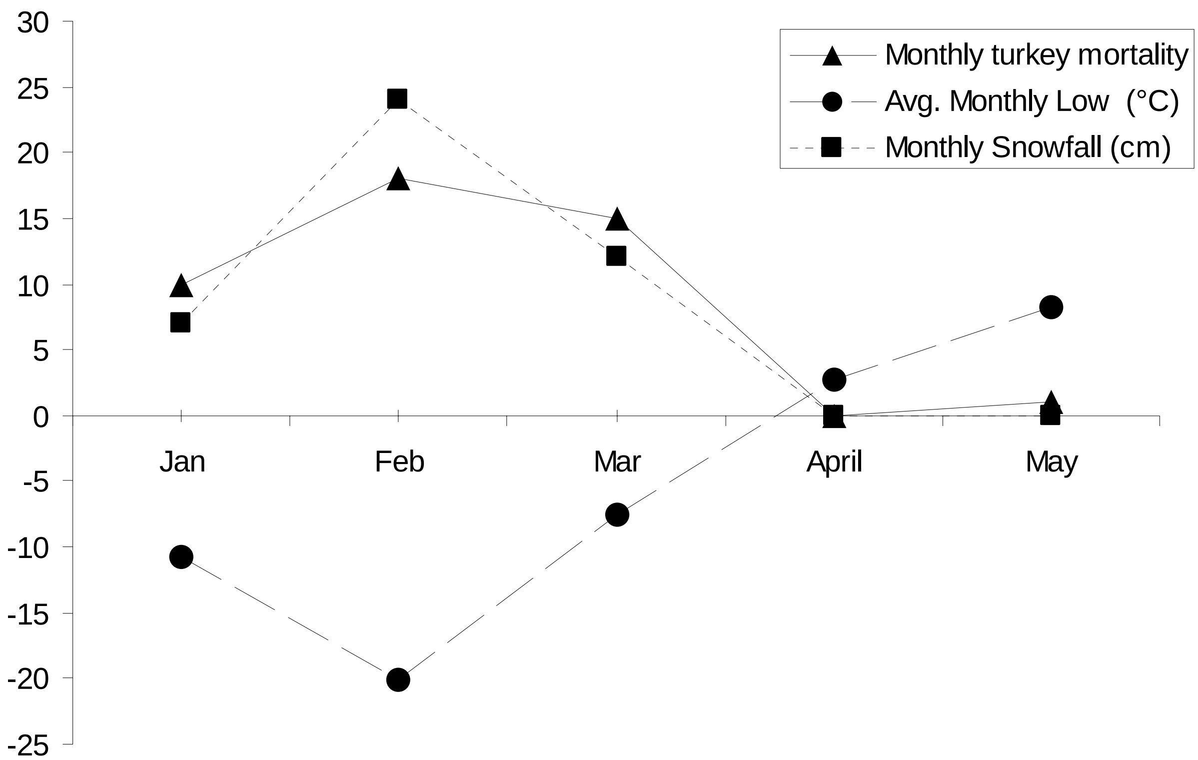

Figure 2. Monthly turkey mortality (%), total monthly snowfall (cm), and average monthly low temperatures (°C), Minnesota, 2006.

MONITORING VEGETATION TO ASSESS CHANGES IN RELATION TO WHITE-TAILED DEER DENSITIES

Emily J. Dunbar and Marrett D. Grund

SUMMARY OF FINDINGS

High densities of white-tailed deer (*Odocoileus virginianus*) result in overbrowsing of forest vegetation. Intensive browsing can change forest ecosystem structure and composition by reducing palatable plant species and increasing unpalatable plant species. Past studies have examined differences in forest vegetation using exclosures between areas with no deer and high densities of deer. Few studies have investigated impacts of forest composition and structure by different or declining densities of deer. This study will examine impacts of declining deer density on forest vegetation at Itasca State Park. This report summarizes the first 2 years of data collection (2005-2006). Three plot arrays were established and sampled in 2005. Seven more plot arrays were added in 2006 and 10 arrays were sampled during summer and will be resampled in future years. Most plot arrays at Itasca State Park were unique in composition. Thus, results should not be compared among sites, but over time within each plot array. Overall, plot arrays were not highly diverse, averaging 2.3 using the Shannon-Weiner Index (0-5). Density and frequency of plant species was fairly low, with many species occurring in small numbers. Herbaceous reproduction was observed infrequently, although reproducing plants were taller on average than non-reproducing plants. Browsing mainly occurred on woody species rather than herbaceous species. Time series analyses will be used in future reports to determine changes in forest vegetation over time in individual plot arrays.

INTRODUCTION

In recent years, white-tailed deer populations reached high densities in many areas of Minnesota. Overabundant deer generate a variety of problems for both humans and forest ecosystems (Cote et al. 2004). Intensive deer browsing, resulting in reduced regeneration or even exclusion of some plant species, directly affects the distribution and richness of both understory and overstory forest vegetation (Rooney 2001) and could impact Minnesota's sustainable forest management certification. Alterations in plant populations may lead to a variety of changes in community structure including increased populations of unpalatable or browse-resilient species, the elimination of preferred woody and herbaceous species, and a decrease in resources for other wildlife (Horsley et al. 2003, Rooney and Waller 2003). Over time, intensive deer browsing can cause a forest ecosystem to succeed to an alternate state, characterized by unpalatable tree species and a ground layer of ferns, grasses, and sedges (Horsley et al. 2003).

Past studies examined differences in forest community structure between no deer inside exclosures and high densities of deer outside exclosures (Wisdom et al. 2006). Few studies investigated changes in forest structure with differing deer densities (Horsley et al. 2003, Tremblay et al. 2006) or declining deer densities. This study will assess impacts of deer browsing on forest vegetation and changes in vegetation due to a declining deer population in Itasca State Park in northwestern Minnesota. In 2005, Itasca State Park was selected as a study area for an alternative deer management research project. Antler-point restriction regulations were implemented during the regular firearms season. Alternative deer management was proposed to reduce deer densities. Our goal was to measure and monitor ecosystem-level effects caused by overabundant deer at Itasca State Park. Our secondary goal was to develop a forest vegetation monitoring protocol that could be used in other areas of Minnesota.

OBJECTIVES

- To determine the impacts of deer browsing at Itasca State Park;
- To assess changes in forest vegetation due to a declining deer population at Itasca State Park; and
- Develop a forest vegetation monitoring protocol for use in Minnesota.

METHODS

Vegetation sampling was conducted at Itasca State Park, in northwestern Minnesota, during July 2005 and 2006. A 16 x 16 grid was placed in the center of the park using Geographical Information Systems (GIS). Three plot arrays were selected in 2005 and 7 additional plot arrays were selected in 2006 (Figure 1) using a random number generator. Thus, we collected data from 10 plot arrays in 2006. Each sampling plot array contained a 50 x 50m (2500-m^2) plot and 5, 1-m^2 subplots. Plots were permanently marked with 0.6-m pieces of rebar at the center, at the corners of the 2500-m^2 sampling plot, and at a pair of diagonal corners of each 1-m^2 subplot (Figure 2).

Data were recorded from each 1-m^2 subplot and 2 m radius plot at the corners of the 2500-m^2 plot, and transects originating at each subplot. We intend to collect data annually at the arrays for at least 5 years. In each 1-m^2 subplot, all woody and herbaceous species (< 2.54 dbh and < 1.5-m tall) were identified and counted. Percent cover of each plant species was recorded using Daubenmire cover classes (Daubenmire 1959). Heights of woody or herbaceous plants were also recorded. We also recorded percent cover of bryophytes and lichens, tree seedlings, rock, and litter. Litter depth was measured and recorded using a meter stick at the center of each subplot.

Photographs were taken above each subplot and also in each cardinal direction to measure forest structure. At each corner of the 2500-m^2 plot, all trees and shrubs (> 1.5-m tall and/or between 2.54 and 12.7 cm dbh) within a 2-m radius of the permanent marker were identified to species, and height and dbh recorded. Percent overstory canopy was estimated using a spherical densitometer at the centers of subplots and a Graphical Resource Solutions densitometer (GRS) at 5, 5-m intervals along transects in each cardinal direction from subplot centers.

Slope, aspect, topographic position, and visual evidence of natural disturbance history (fire scars, insect/disease infestation, blow downs, etc.) were recorded for each sampling plot array. Abiotic differences can lead to differing plant compositions and subsequently, vary deer usage within forest ecosystems. If abiotic differences exist between the plot arrays, results will be compared on an individual array basis, rather than across arrays. To determine if the plot arrays were similar in plant species composition, Renkonen Similarity Index (RSI) was used. This index is robust in regards to sample size and species diversity and is one of the top quantitative similarity coefficients available to ecologists (Wolda 1981). The index ranges from zero (no similarity) to 100 (complete similarity) (Wolda 1981). The index was calculated by transforming number of plants for each species into percentages, using the following formula;

$$P = \Sigma_i \text{ minimum } (p_{1i}, p_{2i})$$

where P = Percentage similarity between sample 1 and 2

p_{1i} = Percentage of species *i* in community sample 1

p_{2i} = Percentage of species *i* in community sample 2

RSI was calculated using the subplots, 2-m radius plots, and overstory canopy along transects.

Plot arrays in 2005 and 2006 were measured for diversity using Shannon-Wiener function. Shannon-Wiener index is sensitive to changes in rare species in a community and ranges from zero (no diversity) to 5 (high diversity) (Peet 1974). The index was calculated using the following formula:

$$H' = -\Sigma_{i=1} (p_i)(\log_2 p_i)$$

where H' = Index of species diversity

p_i = Proportion of total sample belonging to ith species

Shannon-Wiener function of diversity was calculated using the subplots, 2-m radius plots, and overstory canopy along transects.

Density and frequency of plant species were calculated in the subplots and 2-m radius plots for both years. Frequency of the overstory canopy plant species was also recorded in both years. Estimates of forest horizontal cover were obtained in each subplot using a cover board. Plant reproduction was sampled in subplots by the presence/absence of flowers or fruit of each plant (i.e. Canada mayflower (*Maianthemum canadense*). Browsing intensity was recorded for each plant in subplots and 2-m radius plots. Browsing intensity was ranked based on percent of stems browsed and height of plant:

1. Not Browsed – no visible browsing damage
2. Light – 0 to 25% of seedling stems are browsed
3. Moderate – 25 - 50% of stems are browsed
4. Heavy - more than 50% of stems are browsed and the plant is severely hedged, but it is taller than 15 cm
5. Severely browsed – no seedlings of the species within the plot are >15 cm tall and seedlings are severely hedged

RESULTS AND DISCUSSION

A total of 42 plant species were recorded and 949 individual plants were sampled in 3 plot arrays in 2005 In 2006, 71 plant species were recorded and 3,515 individual plants were sampled in the 10 plot arrays. Overall, 2006 RSI scores ranged from dissimilar (5) to somewhat similar (68). The mean RSI score was 30, suggesting there was little similarity among plot arrays (Table 1). In 2006, the most similar subplots were in plot arrays 3 and 10 (Table 1). The plant species composition within 2-m radius plots in 2005 was dissimilar. The similarity of the plant composition of the 2-m radius plots in 2006 ranged from very dissimilar (0) to highly similar (95). In 2006, the similarity of plant composition in the overstory canopy, recorded from transects of each subplot, ranged from 8 to 76. The most similar plot arrays with regards to overstory canopy were arrays 2 and 10. Sample sizes of overstory canopy data were too low in 2005 to calculate similarity.

Average Shannon-Weiner diversity score of plot arrays in 2006 was 2.31, which indicates moderate vegetative diversity. Plot array 5 was most diverse (2.85) and the least diverse plot array was 7 (1.61). Average Shannon-Weiner Index scores associated with subplots within plot arrays was 3.49 (range 2.78 – 3.91) in 2005 and 3.63 (range 1.93 – 4.25) in 2006. The average diversity of the 2-m radius plots within plot arrays during 2005 was 1.48 (range 0.88 – 2.00) and 1.10 (range 0.36 – 2.12) in 2006. The average diversity of the overstory canopy in plot arrays in 2006 was 2.19 (range 1.1 - 3.16). Sample sizes were too low in 2005 to calculate overstory diversity.

