DEPARTMENT OF NATURAL RESOURCES
RESEARCH
REPORT 136
NOV. 1985

RUFFED GROUSE HARVEST LEVELS AND POPULATION CHARACTERISTICS IN CENTRAL WISCONSIN

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ABSTRACT

Ruffed grouse (Bonasa umbellus) were live-trapped and banded from 1978-82 to measure fall harvest rates and assess dispersal in central Wisconsin. The study areas included the Sandhill Wildlife Area and a portion of the Wood County Wildlife Area. This report is a followup to a study published in 1984 which evaluated the effect of known levels of hunter effort and kill on grouse populations on the study areas and specifically addresses band recovery rates and factors contributing to differing harvests. Additional data on population characteristics are also presented.

Recovery rates of banded grouse averaged 42% (range 24-54%) at Sandhill and 29% (range 17-33%) on the Wood County Wildlife Area. Highest recovery rates of banded grouse on Sandhill occurred in 1980 and 1981, averaging 46% and 54%, respectively, and coincided with high grouse harvets and reduced breeding populations. Mean recovery rates on Sandhill translate to an estimated total harvest rate of 65% (range 31-83%). Hunting mortality may be a major factor depressing grouse populations on Sandhill. Our study also suggests that if harvest rates exceeding 40% are sustained over large areas for 2 or more years, a negative impact on breeding grouse densities would be expected.

The ratio of males to females was somewhat higher in live-trapped adult grouse than in hunter-shot birds, but were nearly equal in all other categories. Juveniles constituted 81% and 82% of live-trapped and hunter-shot birds, respectively, and 51% of all live-trapped and hunter-shot birds examined were red phase in tail color. Mean weights of males were greater ($P<0.05\%$) than females in both juveniles at 17+ weeks of age and adults. Most grouse were hatched before 15 June, and brood size appeared to be underestimated using conventional live-trapping techniques. Juveniles dispersed throughout the study areas but direction of dispersal was not random ($P<0.01$). Juveniles were more mobile than adults and nearly all banded birds were shot within 800 m of driveable roads. Juveniles comprised more than 80% of the fall population and few birds survived more than one year, providing additional evidence for cropping the annual surplus by hunting.

KEY WORDS: Band Recoveries, Harvest Rates, Population Characteristics, Movements, Ruffed Grouse.

CONTENTS

INTRODUCTION

Knowledge of the status of ruffed grouse populations relative to various harvest levels is important for determining management priorities and refining harvest strategies. Previous studies in Wisconsin (Dorney and Kabat 1960), Minnesota (Gullion and Marshall 1968), Michigan (Palmer and Bennett 1963), Alberta (Fischer and Keith 1974), and elsewhere concluded that hunting had little or no effect on subsequent breeding grouse populations. Dorney and Kabat (1960) concluded that 30-35% was an acceptable limit in areas without the buffering effect of unhunted coverts in immediately surrounding habitats. Palmer and Bennett (1963) suggested that breeding populations will not be adversely affected if grouse harvests do not exceed 50% of the fall population. Recent studies in Wisconsin (Rodgers 1980, DeStefano 1982) indicated average band recovery rates were within acceptable limits (less than 25%) with no adverse impact on breeding grouse populations.

These results are corroborated by current regional estimates of grouse harvest rates in Wisconsin which do not exceed 25% of the fall population, suggesting minimal hunting impact (Wis. Dep. Nat. Resour. 1979). Wildlife managers suggest that grouse harvests could be increased in northern Wisconsin and in some areas of central Wisconsin where hunter distribution is either limited by road access or large wet marshes. However, harvests must be closely monitored in the remaining farmland and forested ranges, particularly where heavy hunting pressure occurs in isolated habitats or on small tracts of public land (DeStefano and Rusch 1982).

Hunter demand for ruffed grouse is expected to increase, while the supply may decline during the next 20 years in Wisconsin (Wis. Dep. Nat. Resour. 1979). In addition, more hunters are expected to concentrate on ruffed grouse as populations of other game birds, particularly ducks and pheasants, decline in proportion to demand. There has also been a trend toward liberalized grouse regulations in Wisconsin and other states (DeStefano and Rusch 1982). This trend evolved from the attitude that sport hunting has no detrimental effect on grouse populations -- a concept that reflects the principle of compensatory mortality. Thus, as hunter demand increases, the need to determine acceptable limits of harvest while maintaining optimum numbers of breeding grouse becomes more urgent.