In 2005, Canada mayflower had the highest density (4.9 stems/m^2) in the subplots and the average plant density among subplots was 1.1 stems/m^2 (Table 2). Similar to 2005, we found that Canada mayflower had the highest density in subplots (6.4 stems/m^2) and the average plant density was 0.69 stems/m^2 in 2006 (Table 2). The most frequently observed plant species in the subplots in 2005 was sedge (*Carex* spp.). In 2006, the most frequently observed species in the subplots was mountain ricegrass (*Oryzopsis asperfolia*) (Table 2). In the 2005 2-m radius plots, sugar maples (*Acer saccharum*) had highest density (1,393 stems/ha) and the average plant density in 2005 was 517 stems/ha (Table 3). The most frequently observed species was beaked hazelnut (*Corylus cornuta*) (Table 3). In the 2006 2-m radius plots beaked hazelnut had the highest density (1,971 stems/ha) the average density in 2006 was 513 stems/ha (Table 3). The most frequently encountered species in 2005 was ironwood (*Ostrya virginiana*) (Table 3). In overstory canopy, red pines (*Pinus resinosa*) were the most frequently sampled species in 2005 (Table 3). In 2006, the most frequently observed species in the overstory was aspen (*Populus* spp*.)*.

In 2005, the average horizontal cover was 53%. Plot array 1 had the highest horizontal cover (80%) and plot array 3 had the lowest horizontal cover (29%) (Table 1). In 2006, the average horizontal cover was also 53%. Plot array 6 had the highest horizontal cover (90%) and plot array 7 had the lowest horizontal cover (19%) (Table 1).

Plant reproduction was sampled in subplots by the presence/absence of flowers or fruit of each plant. In 2005, 5 plant species had plants that were in the reproductive stage; big-leaf aster (*Aster macrophyllus)*, downy yellow violet (*Viola pubescens)*, early meadow-rue (*Thalictrum dioicum)*, large-flowered bellwort (*Uvularia grandiflora*), and twisted stalk (*Streptopus lanceolatus*) (Table 4). Four of the 5 species had low flowering sample sizes (n $\leq$ 2). The average height of bellwort flowering plants was 38.1 cm (n = 15) and the average height of non-flowering plants was 21.8 cm (n = 26) (Table 4). In 2006, 5 plant species had plants that were in the reproductive stage; bluebead lily (*Clintonia borealis*), Canada mayflower, large-flowered bellwort, jewelweed (*Impatiens capensis*), and twisted stalk (Table 4). Three of the 5 species had low flowering sample sizes (n $\leq$ 3). The average height of flowering bellwort plants was 37.7 cm (n = 13) and non-flowering plants was 27.5 cm (n = 161) (Table 4). The average height of flowering Canada mayflower plants was 8.5 cm (n = 16) and non-flowering plants was 5.0 cm (n = 302) (Table 4).

Browsing intensity was measured in subplots and sapling plots. In 2005, we found that most browsing was concentrated on tree seedlings in the subplots. Most species browsed had small sample sizes (n<10) or had low browse intensity (<2.0). Species browsed that had browsing intensity greater than 2.0 included mountain maple (*A. spicatum)* and ironwood (Table 5). Mountain maple had an average browsing intensity of 2.6 (n=6) and ironwood had an average browsing intensity of 2.7 (n=7). In the 2-m radius plot, no species had an average browsing intensity >1.1. In 2006, species browsed in subplots that had higher browsing intensities ($\geq$ 2.0) included aspen and choke cherry (*Prunus virginiana*) (Table 5). Aspen had an average browsing intensity of 2.9 (n=28) and choke cherry had an average browsing intensity of 2.0 (n=4) (Table 5). In the 2-m radius plots, mountain maple, choke cherry, and red elm (*Ulmus rubra*) had browsing intensities > 2.0 (Table 5). Mountain maple had an average browsing intensity of 2.1 (n=20), choke cherry had a browsing intensity of 3.0 (n=1), and red elm had an average browsing intensity of 2.0 (n=2) (Table 5).

Due to time constraints, we reported frequency data and other descriptive statistics available to summarize the data collection thus far. Time series models will be used in future analyses to determine changes in forest vegetation and to account for differences in plant composition between plot arrays. We believe times series analysis models will facilitate determining "indicator" plant species that may increase in abundance and distribution under lower deer densities.

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LITERATURE CITED

Cote, S. D., T. P. Rooney, J. Tremblay, C. Dussault, and D. M. Waller. 2004. Ecological impacts of deer overabundance. Annual Reviews – Ecology, Evolution, and Systematics 35:113-147.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Science 33:43-64.

Horsley, S. B., S. L. Stout, and D. S. deCalesta. 2003. White-tailed deer impact on the vegetation dynamics of a northern hardwood forest. Ecological Applications 13:98-118.

Peet, R. K. 1974. The measurement of species diversity. Annual Review of Ecology and Systematics 5:285-307.

Rooney, T. P. 2001. Deer impacts on forest ecosystems: a North American perspective. Journal of Forestry 74:201-208.

Rooney, T. P. and D. M. Waller. 2003. Direct and indirect effects of white-tailed deer in forest ecosystems. Forest Ecology and Management 181:165-176.

Tremblay, J., J. Huot, and F. Potvin. 2006. Divergent nonlinear responses of the boreal forest field layer along an experimental gradient of deer densities. Oecologia 150:78-88.

Wisdom, M. J., M. Vavra, J. M. Boyd, M. A. Hemstrom, A. A. Ager, and B. K. Johnson. 2006. Understanding ungulate herbivory-episodic disturbance effects on vegetation dynamics: knowledge gaps and management needs. Wildlife Society Bulletin 34:283-292.

Wolda, H. 1981. Similarity indices, sample size and diversity. Oecologia 50:296-302.

Table 1. Similarity and diversity of plots sampled at Itasca State Park, Minnesota, July 2005, 2006.

Year	Plot array	Area sampled	RSI score[a]	Diversity	% Horizontal[b] cover
2005	1	Subplot	28 (2)	3.91	80
		2 m radius	20 (2)	2	
	2	Subplot	31 (3)	2.78	50
		2 m radius	14 (3)	1.57	
	3	Subplot	46 (1)	3.79	29
		2 m radius	32 (1)	0.88	
2006	1	Subplot	64 (8)	3.97	82
		2 m radius	72 (10)	1.55	
		Transects	47 (8)	2.65	
	2	Subplot	46 (7)	3.19	35
		2 m radius	90 (7)	1.37	
		Transects	76 (10)	1.9	
	3	Subplot	71 (10)	3.64	35
		2 m radius	19 (9)	0.84	
		Transects	53 (5)	2.58	
	4	Subplot	49 (6)	4.25	62
		2 m radius	95 (8)	0.81	
		Transects	66 (9)	2.35	
	5	Subplot	54 (1,3)	3.9	46
		2 m radius	57 (2)	1.5	
		Transects	53 (3)	3.16	
	6	Subplot	60 (1)	3.66	90
		2 m radius	80 (8)	0.83	
		Transects	47 (2)	1.37	
	7	Subplot	46 (2)	1.93	19
		2 m radius	90 (2)	0.88	
		Transects	47 (5)	2.01	
	8	Subplot	64 (1)	4.21	53
		2 m radius	95 (4)	0.72	
		Transects	61 (4)	2.5	
	9	Subplot	49 (1)	3.95	40
		2 m radius	43 (1)	2.12	
		Transects	66 (4)	2.32	
	10	Subplot	71 (3)	3.56	69
		2 m radius	72 (1)	0.36	
		Transects	76 (10)	1.1	

[a] RSI score = highest score for the area sampled and corresponding plot array
[b] % Horizontal cover = average cover for plot array

Table 2. Density and frequency of plant species sampled in subplots at Itasca State Park, Minnesota, July 2005, 2006.

		2005		2005	
Species	Common name	Density[a]	Frequency[b]	Density[a]	Frequency[b]
Acer rubrum	Red maple	0.93	0.53	0.92	0.20
Acer saccharum	Sugar maple	3.80	0.53	4.42	0.40
Acer spicatum	Mountain maple	0.40	0.13	0.58	0.22
Actaea rubra	Red baneberry			0.02	0.02
Amelanchier	Juneberry spp.			0.12	0.06
Amphicarpa bracteata	Hog-peanut	0.13	0.07	0.78	0.14
Anemone canadensis	Canada anemone			0.02	0.02
Anemone cylindrica	Thimbleweed				
Anemone quinquefolia	Wood anemone	0.13	0.07	1.26	0.06
Apocynum androsaemifolium	Spreading dogbane			0.08	0.04
Aralia nudicaulis	Wild sarassparilla	0.47	0.27	0.84	0.42
Aralia racemosa	American spikenard	0.27	0.07		
Arisaema triphyllum	Jack in the pulpit			0.28	0.02
Asarum canadense	Wild ginger			0.48	0.14
Aster macrophyllus	Big-leaf aster	4.80	0.47	4.42	0.62
Athyrium felix-femina	Lady fern	0.27	0.07	0.18	0.06
Betula papyrifera	Paper birch			0.04	0.02
Carex	Sedge spp.	4.67	0.67		
Caulophyllum thalictroides	Blue cohosh			0.02	0.02
Circea alpine	Enchanted nightshade			0.46	0.06
Clintonia borealis	Bluebead lily	0.87	0.13	0.60	0.20
Cornus canadensis	Bunchberry			0.16	0.02
Cornus	Dogwood spp.			0.30	0.14
Corylus americana	American hazelnut	0.33	0.07	0.06	0.02
Corylus cornuta	Beaked hazelnut	2.07	0.47	1.26	0.44
Dirca palustris	Leatherwood			0.10	0.04
Dryopteris carthusiana	Spinulose woodfern			0.06	0.04
Equisetum arvense	Horsetail fern	0.47	0.07	0.28	0.06
Fragaria	Wild strawberry spp.	1.33	0.20	2.48	0.50
Fraxinus nigra	Black ash			0.38	0.20
Fraxinus pennsylvanica	Green ash			0.06	0.04
Galium boreale	Northern bedstraw			0.02	0.02
Galium triflorum	Sweet-scented bedstraw			0.14	0.08
Gymnocarpium dyropteris	Oak fern			0.06	0.02
Hepatica americana	Liverleaf	0.13	0.07	1.14	0.18
Impatiens capensis	Jewelweed			0.20	0.02
Lathyrus ochroleucus	Pale vetchling			0.02	0.02
Lathyrus venosus	Woodland vetch			0.28	0.18
Mainthemum canadense	Canada mayflower	4.93	0.47	6.36	0.58
Matteuccia struthiopteris	Ostrich fern			0.34	0.12
Oryzopsis asperfolia	Mountain rice grass	0.93	0.33	3.80	0.66
Osmorhiza claytonii	Sweet cicley	0.73	0.20	0.70	0.24
Ostrya virginiana	Ironwood	0.47	0.20	0.16	0.08
Parthenocissus vitacea	Woodbine			0.02	0.02
Picea glauca	White spruce			0.02	0.02
Polystichum acrostichoides	Christmas fern	0.07	0.07	0.20	0.04
Populus tremuloides	Trembling aspen	0.07	0.07		
Populus	Aspen spp.			0.56	0.04
Prunus viginiana	Choke cherry			0.08	0.02
Pteridium aquilinum	Bracken fern	0.87	0.33	0.74	0.26
Quercus macrocarpa	Bur oak			0.13	0.08
Quercus rubra	Red oak	0.33	0.20	0.06	0.06
Ribes	Gooseberry spp.			0.22	0.08
Rubus acridens	Red raspberry	3.13	0.33	1.42	0.40
Rubus allegheniensis	Common blackberry	0.73	0.20	0.50	0.20
Rubus pubescens	Dwarf red blackberry			0.02	0.02
Sanicula canadensis	Black snakeroot			0.02	0.02
Sanicula marilandica	Maryland sanicle			0.04	0.02

Table 2. continued.