In Wisconsin, the effect of liberalized regulations on grouse populations has been investigated since 1976 on 4 separate areas (Fig. 1). Three areas studied by researchers from the University of Wisconsin are located where hunting seasons remained open until 31 December or later (Rodgers 1980, DeStefano and Rusch 1982, Rusch et al. 1984). On the Sandhill-Wood County study areas, Kubisiak (1984) evaluated the effect of known levels of hunter effort and kill on grouse populations where hunting sesaons ended about the first week of November, but where total hunter effort was high. Recovery rates, temporal distribution of band recoveries, and grouse dispersal relative to season structure and grouse populations were also discussed. This report is a followup to Kubisiak (1984) and assesses factors contributing to differing harvest levels on the respective study areas, recovery of sex-age classes, and conversion of recovery rates to harvest rates. In addition, information on the sex and age composition, weight, color phases, brood size, hatching chronology, movement, and survival of live-trapped and fall-shot grouse was gathered.

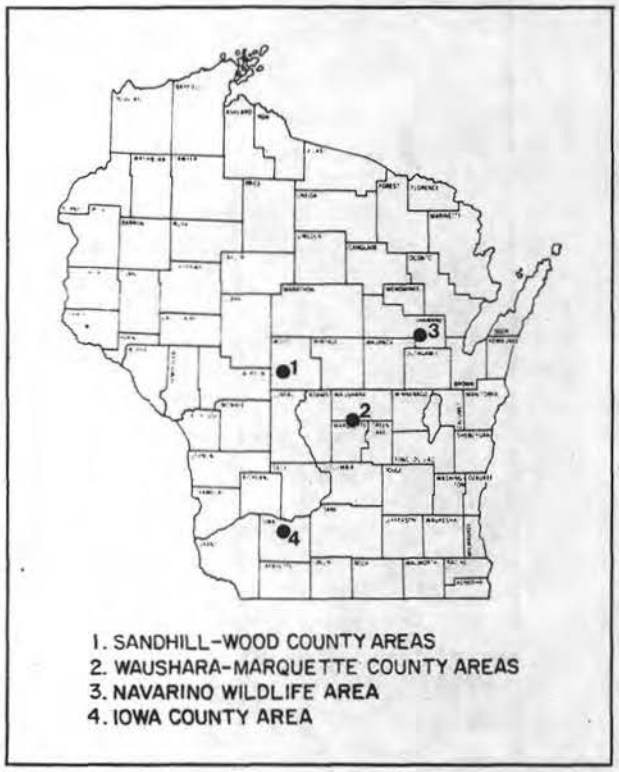

FIGURE 1. Location of ruffed grouse banding studies conducted since 1976.

STUDY AREAS AND METHODS

This study was conducted on the Sandhill Wildlife Area and the nearby Wood County Wildlife Area, located in southwestern Wood County (Fig. 1). Size, vegetative composition, areas open to hunting, and hunting season structure on these areas was described by Kubisiak (1984).

Grouse were live-trapped and banded in 1978-82 using lily pad traps that were distributed along roads throughout Sandhill and part of the Wood County Wildlife Area (Fig. 2). Live-trapping was expanded on the Wood County Area in 1981-82 to include an area more than 1,200 m south of Sandhill. Live-trapping was initiated by 1 August or earlier, except in 1978 when efforts were largely exploratory (Table 1). Traps were set to intercept grouse along edges of openings, recent clear cuts, or marshes and relocated several times during trapping to maximize success. Individual trap cells were placed at one or both ends of wire leads which averaged about 30 m (range = 10-100 m) in length. Height of leads were 0.3 - 0.6 m. Live-trapping was terminated the day before the hunting season on areas open to hunting. But live-trapping was continued on the northern part of Sandhill, which remained closed to hunting throughout the study -- hereafter referred to as the "unhunted area".