Smilacina racemosa	False Solomon's seal			0.02	0.02
Solidago	Goldenrod spp.	0.07	0.07		
Streptopus lanceolatus	Twisted stalk	3.53	0.40	2.00	0.48
Taraxacum	Dandelion spp.			0.02	0.02
Thalictrum dioicum	Early meadow-rue	1.33	0.33	1.44	0.46
Tilia americana	American basswood			0.04	0.02
Toxicodendron rydbergii	Posion ivy	0.07	0.07		
Trientalis borealis	Star flower	0.27	0.07	0.06	0.06
Triillium	Trillium spp.			0.18	0.06
Ulmus rubra	Red elm			0.10	0.04
Uvularia grandiflora	Large-flowered bellwort	2.73	0.53	3.52	0.58
Uvularia sessilifolia	Sessile-leaved bellwort			1.00	0.26
Vaccinium angustifolium	Lowbush blueberry	0.07	0.07	0.46	0.12
Vicia americana	American vetch			0.02	0.02
Viola	Wild violet spp.	0.07	0.13	0.50	0.12
Viola pubescens	Downy yellow violet	0.13	0.07		

[a] density reported as stem/m^2
[b] frequency reported as number of plots with plant present/total number of plots

Table 3. Density and frequency of plant species in 2 m radius plots and frequency of plant species on transects at Itasca State Park, Minnesota, July 2005, 2006.

		2005			2006		
Species	Common name	Sapling density[a]	Sapling frequency[b]	Canopy frequency[c]	Sapling density[a]	Sapling frequency[b]	Canopy frequency[c]
Acer rubrum	Red maple	1062	0.200	0.003			0.024
Acer saccharum	Sugar maple	1393	0.333	0.093	557	0.600	0.119
Acer spicatum	Mountain maple				378	0.267	0.001
Betula papyrifera	Paper birch	199	0.067	0.063			0.093
Corylus cornuta	Beaked hazelnut	1261	0.400		1971	0.600	
Fraxinus nigra	Black ash				239	0.400	0.114
Fraxinus pennsylvanica	Green ash						0.026
Fraxinus	Ash spp.	199	0.133				
Ostrya virginiana	Ironwood	331	0.133	0.047	438	0.867	0.037
Picea glauca	White spruce			0.003			
Pinus resinosa	Red pine			0.130			0.056
Pinus strobes	White pine						0.019
Populus tremuloides	Trembling aspen	66	0.067		916	0.600	
Populus grandidentata	Big-toothed aspen	531	0.133			0.133	
Populus spp.	Aspen spp.			0.087			0.283
Prunus viginiana	Choke cherry				20	0.067	
Quercus macrocarpa	Bur oak	66	0.067		60	0.133	0.035
Quercus rubra	Red oak						0.037
Quercus	Oak spp.			0.063			
Rubus allegheniensis	Common blackberry	66	0.067				
Tilia Americana	American basswood						0.062
Ulmus rubra	Red elm				40	0.133	0.008

[a] density reported as stems/ha
[b] frequency reported as number of plots with plant present/total number of plots
[c] frequency reported as number of points on transect with plant present/total number of points

Table 4. Plant reproduction in subplots sampled at Itasca State Park, Minnesota, July 2005-2006.

Species	Common name	Flowering?	N	2005 height (cm)	N	2006 height (cm)
Aster macrophyllus	Big-leaf aster	Yes	1	24.00		
		No	71	12.24		
Clintonia borealis	Bluebead lily	Yes			1	27.00
		No			29	17.97
Impatiens capensis	Jewelweed	Yes			1	50.00
		No			9	15.56
Mainthemum canadense	Canada mayflower	Yes			16	8.47
		No			302	5.03
Thalictrum dioicum	Early meadow-rue	Yes	1	50.00		
		No	19	33.42		
Uvularia grandiflora	Large-flowered bellwort	Yes	15	38.13	13	37.69
		No	26	21.80	161	27.46
Streptopus lanceolatus	Twisted stalk	Yes	2	32.00	3	41.33
		No	51	14.94	97	15.81
Viola pubescens	Downy yellow violet	Yes	2	24.00		
		No	0	0.00		

Table 5. Browsing intensity of plants sampled in subplots and 2 m radius plots at Itasca State Park, Minnesota, July 2005, 2006.

Species	Common name	2005 subplot	2006 subplot	2 m radius
Acer spicatum	Mountain maple	2.3 (6)[a]		2.1 (20)
Ostrya virginiana	Ironwood	2.7 (7)		
Populus	Aspen spp.		2.9 (28)	
Prunus viginiana	Choke cherry		2.0 (4)	3.0 (1)
Ulmus rubra	Red elm			2.0 (2)

[a] = sample size

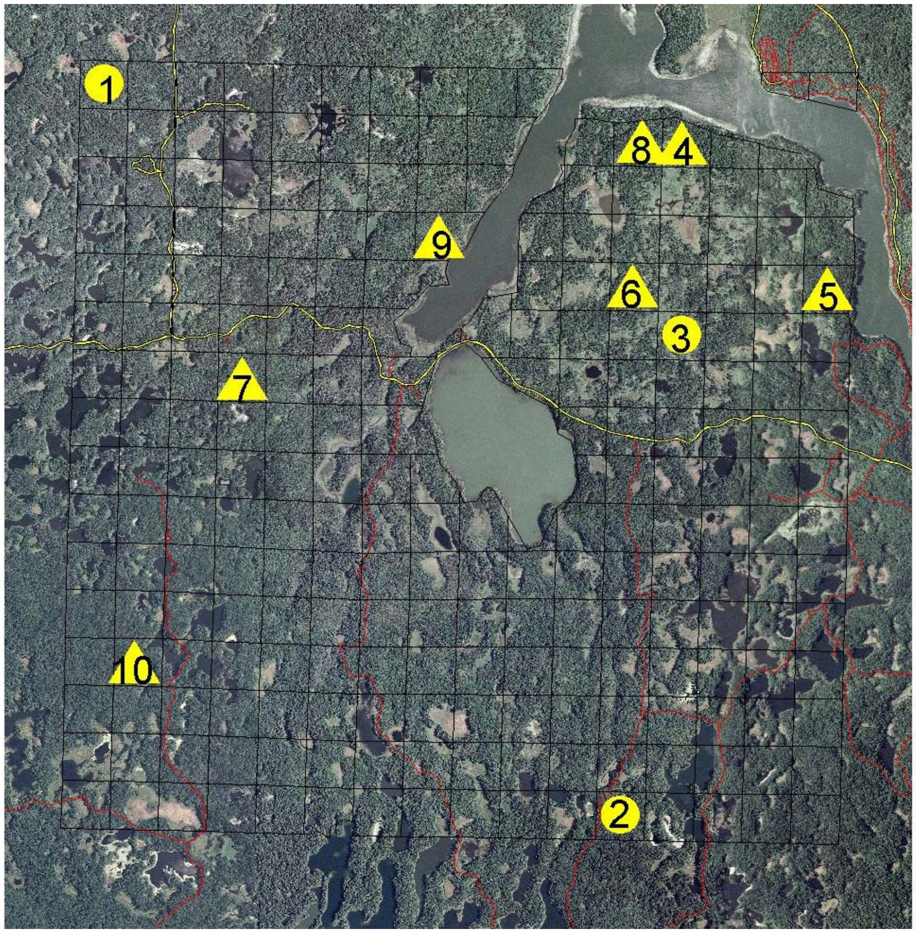

Figure 1. Plot arrays sampled at Itasca State Park, Minnesota, July 2005, 2006.

MANAGEMENT IMPLICATIONS ASSOCIATED WITH HUNTER PREFERENCES TOWARD ALTERNATIVE HUNTING REGULATIONS IN MINNESOTA

Marrett D. Grund, Lou Cornicelli, and David Fulton[1]

SUMMARY OF FINDINGS

Recreational hunting is the primary tool to manipulate white-tailed deer (*Odocoileus virginianus*) populations. In some areas of Minnesota, the number of antlerless deer harvested by hunters under the current seasonal framework is not adequate to reduce deer densities toward population goals. As a result, we surveyed hunters to assess preferences toward regulations that may be more effective at increasing the numerical antlerless deer harvest. We found hunters supported early antlerless-only seasons and ranked early antlerless-only seasons higher than other hunting regulations that we presented in the survey. However, hunters ranked antler-point restriction and earn-a-buck regulations at relatively high levels when we presented regulations that could be used in deer population reduction management scenarios. Our findings suggest that implementing early antlerless-only seasons would be a logical first step toward managing overabundant deer populations followed by antler-point restriction or earn-a-buck regulations. We believe that a public outreach effort may be required if earn-a-buck regulations are implemented as hunter support for this regulation was relatively low. To maintain long-term hunter satisfaction, we speculate that implementing a regulation that protects bucks may be a necessary management component while managing deer densities at prescribed goal levels.

INTRODUCTION

State wildlife agencies rely on recreational hunting to manage deer populations (Woolf and Roseberry 1998). Historically, most state wildlife agencies allowed hunters to harvest 1 antlered deer per year and then restricted antlerless harvests through allocating limited quotas of antlerless licenses. The allowable number of antlerless deer to be harvested depended on, in large part, where the deer population density was relative to a predetermined population goal. Over the past 70 years, deer management has changed from augmenting population growth of deer through habitat protection, hunting regulations, and predator control to serious concerns about how best to limit deer densities and the consequent impacts of deer on society (Conover 1997) and forest ecosystems (Garrott et al. 1993). Today, many state wildlife agencies allow hunters to harvest 1 antlered deer and multiple antlerless deer, but are finding that the majority of hunters are unwilling or unable to harvest more than 1 deer. Consequently, managing overabundant white-tailed deer has emerged as 1 of the most challenging issues in natural resource conservation this past decade (McShea et al. 1997).

Although state wildlife agencies rely on hunters to manage deer populations, previous research suggests that most hunters do not typically perceive hunting as a population management tool (Decker and Connelly 1990). Hunters consider hunting as a recreational activity and consequently, regulations associated with hunting are often debated as to how they affect recreational opportunity, not deer population management goals. Thus, assessing hunter opinions regarding hunting regulations is an important step in the process of implementing innovative management strategies to improve deer population management if the goal is to maintain hunter satisfaction.

This study was conducted by the Minnesota Cooperative Fish and Wildlife Research Unit, Department of Fisheries, Wildlife, and Conservation Biology at the University of Minnesota. A detailed final report, which includes broader deer management issues and strategies, is

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available from Dr. David Fulton (Fulton et al. 2006). This report summarizes key findings from the original report (Fulton et al. 2006) and we suggest a framework for implementing alternative deer hunting regulations based specifically on managing overabundant deer populations.

OBJECTIVES

- Describe hunter effort in Minnesota in 2004 including: type of land hunted, hunting methods and locations, and number of years hunting;
- Describe hunting satisfaction with deer hunting in Minnesota in 2004, and identify activities and experiences that affect hunting satisfaction;
- Determine Minnesota deer hunter support for various regulatory changes that might lead to more mature bucks in the deer population; and
- Determine deer hunter preference for regulatory changes when a finite number of choices are presented to the respondent.

METHODS

Sampling

The study sample was divided into 4 strata: Northwest, Transition Zone, East Central, and South East (Figure 1). These areas represented locations where alternative harvest strategies may be necessary to control and manage deer population growth. Samples were drawn using stratified random sampling of 2004 licensed deer hunters that were >17 years of age in the Electronic Licensing System (ELS) database. At the time of license purchase, hunters were asked to indicate which permit area they intended to hunt most often. Deer harvest data indicated ~90% of successful hunters harvested a deer in the permit area they indicated that they would hunt most often (L. Cornicelli, unpublished data). For this reason, we used responses to the question of which permit area they intended to hunt most often as the basis for stratification of our sample. The target sample size for firearm deer hunters who hunted in each region was 700 (*n*=2,800 statewide). An initial stratified random sample of 6,000 individuals (1,500 in each region) was drawn from the ELS database.

Survey Design

The survey contained 4 sections. The first section contained questions that assessed recent hunter experiences and general perceptions about hunting deer in Minnesota. The second section included questions to quantify hunter support for alternative deer hunting regulations, and the third section focused on past deer hunting experience.