All birds were marked with 2 numbered leg bands, 1 of which was labeled with the address of the Department of Natural Resources, Bureau of Research and a $5.00 reward notice. Sex and age were determined according to procedures of Hale et al. (1954) and Roussel and Ouellet (1975). Ruffed grouse were classified as adult males, adult females, juvenile males, juvenile females, or juveniles of undetermined sex. Approximate hatching dates of live-trapped juveniles were based on progression of the primary moult (Bump et al. 1947). Color phase, weight, and the general condition of each bird were also recorded. After handling, all birds were released near the trap. Sex, age, and tail color data were analyzed by a log linear approach with "logit"

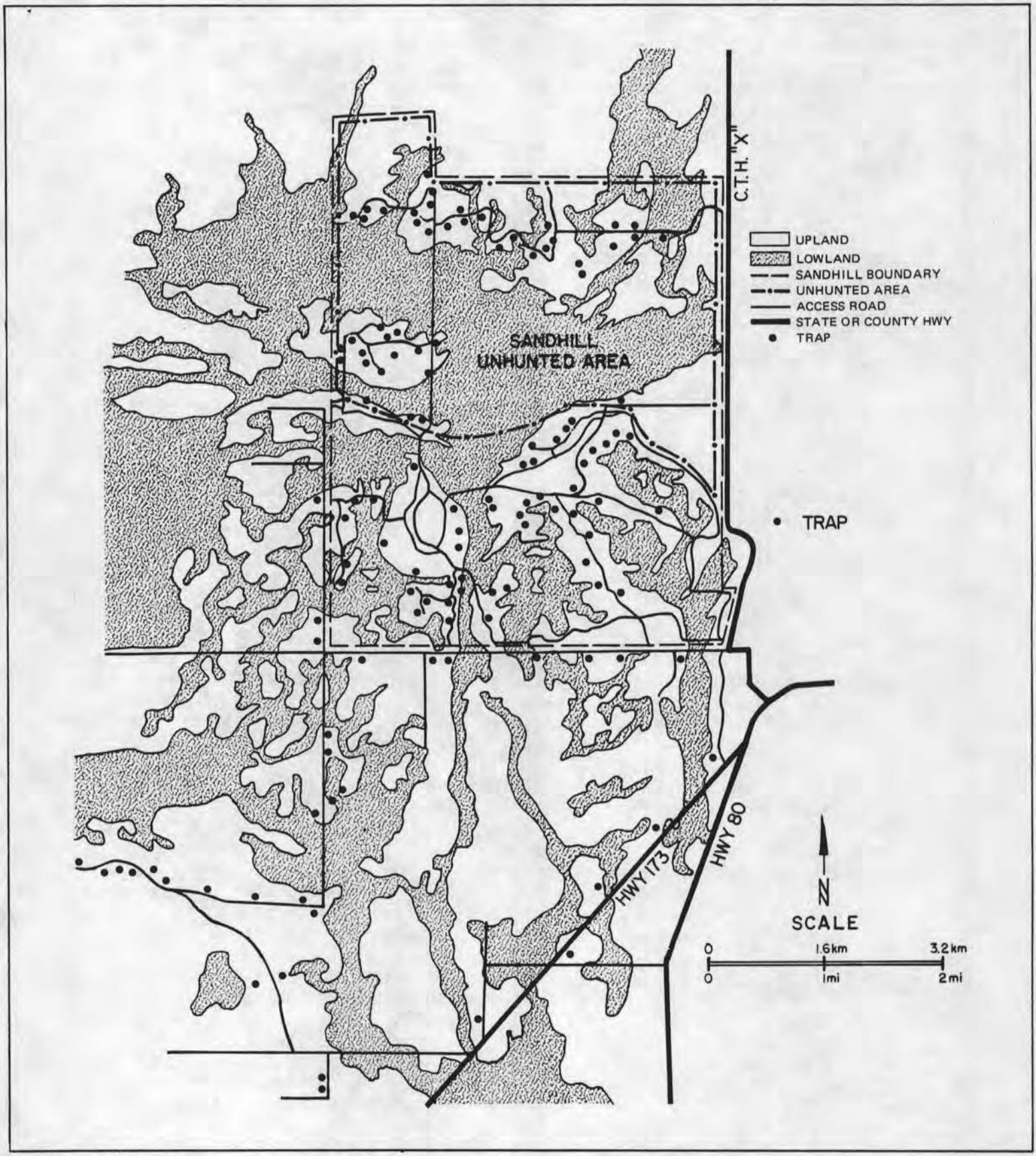

FIGURE 2. Distribution of lily pad traps on the Sandhill-Wood County study areas, 1978-82.