In the fourth section, we provided hunters with different population management scenarios and queried them about what changes in deer hunting regulations were most preferable. Hunters were presented with 5 scenarios related to Minnesota deer management. In total, there were 7 choices within each management scenario, but each hunter was presented only 3 choices in which they were asked to rank preference in descending order (1, 2, 3). Each choice was assigned at random using a balanced incomplete block design (Cochran and Cox 1957), which allowed for the same number of choices represented in all 6,000 surveys. The option of ‘doing nothing’ was not a choice under any scenario as the intent of the instrument was to gauge acceptance of regulation change. However, the options of ‘not hunting’ or ‘moving to another area’ were offered as choices on some scenarios.

This final section of the survey was not designed to gauge hunter support on an issue; rather, it was designed to elucidate a rank-ordering of preferences for management alternatives in response to a specific deer management scenario. We developed 5 scenarios that we believed would occur in Minnesota and asked hunters to rank their preferences for regulation change. The scenarios were:

1. The deer population is stable and within population goals. It is currently being managed so that either-sex licenses are available over the counter and hunters can also buy additional antlerless permits. Based on requests from some hunters, this area will be managed in the future for more mature bucks.
2. The deer population is currently 25% above the management goal. The current strategy of allowing 5 deer per hunter has not been effective in lowering the deer population. A new strategy needs to be developed that lowers the deer population to goal levels within 3 to 5 years.
3. The deer population is currently 50% above the management goal. The current strategy of allocating 5 deer per hunter has not been effective in lowering the deer population. A new strategy needs to be developed that lowers the deer population to goal levels within 3 to 5 years.
4. The deer population is stable or below the population goal and the harvest rate on 1½ year-old bucks is high. Consequently, a low percentage of the buck population lives beyond 1½ years. Currently, buck licenses are available over the counter, either-sex permits are available through the lottery, and hunters can only kill 1 deer. Based on requests from hunters, this area may be managed in the future to protect young bucks and allow them to get to the next age class.
5. Antler point restriction regulations are currently being used by several states to encourage antlerless harvest and protect 1½-year-old bucks. The number of hunters and sporting organizations interested in antler-point restriction regulations seems to be increasing in Minnesota. While the harvest rate of bucks varies in Minnesota, the majority of the bucks killed during the firearm season are 1½ years old. Typically, 50 to 75% of the 1½ year-old buck population is harvested during the firearm season.

Choices were designed to be representative of regulations that might be adopted for that management scenario. For example, earn-a-buck regulations have the potential to decrease deer populations; therefore, earn-a-buck was not a choice in the scenarios where the deer population was stable and/or within goal range. Also, the choice of moving the deer season out of the rut was not presented in the scenarios where the deer population was 25% or 50% above goal density because that regulation likely would not lower deer populations appreciably. Conversely, moving the season was presented as a choice when the scenario suggested the deer population was within goal levels and the desire was to manage for more mature bucks.

We analyzed choice data at 2 levels. First, we consolidated choices into 7 'packages' (e.g., all possible antler-point restriction regulation choices) and looked at the grand mean for each package. Second, we used the mean of the ranks to distinguish between preferred choices by scenario and survey area. We did not include scenario 5 in the consolidation because it was a scenario that included only antler-point restriction regulations and we observed a difference in means between scenarios 1 through 4 and scenario 5 ($t = -5.28$, $p < 0.001$).

Using this approach, we were able to identify both the specifically preferred choice (e.g., antler point restriction with party hunting vs. antler point restriction without party hunting) and preferences for major regulatory changes (e.g., antler point restrictions vs. earn-a-buck). A mean close to 1 implied a preferred choice while a mean approaching 3 indicated a non-preferred choice.

Data Collection

Data were collected using a mail-back survey questionnaire following the process outlined in Dillman (2000). The process involved development of a survey that was relatively easy and was not time consuming to complete. The first 3 sections of the survey were relatively easy to complete; however, the fourth section did require more thought and consideration as it asked hunters to rank order several scenarios that may have had only slight differences between the choices. In total, 3 attempts were made to contact potential respondents. The first mailing was sent in late October, 2005. In the initial attempt, a cover letter, survey questionnaire, and postage-paid envelope were sent to participants. The cover letter attempted to convey the importance of completing and returning the survey. Approximately 30 days later, a second survey, postage-paid envelope and new cover letter was sent to non-respondents. Approximately 8 weeks after the first mailing, a third mailing was sent to non-respondents with another survey, postage-paid envelope, and cover letter. Returned surveys were collected through March, 2006.

Survey Instrument

The survey was a 16-page (14 pages of questions), self-administered questionnaire (Fulton et al. 2006). The survey was organized into 4 sections and addressed the following topics: 1) Minnesota deer hunting experiences, 2) Deer management in Minnesota, 3) Past hunting experiences, and 4) Choice preferences for deer season options and regulatory changes.

Data Entry and Analysis

The data entry template was designed using the Questionnaire Programming Language version 5 (http://qpl.gao.gov) that allowed for online data entry at any computer with internet access. Data were entered by University of Minnesota undergraduate students where 1 student would enter data and another would proof data entered from the same survey. This method assured 2 individuals reviewed each survey, which decreased data entry errors. Data were analyzed using the Statistical Program for the Social Sciences (SPSS 14). For the statewide level, descriptive statistics and frequencies were computed. Regional level results were compared using chi-square tests, analysis of variance (ANOVA), and cross-tabulations. The choice portion of the survey (Section 4) was analyzed using ANOVA.

Variable Weights and Margin of Error

The study sample was drawn from a stratified random sample of individuals who indicated they hunted in 1 of 4 regions. Therefore, data were weighted to reflect the proportion of hunters sampled within each region and the proportion of regional respondents. For total estimates, data were weighted based on these proportions.

The margin of error for this survey was calculated using the formula provided by Scheaffer et al. (2000). We opted to calculate a maximum error rate, which implied a 50:50 split between responses. Overall, our stratified error rate for this survey was 0.3% and ranged from 3.3% to 3.5% at the regional level. If respondents were treated as a simple random sample drawn statewide, the error estimate was 1.7%. Overall, samples sizes were adequate to draw conclusions both in total and by individual survey areas.

RESULTS AND DISCUSSION

Survey Response Rate

Of the 6,000 questionnaires mailed, 426 were undeliverable, which resulted in 5,574 valid surveys. A total of 3,293 deer hunters completed and returned the questionnaire, yielding an overall response rate of 59%.

Characteristics of Minnesota Deer Hunters

Throughout the regions of Minnesota that we surveyed, we found that virtually all (99%) deer hunting license buyers hunted deer in 2004. In total, deer hunters had approximately 25 years (SD=14 years) of deer hunting experience and the average age of Minnesota hunters was 39 years old. Hunters had approximately 2 years less experience in southeastern Minnesota, which was statistically different ($P< 0.05$) than the other 3 regions, but probably had little affect on practical deer hunting skills. Also in the southeast, a smaller percentage (13%) of respondents used public-owned lands for hunting deer than the other 3 regions (range=27–30%). In all regions that we surveyed, approximately 90% of respondents hunted in the same areas every year, which indicated that they might not be willing to move if new regulations were implemented in their traditional area.

We found that approximately 10% of Minnesota hunters only hunt "big bucks" and another 6% hunt only legal bucks throughout the hunting season. Further, another 21% of hunters are willing to harvest a big buck early, than any deer later in the hunting season. Since nearly 60% of the total firearm deer harvest occurs during the opening weekend (L. Cornicelli, unpublished data), these data indicate that almost 40% of Minnesota deer hunters are not willing to hunt antlerless deer during the period when the vast majority of deer are being harvested in Minnesota. Only 25% of hunters indicated that they were willing to hunt antlerless deer first, and then hunt for antlered deer after an antlerless deer was harvested. These results are encouraging because it indicates that there are many more hunters who could harvest antlerless deer if the DNR implements a regulation that requires or encourages the harvest of antlerless deer.

Perceptions of Deer Populations

Hunters were evenly divided with regards to satisfaction related to "buck quality" in the area that they hunt (Table 1). Interestingly, while antler characteristics of bucks differ among regions in Minnesota (Grund 2004), there were no regional differences in buck quality satisfaction data (Fulton et al. 2006). Bucks likely have larger antlers at younger ages in southern Minnesota due to better soils, more abundant high-quality food, and more mild winters than in northern Minnesota (Grund 2004). These findings may suggest that Minnesota hunters define "buck quality" based on their expectations of what they experienced in the field from prior observations of bucks in that area. In other words, a 6-point buck in northern Minnesota may be defined as a "quality buck" whereas a 6-point buck in southeastern Minnesota would not be considered a "quality buck". Further analysis to examine this relationship is warranted.

Hunter opinion with regards to the number of "mature bucks" in the area that they hunt was different than the perceptions about "buck quality". About half of the respondents agreed that there were not enough "mature bucks" in the area that they hunt (Table 1). It is important to point out that "buck quality" may mean different things to different people (Duda et al. 2002). Whether our respondents interpreted "mature bucks" simply as antlered deer or as large-racked bucks is unknown, but half of the hunters that we surveyed indicated that there were not a sufficient number of bucks in the area that they hunted.

Approximately 77% of hunters were satisfied with the number of antlerless deer in the area they hunted, which suggests that Minnesota hunters are not requesting the DNR to restrict the antlerless harvest. The 4 regions of Minnesota that we surveyed had relatively high densities of deer, so this finding was expected. However, about 67% of hunters indicated that they were satisfied with the hunting season because of the number of deer in the area that they hunt (Table 1). This indicates that hunter satisfaction will likely decline as the result of reduced deer densities because hunter satisfaction is often related to the number of deer observed in the field by hunters (Thomas et al. 1973). We believe the ability of hunters to redefine satisfaction on a factor unrelated to overall deer numbers is paramount for responsible deer management to occur in the future.

Perceptions of Hunting Regulations

Although only 50% of respondents indicated they were not satisfied with the number of mature bucks in the area that they hunted, approximately 66% indicated that they would support a regulation that increased the proportion of bucks in the area that they hunt. In contrast, only 13% of hunters indicated they opposed a regulation that would increase the proportion of bucks in the area that they hunt (Table 1). Apparently, there is a discrepancy between current satisfaction levels related to the number of "mature bucks" in current deer populations (Table 1) versus a hunter's willingness to increase the proportion of "mature bucks" in deer populations. There are >5 times as many hunters supportive of implementing a regulation to increase the proportion of "mature bucks" as there are opposing such a regulation (Table 1). This finding presents a challenge because the only regulatory options the DNR has to choose from is to increase the number of bucks through decreased mortality of bucks or increased mortality of antlerless deer (Grund 2004). To increase the proportion of bucks in a population through reducing buck mortality, the DNR would need to adopt some hunting regulation that would reduce hunting pressure on the buck population. To increase the proportion of bucks in a population through increasing antlerless deer mortality, which would ultimately reduce deer densities, the DNR would need to increase hunter pressure on the antlerless deer population while maintaining an equal amount of hunting pressure on the buck population. However, buck harvest mortality rates and deer density are inversely related under either-sex deer seasons (Roseberry and Woolf 1991), so some regulation would likely be required to reduce hunting pressure on bucks while deer densities decline.

In terms of support for alternative hunting regulations, hunter support exceeded opposition for early antlerless-only seasons, antler-point restriction regulations, and eliminating cross-tagging of bucks (Table 1). In general, about 2 hunters opposed buck license lottery regulations, moving the season outside the rut, and eliminating cross-tagging of all deer for every hunter that supported such regulations. These results suggest that a majority of hunters are willing to support some new hunting regulations, but other regulations will receive minority support if the regulation is simply implemented without educational/outreach efforts. The degree to which hunter support toward a regulation may be affected by educational efforts is unknown, but definitely warrants an attempt with coinciding research.