transformations. Weights were regressed at weekly intervals for 7 - 17+ week-old juveniles using a quadratic regression and monthly using a linear function for adults. Differences in the regression lines within age classes were tested by analysis of covariance. Dispersal data were analyzed using a circular distribution test according to Zar (1974).

Band recovery rates were based on the recovery of banded ruffed grouse reported by hunters during the hunting season. Hunters were required to report banded birds on Sandhill whereas reports of banded birds on surrounding areas were dependent upon hunter cooperation. Information on grouse dispersal was determined from band recoveries, recaptures of banded birds, or birds found dead incidental to other field work.

RESULTS AND DISCUSSION

TRAPPING SUCCESS

Live-trapping success was highest in 1979-81 when over 300 birds were banded each year (Table 2). Lowest trapping success (73 birds) occurred in 1982 following a population crash. Forty-four of the grouse captured were recaptures of birds banded in a previous year. Two percent of the grouse captured died of trapping injuries or predation by raccoons, weasels, or raptors; 4% had severe head scalping injuries; 10% had minor scalping. About 1% escaped unbanded either through holes in the net covering the trap or while being handled.

RECOVERY OF BANDED GROUSE

Recovery rates of banded grouse averaged 42% (range 20-54%) on the Sandhill hunted area and 29% (range 17-33%) on th Wood County Wildlife Area (Table 3). Highest recovery rates of banded grouse on Sandhill occurred in 1980 and 1981, averaging 46% and 54%, respectively. Recovery rates of banded grouse on Sandhill were higher in most years than any reported in the literature. These high rates coincided with high grouse harvests and reduced or declining populations (Kubisiak 1984). It should be emphasized that recovery rates of banded grouse probably represent minimum estimates since several factors discussed under the section on Estimated Harvest Rates affect the number of banded birds eventually shot and reported by hunters. However, it is clear that recovery rates of this magnitude had a negative impact on grouse populations. A negative impact on breeding grouse densities would also be expected if recovery rates exceeding 25-30% are sustained over large areas for 2 or more years. Recovery rates of this magnitude translate to a harvest rate of about 40-45%, and is discussed under Estimated Harvest Rates.

The highest recovery rates previously reported in Wisconsin were observed from 1978-81 at Navarino and 1982 in Waushara and Marquette counties (DeStefano 1982, Rusch et al. 1984). At Navarino, hunters recovered an average of 23% (range 18-31%) of the banded birds on an area where hunting seasons opened about 1 October and closed 31 December. At this level of harvest, drumming grouse populations remained stable, suggesting that hunting season removals were within acceptable limits. In comparison, the recovery rate was 30% in Waushara and Marquette counties, where hunting seasons opened about 1 October and closed 31 December. In contrast, recovery rates were only 5% in 1976-78 in southwestern Wisconsin (Rodgers 1980). In Michigan, hunters removed an average of 30% (range 18-53%) of the estimated preseason population from 1950-56 with no apparent negative impact on breeding populations (Palmer and Bennett 1963). However, grouse populations were estimated by a strip census combined with a complete count of drummers on representative areas, and no banding was attempted.

TABLE 1. Ruffed grouse live-trapping effort on the Sandhill-Wood County study areas, 1978-82.

Year	Trapping Period	Avg. No Traps Set/Day	No. Trap Locations
1978	8 Sep - 9 Nov	19	29
1979	1 Aug - 31 Oct	23	65
1980	18 Jul - 9 Oct	25	73
1981	27 Jul - 1 Oct	32	84
1982	26 Jul - 11 Oct	35	82

TABLE 2. Ruffed grouse live-trapping success on the Sandhill-Wood County study areas, 1978-82.