Choosing an Alternative Hunting Regulation

Overall, hunters indicated a clear preference for going hunting, even though they may not agree with changing regulations. In our sample, the option of not hunting in an area if regulations were adopted consistently ranked below all other options. The early antlerless season ranked highest (mean = 1.6/3.0), followed by antler point restrictions (mean = 1.8/3.0), earn-a-buck (mean = 1.8/3.0), move the deer season (mean = 1.8/3.0), continue to hunt despite objecting to regulations (mean = 2.0/3.0), buck license lottery (mean = 2.2/3.0), and will not hunt in the area if regulations are implemented (mean = 2.6/3.0).

Management Scenario 1: Population at Goal but Manage for Mature Bucks—We observed distinct trends in that hunters seemed willing to accept regulation changes so long as they were able to continue hunting every year. In this scenario, the least restrictive antler-point restriction regulation ranked highest, followed by moving the season out of the rut and then the most restrictive antler-point restriction regulation. Buck license lotteries and changing hunting locations if regulations were enacted ranked very low overall. Consequently, in this scenario, it appeared hunters would be accepting of some regulation change so long as they were able to pursue bucks every year. When faced with the choice of a buck license lottery, which would mean a hunter would not obtain an annual buck license annually, hunters tended to rank this option lower than the others.

Overall, the following regulatory options were ranked as follows:

1. Antler-point restriction regulation to protect 50% of the yearling buck population and no buck party hunting (mean = 1.7/3.0).
2. Antler-point restriction regulation to protect 75% of the yearling buck population and party hunting legal (mean = 1.8/3.0).
3. Move the deer season out of the rut (mean = 1.8/3.0).
4. Antler-point restriction regulation to protect 75% of the yearling buck population and no buck party hunting (mean = 1.9/3.0).
5. Buck license lottery, party hunting legal, fewer buck licenses (mean = 2.1/3.0).
6. Buck license lottery, party hunting not legal, more buck licenses (mean = 2.2/3.0).
7. Would not hunt the area if the regulations were changed (mean = 2.6/3.0).

Management Scenario 2: Population is 25% Above Goal—Hunters generally ranked their choices from least intrusive (early antlerless-only season) to the most restrictive (buck license lottery). The option of changing hunting location again ranked low and the motivational trends appeared similar to scenario 1 in that hunters want the option of pursuing bucks every year.

Overall, the following regulatory options were ranked as follows:

1. Early antlerless-only season (mean = 1.7/3.0).
2. Antler-point restriction regulation to protect 50% of the yearling buck population and no buck party hunting (mean = 1.8/3.0).
3. Antler-point restriction regulation to protect 75% of the yearling buck population and buck party hunting legal (mean = 1.8/3.0).
4. Earn-a-buck regulation (mean = 1.8/3.0).
5. Buck license lottery, party hunting not legal, more buck licenses (mean = 2.1/3.0).
6. Buck license lottery, party hunting legal, fewer buck licenses (mean = 2.2/3.0).
7. Would not hunt the area if the regulations were changed (mean = 2.6/3.0).

Management Scenario 3: Population is 50% Above Goal—Hunters again ranked the early antlerless-only season highest. Mean values under this scenario were comparable to scenario 2 except that hunters ranked earn-a-buck regulations slightly higher than antler-point restriction regulations.

Overall, the following regulatory options were ranked as follows:

1. Early antlerless-only season (mean = 1.6/3.0).
2. Earn-a-buck regulation (mean = 1.8/3.0).

3. Antler-point restriction regulation to protect 75% of the yearling buck population and party hunting legal (mean = 1.8/3.0).
4. Antler-point restriction regulation to protect 50% of the yearling buck population and no buck party hunting (mean = 1.8/3.0).
5. Buck license lottery, party hunting not legal, more buck licenses (mean = 2.2/3.0)
6. Buck license lottery, party hunting legal, fewer buck licenses (mean = 2.2/3.0).
7. Would not hunt the area if the regulations were changed (mean = 2.7/3.0).

Management Scenario 4: Population at Goal, High Buck Harvest Rates, Limited Antlerless Harvest—Choices in this scenario ranged from moving the deer season out of the rut to limiting the number of buck licenses that would be allocated. Earn-a-buck and early antlerless seasons were not offered as choices because this management scenario did not relate to the need to increase antlerless deer harvests in order to lower deer densities. Overall, hunters displayed a clear interest in having buck hunting opportunity every year as the lottery option ranked lowest again.

Overall, the following regulatory options were ranked as follows:

1. Antler-point restriction regulation to protect 75% of the yearling buck population, party hunting legal, youth can take any buck (mean = 1.7/3.0).

2. Antler-point restriction regulation to protect 75% of the yearling buck population, party hunting legal, youth must abide by regulation (mean = 1.7/3.0).
3. Antler-point restriction regulation to protect 50% of the yearling buck population, no buck party hunting, youth must abide by regulation (mean = 1.8/3.0).
4. Move the deer season out of the rut (mean = 1.8/3.0).
5. All licenses lottery (buck and antlerless), party hunting legal (mean = 2.2/3.0).
6. All licenses lottery (buck and antlerless), party hunting not legal (mean = 2.3/3.0).
7. Would not hunt the area if the regulations were changed (mean = 2.5/3.0).

Management Scenario 5: Implementation of Antler-Point Restriction Regulations—Hunters displayed a preference for a regulatory package that allowed youth hunters to shoot any buck, and ranked the antler-point restriction regulation that protected 75% of the yearling buck population highest but still allowed party hunting. In general, regulations that were increasingly restrictive and did not provide for youth to harvest any deer were ranked lower. The choice of 'not liking antler point regulations but would hunt anyway' ranked higher than the most restrictive antler point regulation (protect 75%, no party hunting, youth abide). As in the other 4 scenarios, the option of changing hunt location if regulations were adopted ranked lowest.

Overall, the following antler point restriction regulation options were ranked as follows:

1. Protect 75% of the yearling buck population, party hunting legal, youth can take any deer (mean = 1.7/3.0).
2. Protect 50% of the yearling buck population, buck party hunting not legal, youth can take any deer (mean = 1.9/3.0).
3. Protect 50% of the yearling buck population, buck party hunting not legal, youth must abide by the regulation (mean = 1.9/3.0).
4. Protect 75% of the yearling buck population, party hunting legal, youth must abide by the regulation (mean = 1.9/3.0).
5. Opposed to antler point restriction regulations but would still hunt the area (mean = 2.0/3.0).
6. Protect 75% of the yearling buck population, buck party hunting not legal, youth must abide by the regulation (mean = 2.0/3.0).
7 Would not hunt the area if the regulations were changed (mean = 2.7/3.0).

MANAGEMENT IMPLICATIONS

Perhaps the most important finding from this survey is that hunters indicated that they will choose to hunt even if they disagree with a new deer hunting regulation. This finding is critical because the effectiveness associated with a hunting regulation will ultimately depend on the hunter's willingness and ability to harvest deer under the new regulation. Thus, it is imperative that hunters are willing to hunt even though they may not support a particular regulation.

This study found that a very high percentage of Minnesota deer hunters are not interested in harvesting an antlerless deer early during the hunting season. Current statewide regulations allow any deer hunter to hunt for a buck without linking that opportunity to harvesting an antlerless deer. Regulations that require or encourage harvest of antlerless deer during the early part of the season may be very effective at increasing the antlerless harvest since most (67%) of the deer harvest occurs during that time frame. An example of a regulation that would require antlerless deer to be harvested early in the season would be an earn-a-buck regulation. There are many ways to encourage antlerless deer harvest. Two examples of regulations that may encourage hunters to harvest antlerless deer may be to allow the taking of a second buck or providing a free late-season hunting license if an antlerless deer is registered during the opening weekend. We are not recommending any of the aforementioned regulations be implemented in Minnesota. We provide these regulations as examples of strategies that may encourage or require the harvest of antlerless deer during the early part of the hunting season.

We also found that the majority of hunters were satisfied with the current number of antlerless deer in deer populations. Based on previous studies that demonstrate hunter satisfaction is related to the number of deer a hunter observes (Thomas et al. 1973), it is reasonable to expect that hunter satisfaction will decline as a result of implementing an alternative hunting regulation that causes deer population reduction. However, this study also found that hunters strongly supported regulations that would increase the proportion of mature bucks in the population. We cannot discern if hunter satisfaction would remain at higher levels if a greater proportion of the population is comprised of mature bucks after deer densities are reduced. However, the management strategy of maintaining a higher proportion of mature bucks in the population, which should increase hunter satisfaction (while deer densities that are managed at lower densities should reduce hunter satisfaction), may be the most logical long-term management strategy to maintain hunter satisfaction given our findings from this survey. Thus, regulations that reduce harvest vulnerability of antlered deer may be a necessary component to deer management if the long-term goal is to maintain deer densities at substantially lower levels. Further research is needed to evaluate this theory.

When the management scenario involved population reduction, hunters ranked early antlerless-only seasons over other regulatory options that we presented. Further, hunters supported early antlerless-only seasons over other proposed regulations as well. However, from a practical management perspective, ranked means associated with antler-point restriction regulations and earn-a-buck regulations were not substantially different than early antlerless-only seasons. Even though hunters generally opposed earn-a-buck regulations (Table 1), it appears that hunters recognized the need for the regulation when population reduction was necessary and a suite of hunting regulation alternatives were presented to them in management scenarios 2 and 3. This might suggest that the Agency ought to invest substantial efforts into educating hunters so that hunters understand the proposed population reduction management scenario as well as management alternatives to manipulate the deer population toward the population goal.

We suggest a reasonable management approach for population reduction would be to first implement early antlerless-only seasons, then implement antler-point restriction or earn-a-buck regulations (with outreach efforts preceding the implementation of the regulations) if the early antlerless-only season did not provide an adequate antlerless harvest for population reduction. Whether antler-point restriction or earn-a-buck regulations are implemented would depend on the harvest efficiency associated with each regulation relative to the numerical antlerless deer harvest required for population reduction. In order to maintain long-term hunter satisfaction, implementation of a regulation that would maintain higher proportions of mature bucks in deer populations may be warranted once deer populations reach goal levels. Our survey indicates that implementing antler-point restriction regulations as part of this long-term population maintenance phase would be the most acceptable regulation.

LITERATURE CITED

Cochran, W.G. and G.M. Cox. 1957. Experimental Designs. Wiley Publishing, New York, New York.

Conover, M. R. 1997 Monetary and intangible valuation of deer in the United States. Wildlife Society Bulletin 25-398-305.

Decker, D. J., and N. A. Connelly. 1990. The need for hunter education in deer management: insights from New York. Wildlife Society Bulletin 18:447-452.

Dillman, D.A. 2000. Mail and Internet surveys: The tailored design method. Wiley Publishing, New York, New York.

Duda, M. D., P.E. De Michele, S.J. Bissell, P. Wang, J.B. Herrick, A.J. Lanier, W. Testerman, C.A. Zurawski, M. Jones, and J. Dehoff. 2002. Minnesota Deer Hunters' Opinions and Attitudes Toward Deer Management. Project Report. Minnesota Department of Natural Resources, St. Paul, Minnesota.

Fulton, D. C., L. Cornicelli, and M. D. Grund. 2006. 2005 Survey of deer hunter satisfaction and preferences for regulation changes. Project Report: Minnesota Department of Natural Resources, St. Paul, Minnesota, USA. 81pp.

Garrott, R. A., P. J. White, and C.A.V. White. 1993. Overabundance: an issue for conservation biologists? Conservation Biology 7:946-949.

Grund, M. D. 2004. Simulating antler-point restriction regulations in populations of white-tailed deer in northwest Minnesota using a generalized sustained yield model. Pages 9-20 *in* P. J. Wingate, R. O. Kimmel, J. S. Lawrence, and M. S. Lenarz, editors. Summaries of Wildlife Research Findings, 2004. Division of Wildlife, Minnesota Department of Natural Resources, St. Paul, Minnesota, USA.

McShea, W. J., H. B. Underwood, and J. H. Rappole, editors. 1997. The science of overabundance: Deer ecology and population management. Smithsonian Institution Press, Washington, D. C., USA.

Roseberry, J. L., and A. Woolf. 1991. A comparative evaluation of techniques for analyzing white-tailed deer harvest data. Wildlife Monographs 117.

Scheaffer, R.L., W. Mendenhall, and L. Ott. 1990. Elementary survey sampling. Duxbury Press, Belmont, California.

Thomas, J. W., J. C. Pack, W. M. Healy, J. D. Gill, and H. R. Sanderson. 1973. Territoriality among hunters—The policy implications. Transactions of the North American Wildlife and Natural Resources Conference 38:274-280.

Woolf, A., and J. L. Roseberry. 1998. Deer management: our profession's symbol of success or failure. Wildlife Society Bulletin 26:515-521.

Table 1. Percentages of hunters agreeing/disagreeing with survey questions related to population management and alternative deer hunting regulations (from Fulton et al. 2006).

Question	Hunters agree (%)	Hunters disagree (%)	Agree:Disagree
Satisfied with buck quality in area that you hunt?	43	43	1.0:1.0
Satisfied with number of mature bucks in area that you hunt?	39	50	0.8:1.0
Satisfied with number of antlerless deer in area that you hunt?	77	15	5.1:1.0
Satisfied with total number of deer in area that you hunt?	67	24	2.8:1.0
Support regulation to increase proportion of mature bucks?	66	13	5.1:1.0
Support early antlerless-only season?	50	32	1.6:1.0
Support antler-point restriction regulation?	47	43	1.1:1.0
Support regulation that would prohibit cross-tagging of bucks?	46	42	1.1:1.0
Support earn-a-buck regulation?	37	48	0.8:1.0
Support limiting the number of buck license?	29	59	0.5:1.0
Support moving season outside the rut?	29	55	0.5:1.0
Support regulation that would prohibit cross-tagging of all deer?	28	61	0.5:1.0

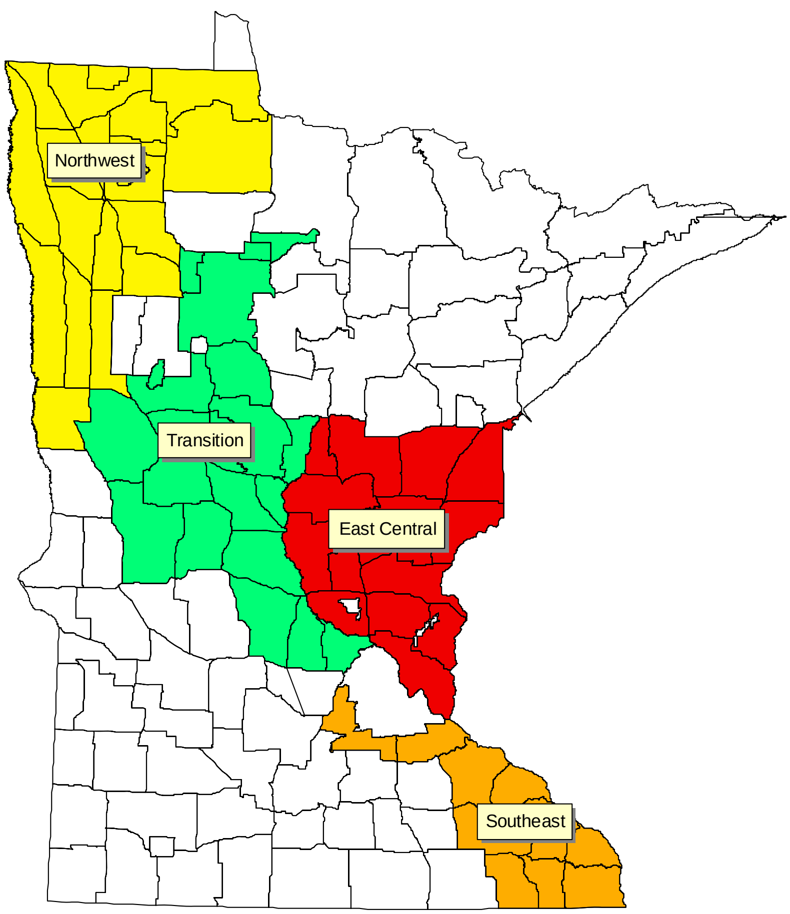

Figure 1. Deer permit areas in Minnesota with choice survey regions shaded, 2004.

ESTIMATING WHITE-TAILED DEER ABUNDANCE USING AERIAL QUADRAT SURVEYS

Brian S. Haroldson and John H. Giudice

SUMMARY OF FINDINGS

We estimated white-tailed deer (*Odocoileus virginianus)* abundance in select permit areas using stratified random and 2-dimensional systematic quadrat surveys to recalibrate deer population models and evaluate the impact of deer season regulation changes on population size. With rare exception, precision of population estimates was similar among permit areas. However, because population estimates were not corrected for sightability, estimates represent minimum counts and are biased low. Beginning in 2008, we will begin to develop a sightability estimator to adjust estimates for animals missed during surveys.

INTRODUCTION

Management goals for animal populations are frequently expressed in terms of population size (Lancia et al. 1994). Accurate and precise estimates of animal abundance allow for documentation of population trends, provide the basis for setting harvest quotas (Miller et al. 1997), and permit assessment of population and habitat management programs (Storm et al. 1992).

The Minnesota Department of Natural Resources (MNDNR) uses simulation modeling to estimate and track changes in deer abundance and, subsequently, to develop harvest recommendations to keep deer populations within goal levels. In general, model inputs include estimates of initial population size and spatial/temporal estimates of survival and reproduction for various age and sex cohorts. Because simulated population estimates are subject to drift as model input errors accumulate over time, it is imperative to periodically recalibrate the starting population within these models with independent deer population estimates (Grund and Woolf 2004).

Minnesota's deer numbers are managed according to numeric population goals within each of the 125 permit areas (PA). Traditionally, these goals were established by wildlife managers, largely without public input. MNDNR is currently revising deer population goals within each PA using a consensus-based, round–table approach consisting of 15-20 citizens representing varied interest groups (e.g. deer hunters, farmers, foresters, environmental groups, etc.; Stout et al. 1996). Once goals are established, they are used to guide deer-harvest recommendations. Currently, deer populations exceed management goals in many PAs. A conventional approach of increasing the bag limit within the established hunting season framework has failed to reduce deer densities. As a result, MNDNR has begun testing the effectiveness of 3 non-traditional harvest regulations to increase the harvest of antlerless deer and reduce overall population levels (Grund et al. 2005). Accurate and precise estimates of deer abundance are needed to evaluate these regulations.

The objective of this study is to provide independent estimates of deer abundance in select PAs. These data will be used to recalibrate population models to improve population management and to evaluate impacts of deer season regulation changes on deer abundance.

METHODS

We estimated deer populations in the PAs using a quadrat-based, aerial survey design. Quadrat surveys have been used to estimate populations of caribou (*Rangifer tarandus*; Siniff and Skoog 1964), moose (*Alces alces*; Evans et al. 1966), and mule deer (*O. heimonus*; Bartmann et al. 1986) in a variety of habitat types. We employed a stratified, random sampling design, with quadrats stratified into 2 abundance classes (low, high) based on relative deer densities, in PAs where the local wildlife manager had prior knowledge about deer abundance and distribution. In other areas, we used a 2-dimensional systematic sampling design (Cressie 1993, D'Orazio 2003). Systematic designs are typically easier to implement, maximize sample distribution, and are often more efficient than simple or stratified random sampling designs (Cressie 1993, D'Orazio 2003).

Within each PA, quadrats were delineated by Public Land Survey section boundaries and a 20% sample was selected for surveying. Sample size calculations indicated this sampling effort was needed to provide 90% confidence interval population estimates that were within 20% of the true population size. We excluded quadrats containing navigation hazards or high human development, and selected replacement quadrats in stratified PAs. Replacement quadrats were unavailable in the systematic PAs because of the rigid, 2-dimensional design. We used OH-58 helicopters during most surveys. However, a Cessna 182 airplane was used in 3 PAs dominated by intensive row-crop agriculture. To increase visibility, we completed surveys after leaf-drop by deciduous vegetation and when snow cover measured at least 15 cm. The pilot and 2 observers searched for deer along transects, generally spaced at 270-m intervals within each quadrat, until they were confident no more animals would be observed. We used a real-time, moving-map software program (DNR Survey; MNDNR 2005), coupled to a global positioning system receiver and a tablet-style computer, to guide transect navigation and record deer locations and aircraft flight paths directly to ArcView GIS (Environmental Systems Research Institute 1996) shapefiles. We estimated deer abundance from stratified surveys using SAS Proc SURVEYMEANS (SAS 1999) and from systematic surveys using formulas developed by D'Orazio (2003).

RESULTS AND DISCUSSION

We completed 5 surveys during January-February 2005, 8 surveys during January-March 2006, and 7 surveys during January-March 2007 (Table 1). Stratified fixed-wing surveys were conducted in PAs 421 and 423. Based on long-term deer harvest metrics, population estimates in these areas were biased low. Several possibilities may explain this result: 1) quadrats were stratified incorrectly; 2) deer were clustered in unsampled quadrats; 3) deer were wintering outside PA boundaries; 4) sightability was biased using fixed-wing aircraft; and/or 5) kill locations from hunter-killed deer were reported incorrectly. Land cover in these PAs was dominated by intensive row crop agriculture. After crops are harvested each fall, deer habitat was limited to riparian areas, wetlands, abandoned farm groves, and undisturbed grasslands, including those enrolled in state and federal conservation programs. Although recreational feeding of deer could influence distribution, it was not a common practice in these PAs. Thus, we had no evidence to support poor stratification (1) or non-traditional deer distribution (3) in these units. We also had no reason to believe hunter registration errors had greater bias in these units than in other PAs (5). Although it was possible that deer occupied unsampled quadrats by chance (2), our use of optimal allocation to increase sampling effort in high strata plots because of expected higher deer densities should minimize this possibility. Furthermore, we surveyed 100% of the high-strata plots in PA 421, resulting in no unsampled quadrats. Sightability bias (4), however, is greater in fixed-wing aircraft than helicopters (LeResche and Rausch 1974, Kufeld et al. 1980, Ludwig 1981) and likely explained much of the bias we observed in these PAs. Beginning in 2007, all surveys were conducted using a helicopter.

With the exception of PAs 421, 423, and 201, precision (CV, relative error) of our population estimates was similar among PAs (Table 1). High precision in PA 421 was, in part, an artifact of sample design. Based on optimal allocation formulas, we selected and surveyed all high strata quadrats. Thus, because no sampling occurred within the high stratum (100% surveyed), sampling variance was calculated only from low strata quadrants. We observed few deer in these low strata quadrats, resulting in low sampling variance and, therefore, high precision of the population estimate. It is unlikely that this design (i.e., sampling 100% of high strata quadrats) will be feasible in all areas, especially if deer are more uniformly distributed throughout the landscape.

In contrast, survey precision in PAs 423 and 201 was poor. We observed few deer during either survey (n=144 and 56, respectively). In addition, most quadrats contained no deer, and nearly all observations occurred within 1 or 2 quadrats. Resulting confidence intervals were only within 60% of the true population size (Table 1). Kufeld et al. (1980) described similar issues with precision due to nonuniformity of mule deer distribution within strata in Colorado.

We did not correct population estimates for sightability. Thus, estimates represent minimum counts and are biased low. Although sightability correction factors for deer are available in the literature (Rice and Harder 1977, Ludwig 1981, Stoll et al. 1991, Beringer et al. 1998), we believe it would be inappropriate to apply them to our survey areas because of differences in sampling design and habitat characteristics. Beginning in 2008, we will attempt to develop a sightability estimator to adjust for animals missed during surveys. This estimator will improve our population estimates by reducing visibility bias. Future analysis will also include *post-hoc* evaluation of habitat features present in quadrats containing deer. This will provide additional empirical data for use in quadrat stratification. In addition, the prevalence of winter feeding by landowners, and its impact on deer distribution, will also be examined to determine if pre-survey stratification flights (Gasaway et al. 1986) are warranted.

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LITERATURE CITED

BARTMANN, R. M., L. H. CARPENTER, R. A. GARROTT, AND D. C. BOWDEN. 1986. Accuracy of helicopter counts of mule deer in pinyon-juniper woodland. Wildlife Society Bulletin 14:356-363.