Year	No. Trap-Days	No. Grouse Banded*	Total Captures	No. Trap-Days Per Grouse Banded	No. Trap-Days Per Capture
1978	1,197	91 (0)**	98	13.2	12.2
1979	2,033	323 (9)	414	6.3	4.9
1980	1,619	356 (21)	478	4.6	3.4
1981	2,140	350 (13)	468	6.1	4.6
1982	2,756	73 (1)	85	37.8	32.4
Average				8.2	6.3

* Includes 14 birds banded on the Sandhill hunted area after the hunting season began in 1978 and 9 banded birds which died during the same trapping period (2 in 1979, 4 in 1981, and 1 in 1982).

** Number of recaptures from previous year in parentheses.

TABLE 3. Hunting recovery of banded ruffed grouse on the Sandhill-Wood County study areas, 1978-82.

Year	No. Banded* Sandhill Hunted	No. Banded* Wood County	Recovery Rate (%) Sandhill Hunted	Recovery Rate (%) Wood County
1978	35	18	20	22
1979	121	49	33	22
1980	147	43	46	30
1981	142	115	54	33
1982	31	12	32	17
Average Percent ± SE			42 ± 5.9	29 ± 2.9

* Includes new birds and recaptures of birds banded previously.

Higher rates of recovery, particularly on Sandhill are due, in part, to accessibility of grouse habitat to hunters. More than 20 km of driveable roads (2.4 km/km^2 of grouse habitat) are distributed throughout the Sandhill hunted area (Fig. 3). In contrast, road access is considerably less on the Wood County area with 48 km of driveable roads (1.2 km/km^2 of grouse range). Although all banded birds were captured and subsequently released along driveable roads, it might have been expected that vulnerability of grouse, particularly juveniles, may have been offset by dispersal. However, the distribution of banded grouse recovered by hunters illustrates most banded birds were taken close to driveable roads.

Hunter recoveries of banded grouse indicated the proportion of birds recovered less than 400 m, 401-800 m, and more than 800 m from driveable roads were not different ($P>0.05$) on Sandhill (Table 4). In contrast, a greater than expected ($P<0.05$) proportion of banded birds were recovered within 400 m of driveable roads on the Wood County area, and a less than expected ($P<0.01$) proportion at more than 800 m from driveable roads. Recovery data for juveniles and adults were combined since they were not different ($P>0.05$) for either area. Of 268 banded birds shot on Sandhill, 261 (97%) were taken within 800 m of driveable roads compared to 96% of 106 birds shot on the Wood County area.

No sex or age-related difference ($P>0.05$) in recovery rates was detected, suggesting that all birds were equally vulnerable to hunters (Table 5). Rusch et al. (1984) also found juveniles were recovered at rates comparable to adults of the same sex on the Navarino and Wautoma study areas. In northern Wisconsin, Dorney and Kabat (1960) found recovery rates of juveniles of both sexes combined were 19% compared to 10% for adults. In addition, recovery rates of adult males were lower than juvenile males (9% vs. 25%), but their data included adult males banded in the spring. The authors suggested adult males may have been less accessible to hunters, many of whom hunted along roads. However, Rusch et al. (1984) found recovery rates of adult and juvenile males banded in summer were similar on their study areas.

ESTIMATED HARVEST RATES

An estimate of harvest rate is obtained by adjusting the band recovery rate for mortality of banded birds before the hunting season, unrecovered cripples, and lost or nonreported bands. In addition, movements of banded birds into the Sandhill unhunted area or other lands which are either closed to public hunting or inaccessible to hunters is a factor contributing to underestimating harvest rates.

Mean recovery rate on Sandhill was converted to an estimated mean harvest rate of 65% (range 31-83%) using a factor of 1.54.* In comparison, mean estimated harvest rate was 38% (range 28-48%) at Navarino (DeStefano 1982), where the factor used was also 1.54 (MSR = 77%, CR = 13%, BLR = 1%, NRR = 4%).

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*The conversion factor was determined using the formula: HR = RR (1 + CR) (1 + BLR) + (1+NRR) ÷ MSR where: HR = harvest rate, RR = recovery rate, CR = crippling rate (12%), BLR = band loss rate (about 1%), NRR = nonreporting rate (about 1%), and MSR = mean preseason survival rate (0.74 $\pm$ SE = 0.27) based on pooled estimates of average daily survival from 1979-81 mark-recapture data according to DeStefano (1982) and Seber (1973).