BERINGER, J., L. P. HANSEN, AND O. SEXTON. 1998. Detection rates of white-tailed deer with a helicopter over snow. Wildlife Society Bulletin 26:24-28.

CRESSIE, N. A. C. 1993. Statistics for spatial data. Second edition. Wiley, New York, New York, USA.

D'ORAZIO, M. 2003. Estimating the variance of the sample mean in two-dimensional systematic samplings. Journal of Agricultural, Biological, and Environmental Statistics 8:280-295.

ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE. 1996. ArcView GIS. Version 3.x. Environmental Systems Research Institute, Inc., Redlands, California, USA.

EVANS, C. D., W. A. TROYER, AND C. J. LENSINK. 1966. Aerial census of moose by quadrat sampling units. Journal of Wildlife Management 30:767-776.

GASAWAY, W. C., S. D. DUBOIS, D. J. REED, AND S. J. HARBO. 1986. Estimating moose population parameters from aerial surveys. Biological Papers, University of Alaska, Number 22, Fairbanks.

GRUND, M., L. CORNICELLI, D. FULTON, B. HAROLDSON, E. DUNBAR, S. CHRISTENSEN, AND M. IMES. 2005. Evaluating alternative regulations for managing white-tailed deer in Minnesota – a progress report. Pages 132-137 *in* P. Wingate, R. Kimmel, J. Lawrence, and M. Lenarz, editors. Summaries of Wildlife Research Findings, 2005. Division of Fish and Wildlife, Minnesota Department of Natural Resources, St. Paul.

GRUND, M. D., AND A. WOOLF. 2004. Development and evaluation of an accounting model for estimating deer population sizes. Ecological Modeling 180:345-357.

KUFELD, R. C., J. H. OLTERMAN, AND D. C. BOWDEN. 1980. A helicopter quadrat census for mule deer on Uncompahgre Plateau, Colorado. Journal of Wildlife Management 44:632-639.

LANCIA, R. A., J. D. NICHOLS, AND K. H. POLLOCK. 1994. Estimating the number of animals in wildlife populations. Pages 215-253 *in* T. A. Bookhout, editor. Research and management techniques for wildlife and habitats. Fifth edition. The Wildlife Society, Bethesda, Maryland.

LERESCHE, R. E., AND R. A. RAUSCH. 1974. Accuracy and precision of aerial moose censusing. Journal of Wildlife Management 38:175-182.

LUDWIG, J. 1981. Proportion of deer seen in aerial counts. Minnesota Wildlife Research Quarterly 41:11-19.

MILLER, S. D., G. C. WHITE, R. A. SELLERS, H. V. REYNOLDS, J. W. SCHOEN, K. TITUS, V. G. BARNES, JR., R. B. SMITH, R. R. NELSON, W. B. BALLARD, AND C. C. SCHWARZ. 1997. Brown and black bear density estimation in Alaska using radiotelemetry and replicated mark-resight techniques. Wildlife Monographs 133.

MNDNR. 2005. DNR Survey: an Arcview GIS 3.x extension for enhancing aerial surveys for wildlife. http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/dnrsurvey/dnrsurvey.html.

RICE, W. R., AND J. D. HARDER. 1977. Application of multiple aerial sampling to a mark-recapture census of white-tailed deer. Journal of Wildlife Management 41:197-206.

SAS INSTITUTE. 1999. SAS OnlineDoc, version 8. SAS Institute, Cary, North Carolina, USA. http://v8doc.sas.com/sashtml/. April 2006.

SINIFF, D. B., AND R. O. SKOOG. 1964. Aerial censusing of caribou using stratified random sampling. Journal of Wildlife Management 28:397-401.

STOLL, R. J. JR., W. MCCLAIN, J. C. CLEM, AND T. PLAGEMAN. 1991. Accuracy of helicopter counts of white-tailed deer in western Ohio farmland. Wildlife Society Bulletin 19:309-314.

STOUT, R. J., D. J. DECKER, B. A. KNUTH, J. C. PROUD, AND D. H. NELSON. 1996. Comparison of three public-involvement approaches for stakeholder input into deer management decisions: a case study. Wildlife Society Bulletin 24:312-317.

STORM, G. L., D. F. COTTAM, R. H. YAHNER, AND J. D. NICHOLS. 1992. A comparison of 2 techniques for estimating deer density. Wildlife Society Bulletin 20:197-203.

Table 1. Deer population and density estimates derived from aerial surveys in Minnesota, 2005-2007.

Sampling design	Year	Permit area	Sampling rate (%)	Population estimate *N*	Population estimate 90% CI	CV (%)	Error (%)[1]	Density estimate (deer/mi^2) Mean	Density estimate (deer/mi^2) 90% CI	Model estimate (deer/mi^2)
Systematic	2005	252	16	2,999	2,034 – 3,969	19.5	32.2	2.9	2.0 – 3.9	2
		257	16	2,575	1,851 – 3,299	16.9	28.1	6.2	4.4 – 7.9	7
	2006	204	16	3,432	2,464 – 4,401	17.0	28.2	4.6	3.3 – 5.9	5
		209	17	6,205	5,033 – 7,383	11.4	18.9	9.7	7.9 – 11.5	5
		210	17	3,976	3,150 – 4,803	12.5	20.8	6.3	5.0 – 7.6	7
		256	17	4,670	3,441 – 5,899	15.9	26.3	7.1	5.3 – 9.0	5
		236	16	6,774	5,406 – 8,140	12.1	20.2	16.8	13.4 – 20.2	37
	2007	225	17	5,341	4,038 – 6,645	14.7	24.4	8.0	6.0 – 9.9	24
		227	17	5,101	4,245 – 5,960	10.1	16.8	9.8	8.2 – 11.5	13
		346	16	7,896	5,736 – 10,062	16.4	27.4	22.7	16.5 – 29.0	31
Stratified	2005	206	20	2,486	1,921 – 3,051	13.7	22.5	5.2	4.0 – 6.4	5
		342	20	3,322	2,726 – 3,918	10.8	17.7	9.1	7.5 –10.7	10
		421	20	631	599 – 663	3.0	5.0	0.8	0.8 – 0.9	5
	2006	201	20	274	100 – 449	37.6	61.9	1.6	0.6 – 2.7	6
		420	20	1,740	1,301 – 2,180	15.2	25.1	2.6	2.0 – 3.3	3
		423	20	472	179 – 764	37.4	61.5	0.9	0.3 – 1.4	5
	2007	343	20	6,982	5,957 – 8,006	8.9	14.6	10.1	8.6 – 11.6	29
		344[2]	25	4,116	3,375 – 4,857	10.7	17.7	19.7	16.1 – 23.2	49
		347[2]	21	5,482	4,472 – 6,492	11.1	18.2	12.6	10.3 – 14.9	13
		349[2]	23	10,103	8,573 – 11,633	9.1	15.0	20.4	17.3 – 23.5	35

[1]Relative precision of population estimate (goal: 90% CI that is within +/- 20% of the true pop'n size). Calculated as 90% CI bound ⁄ *N*.

[2]Survey area included State Park property within the permit area.

EFFECTS OF ALTERNATIVE DEER HUNTING REGULATIONS ON HUNTER HARVESTS IN MINNESOTA

Marrett D. Grund

SUMMARY OF FINDINGS

I examined white-tailed deer (*Odocoileus virginianus*) harvest data associated with traditional and alternative hunting regulations being tested in Minnesota. Hunters in early antlerless-only seasons and under earn-a-buck regulations were more willing and able to harvest multiple antlerless deer. Antlerless harvest projections associated with these 2 hunting regulations were highest of those that I investigated. However, a previous study indicated that only 57% of Minnesota hunters are willing to participate in an early antlerless-only season. Accounting for this level of hunting effort, antlerless harvest projections under early antlerless-only seasons remained 14-20% higher than intensive management regulations, which was the most aggressive traditional hunting regulation. However, since an earn-a-buck regulation is not voluntary like the early antlerless-only season, earn-a-buck antlerless harvest projections were 60-86% higher than 5-deer bag limit regulations. I also found that antlerless harvest projections associated with 2-deer bag limits were substantially lower than 5-deer bag limit regulations due to a lower percentage of hunters willing or able to harvest a second antlerless deer in managed permit areas. These preliminary results indicate that early antlerless-only seasons may slightly increase the antlerless harvest in comparison to 5-deer bag limit regulations, but earn-a-buck regulations will markedly increase antlerless harvests.

INTRODUCTION

In 1972, Minnesota Department of Natural Resources (MN DNR) closed the deer hunting season due to the scarcity of white-tailed deer. In 1973, the MN DNR adopted a new seasonal framework that allowed deer hunting to occur each year but also allowed populations to grow. Essentially, hunters were allowed to hunt antlered deer, but antlerless deer could not be harvested unless the hunter was awarded an antlerless permit through a lottery. Since then, annual deer harvests have increased almost 4-fold in Minnesota. Clearly, deer populations successfully recovered due to these regulation changes.

With the exception of the southwest and south-central regions of Minnesota where little woody habitat exists, some wildlife managers are more concerned about controlling increasing population growth rates of deer rather than restricting antlerless harvests. For almost a decade, managers have suggested liberalizing regulations associated with harvesting antlerless deer in attempt to reduce population growth rates. In 2005, the MN DNR adopted an Alternative Deer Management (ADM) research project to examine biological and social ramifications associated with regulations that were traditionally used in Minnesota. The ADM regulations were designed to increase antlerless deer harvests. In this paper, I provide preliminary results associated with comparing traditional deer hunting regulations to those used in the ADM study.

OBJECTIVES

- Analyze harvest patterns of hunters hunting under alternative deer hunting regulations and current statewide deer hunting regulations; and
- Estimate numerical harvests associated with alternative deer hunting regulations and current statewide deer hunting regulations.

METHODS

There were 4 hunting zones in Minnesota that are used to determine season timing and length in Minnesota during 2005 and 2006 (see 2005 and 2006 Minnesota Hunting and Trapping Regulations Handbooks). In addition, there were approximately 130 permit areas in Minnesota where deer hunting regulations were applied. At the statewide level, there were 3 basic hunting regulations used for deer management in permit areas: 1) Lottery (LOT) – hunters could hunt only antlered deer unless an individual was awarded an antlerless permit through a lottery of a limited number of antlerless permits; 2) Managed (MAN) – hunters were provided with an either-sex hunting license and an additional antlerless-only hunting license; and 3) Intensive (INT) – hunters were provided with an either-sex hunting license and an antlerless-only hunting license, and hunters could purchase up to 3 additional antlerless-only hunting license at a reduced license fee.

As part of this study, early antlerless-only hunting seasons were offered in 5 permit areas in northwestern Minnesota and 3 permit areas in east-central Minnesota. Hunters were required to purchase an early antlerless-only hunting license at a reduced cost to hunt during this voluntary season, which was held during the second weekend of October. I evaluated antler-point restriction and earn-a-buck regulations in 7 state parks in Minnesota. Deer bag limits were identical to INT permit areas for all study areas associated with this study.

Hunters participating in each hunting regulation in 2005 and 2006 were identified in the Electronic Licensing System (ELS) database and were categorized according to each hunting zone. I then conducted simple frequency analyses to determine the number of hunters intending to hunt under each regulation. Similarly, I used the ELS deer harvest database to identify the number of deer individual hunters harvested under each hunting regulation. I then conducted a simple frequency analysis to estimate the percentage of hunters that were unsuccessful, and the number of hunters that harvested 1, 2, and >2 deer for each hunting regulation.

In order to compare harvest efficiency associated with each hunting regulation, I projected numerical harvests by standardizing the number of hunters (effort) for each regulation. To standardize effort, I assumed that there were 1,000 hunters hunting under each regulation and projected the number of antlerless deer harvested based on the proportion of hunters who harvested 0, 1, 2, and >2 deer.

RESULTS AND DISCUSSION

Harvest Patterns Among Regulations

The number of permit areas associated with each hunting regulation differed between 2005 and 2006 due to changes in hunting regulations needed to manage deer populations according to population goals (Tables 1 and 2). However, from a practical harvest management perspective, there were very similar trends in the proportion of hunters taking 0, 1, 2, or >2 deer under each hunting regulation between years. An exception was the earn-a-buck regulation. The percentage of hunters not harvesting an antlerless deer under earn-a-buck regulations increased from 54% in 2005 to 63% in 2006. Hunter success rates are usually inversely related to deer density in a linear fashion (Roseberry and Woolf 1991). Thus, the increased proportion of hunters not harvesting an antlerless deer in 2006 may be attributable to a reduction in deer densities between years.

Projected Antlerless Harvests

In general, ADM regulations were more effective at increasing projected antlerless harvests than non-ADM regulations (Tables 3 and 4). Early antlerless-only seasons produced the highest antlerless harvest projections of the 3 ADM regulations. This result may be misleading, however, because early antlerless-only seasons are voluntary and only 57% of hunters indicated they would participate in an early antlerless-only season if that season was available in their area (Fulton et al. 2006). The early antlerless-only season harvest projections adjusted for this level of hunter effort remained 14-20% higher than harvest projections associated with comparable INT regulations. In contrast to the voluntary antlerless-only seasons, all hunters would need to participate under antler-point restriction and earn-a-buck regulations because those regulations would be applied during the regular firearms season. In 2005, projected antlerless harvests under antler-point restriction regulations were similar to projected antlerless harvests under INT regulations. However, the projected antlerless harvest under antler-point restriction regulations increased during 2006. This might suggest that hunters adapted to the antler-restriction regulation and were more willing to harvest antlerless deer during their second year of experience under the regulation. Harvest projections associated with earn-a-buck regulations were 60-86% higher than comparable INT regulations. At this point, my study suggests that earn-a-buck regulations will produce the highest antlerless harvests of the 3 ADM regulations when applied during the regular firearms season.

Projected antlerless harvests were highest under INT regulations followed by MAN and LOT regulations. It has been suggested that there is little practical difference in the number of antlerless deer that would be harvested under MAN or INT regulations. However, antlerless harvest projection comparisons between INT and MAN regulations suggest otherwise (Tables 3 and 4). Deer density may explain some of this occurrence since a MAN regulation would more likely be used under lower deer densities than INT regulations. However, deer densities are markedly different in permit areas located in Zones 2 and 3 that used MAN regulations compared to permit areas located in Zones 1 and 4 that used MAN regulations (Grund 2005, Lenarz 2005); yet the projected antlerless harvests under MAN regulations were comparable in all zones.

Observed differences between MAN and INT regulations have little to do with the hunter's ability to harvest up to 5 antlerless deer under INT regulations. Rather, it appears that hunters are more willing to harvest a second antlerless deer under INT regulations than under MAN regulations. There are 2 likely reasons for hunters to be more willing to harvest a second antlerless deer under INT regulations. First, a hunter who harvested an antlerless deer during the early part of the hunting season under MAN regulations may be less willing to harvest another antlerless deer because that would prevent the hunter from harvesting a buck. The other scenario is a hunter who harvested an antlered deer during the early portion of the hunting season under MAN regulations is only able to harvest 1 additional antlerless deer. Regardless, managers should use caution when considering MAN regulations when high numerical antlerless harvests are needed or desired.

LITERATURE CITED

Fulton, D. C., L. Cornicelli, and M. D. Grund. 2006. 2005 Survey of deer hunter satisfaction and preferences for regulation changes. Project Report: Minnesota Department of Natural Resources, St. Paul, Minnesota, USA. 81pp.

Grund, M. 2005. Population trends of white-tailed deer in Minnesota's farmland/transition zone—2005. *in* Dexter, M. H., editor. 2005. Status of wildlife populations, fall 2005. Unpublished report, Division of Fish and Wildlife, Department of Natural Resources, St. Paul, Minnesota. 270 pp.

Lenarz, M. 2005. Population trends of white-tailed deer in Minnesota's forest zone—2005. *in* Dexter, M. H., editor. 2005. Status of wildlife populations, fall 2005. Unpublished report, Division of Fish and Wildlife, Department of Natural Resources, St. Paul, Minnesota. 270 pp.

Roseberry, J. L., and A. Woolf. 1991. A comparative evaluation of techniques for analyzing white-tailed deer harvest data. Wildlife Monographs 117.

Table 1. Number of management areas, number of hunters, and number of hunters registering antlerless deer under different management strategies employed throughout Minnesota during the 2005 deer hunting season.

	Management areas	Hunters[a]	Number of Hunters Registering (%)			
			No antlerless[b]	1 antlerless	2 antlerless	>2 antlerless
Zone 1						
Lottery	9	25,099	22,204 (89)	2,828 (11)	62 (0)	5 (0)
Managed	14	90,310	68,904 (76)	19,107 (21)	2,213 (2)	86 (0)
Intensive	7	55,205	39,537 (72)	12,401 (22)	2,495 (5)	772 (1)
Zone 2[c]						
Lottery	0	0	n/a	n/a	n/a	n/a
Managed	9	14,694	10,960 (75)	3,363 (23)	353 (2)	18 (0)
Intensive	29	105,571	75,016 (71)	24,225 (23)	4,909 (5)	1,421 (1)
Zone 3[de]						
Lottery/Lottery	1	2,539	2,222 (88)	309 (12)	8 (0)	2 (0)
Lottery/Managed	3	5,888	4,813 (82)	982 (17)	86 (1)	7 (0)
Lottery/Intensive	3	12,369	9,343 (76)	2,431 (20)	474 (4)	121 (0)
Managed/Intensive	4	15,730	10,757 (69)	3,823 (24)	836 (5)	314 (2)
Zone 4						
Lottery	24	35,254	30,421 (86)	4,772 (14)	58 (0)	2 (0)
Managed	12	26,831	21,195 (79)	5,636 (21)	274 (1)	10 (0)
Intensive	11	36,725	25,279 (69)	9,619 (26)	1,468 (4)	357 (1)
Alternative Regulations						
Early Antlerless Season	8	4,848	2,676 (55)	1,338 (28)	561 (12)	273 (6)
Antler-Point Restriction	3	765	540 (71)	174 (23)	39 (5)	12 (1)
Earn-a-Buck	4	900	484 (54)	279 (31)	104 (12)	33 (4)

[a] Hunters who declared where they intended to hunt
[b] Estimated based on the number of hunters registering deer versus the number of hunters declaring where they intended to hunt
[c] Excluding Permit Area 228
[d] Split Season: A Season Strategy/B Season Strategy
[e] Excluding Permit Area 337

Table 2. Number of management areas, number of hunters, and number of hunters registering antlerless deer under different management strategies employed throughout Minnesota during the 2006 deer hunting season.

	Permit areas	Hunters[a]	Number of Hunters Registering (%)			
			No antlerless[b]	1 antlerless	2 antlerless	>2 antlerless
Zone 1						
Lottery	4	2,448	2,221 (91)	222 (9)	2 (0)	3 (0)
Managed	15	92,131	72,231 (79)	17,880 (19)	1,991 (2)	29 (0)
Intensive	11	71,635	54611 (76)	13,994 (20)	2,416 (3)	614 (1)
Zone 2[c]						
Lottery	1	247	214 (87)	32 (13)	1 (0)	0 (0)
Managed	12	31,363	25,393 (81)	5,370 (17)	570 (2)	30 (0)
Intensive	34	120,089	90,518 (75)	23,831 (20)	4,531 (4)	1,209 (1)
Zone 3[de]						
Lottery/Lottery	1	2,600	2,172 (84)	416 (16)	12 (0)	0 (0)
Lottery/Managed	2	3,277	2,896 (88)	354 (11)	24 (1)	3 (0)
Lottery/Intensive	2	8,210	6730 (82)	1,257 (15)	178 (2)	45 (1)
Managed/Intensive	4	14,308	11,260 (79)	2,556 (18)	391 (3)	101 (0)
Intensive/Intensive	2	9,118	6,682 (73)	1,881 (21)	424 (5)	131 (1)
Zone 4						
Lottery	28	47,622	42,207 (89)	5,369 (11)	42 (0)	4 (0)
Managed	10	16,553	13,989 (85)	2,419 (15)	136 (0)	9 (0)
Intensive	1	1,836	1,448 (79)	343 (19)	39 (2)	6 (0)
Alternative Regulations						
Early Antlerless Season	8	6,041	3,248 (54)	1865 (31)	680 (11)	248 (4)
Antler-Point Restriction		745	516 (69)	165 (22)	42 (6)	22 (3)
Earn-a-Buck	4	783	497 (63)	210 (27)	57 (7)	19 (3)

[a] Hunters who declared where they intended to hunt
[b] Estimated based on the number of hunters registering deer versus the number of hunters declaring where they intended to hunt
[c] Excluding Permit Area 228
[d] Split Season: A Season Strategy/B Season Strategy
[e] Excluding Permit Area 337

Table 3. Projected antlerless harvests based on a hypothetical scenario of 1,000 hunters in each management area. Numerical harvests were derived based on proportional harvest patterns for each management strategy used in the 2005 Minnesota deer hunting season (see Table 1).

	Hunters	Numerical Antlerless Harvest Based on Hunters Registering:				Total
		No antlerless	1 antlerless	2 antlerless	>2 antlerless[a]	
Zone 1						
Lottery	1,000	0	110	0	0	110
Managed	1,000	0	210	40	0	250
Intensive	1,000	0	220	100	35 (3.5)	355
Zone 2						
Lottery	n/a	n/a	n/a	n/a	n/a	n/a
Managed	1,000	0	230	40	0	270
Intensive	1,000	0	230	100	35 (3.5)	365
Zone 3						
Lottery/Lottery	1,000	0	120	0	0	120
Lottery/Managed	1,000	0	170	20	0	190
Lottery/Intensive	1,000	0	200	80	0 (3.3)	280
Managed/Intensive	1,000	0	240	100	66 (3.3)	406
Zone 4						
Lottery	1,000	0	140	0	0	140
Managed	1,000	0	210	20	0	230
Intensive	1,000	0	260	80	32 (3.2)	372
Alternative Regulations						
Early Antlerless Season	1,000	0	280	240	210 (3.5)	730
Antler-Point Restriction	1,000	0	230	100	32 (3.2)	362
Earn-a-Buck	1,000	0	310	240	128 (3.2)	678

[a] Average number of deer registered by hunters registering >2 antlerless deer is in parentheses after the projected numerical harvest.

Table 4. Projected antlerless harvests based on a hypothetical scenario of 1,000 hunters in each management area. Numerical harvests were derived based on proportional harvest patterns for each management strategy used in the 2006 Minnesota deer hunting season (see Table 2).

	Hunters	Numerical Antlerless Harvest Based on Hunters Registering:				Total
		No antlerless	1 antlerless	2 antlerless	>2 antlerless[a]	
Zone 1						
Lottery	1,000	0	90	0	0	90
Managed	1,000	0	190	40	0	230
Intensive	1,000	0	200	60	36 (3.6)	296
Zone 2						
Lottery	1,000	0	130	0	0	130
Managed	1,000	0	170	40	0	210
Intensive	1,000	0	200	80	37 (3.7)	317
Zone 3						
Lottery/Lottery	1,000	0	160	0	0	160
Lottery/Managed	1,000	0	110	20	0	130
Lottery/Intensive	1,000	0	150	40	34 (3.4)	224
Managed/Intensive	1,000	0	180	60	0 (3.5)	240
Intensive/Intensive	1,000	0	210	100	37 (3.7)	347
Zone 4						
Lottery	1,000	0	110	0	0	110
Managed	1,000	0	150	0	0	150
Intensive	1,000	0	190	40	0 (3.2)	230
Alternative Regulations						
Early Antlerless Season	1,000	0	310	220	140 (3.5)	670
Antler-Point Restriction	1,000	0	220	120	102 (3.4)	442
Earn-a-Buck	1,000	0	270	140	96 (3.2)	506

[a] Average number of deer registered by hunters registering >2 antlerless deer is in parentheses after the projected numerical harvest.