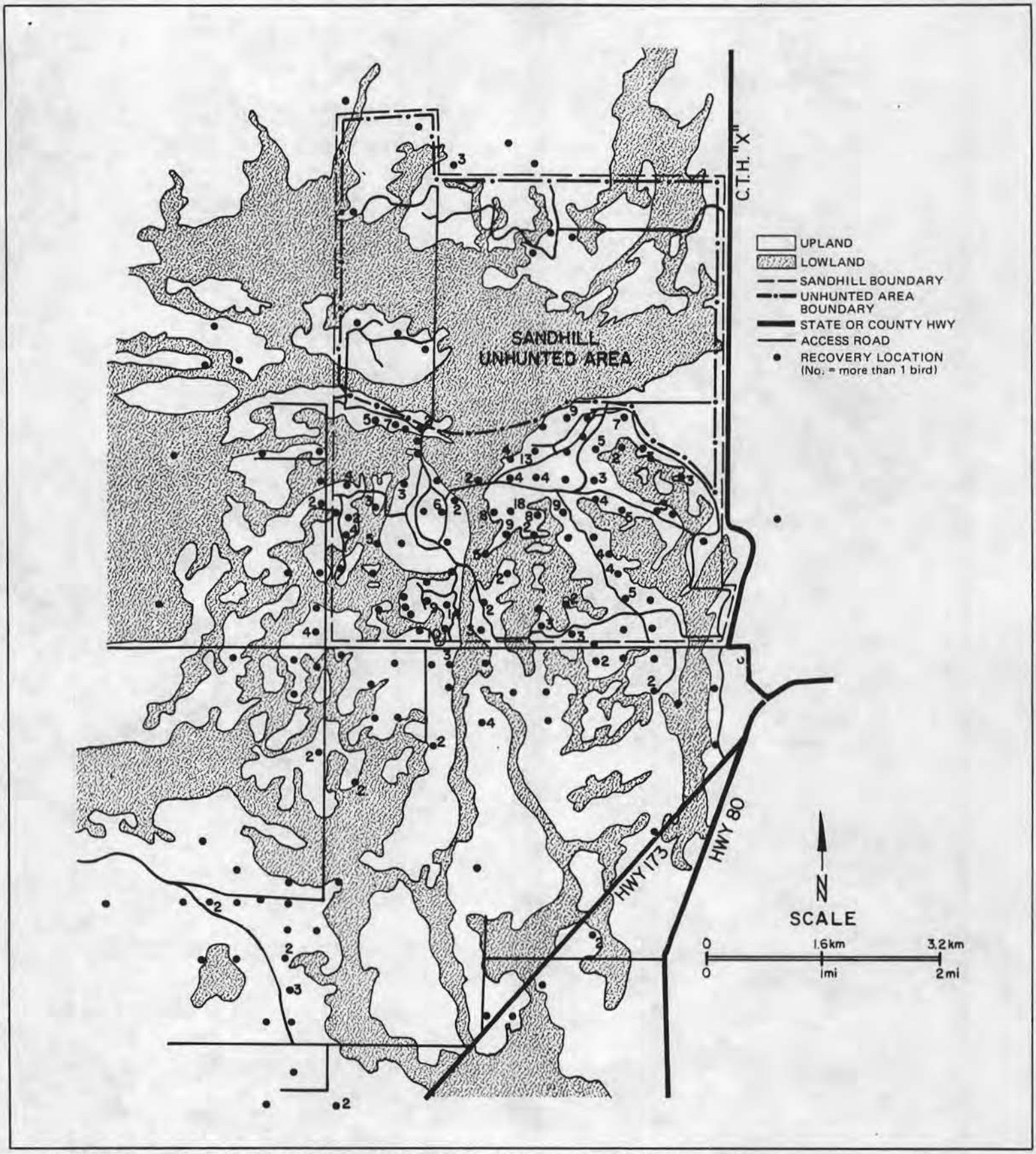

FIGURE 3. Distribution of banded grouse shot or found dead on the Sandhill-Wood County study areas, 1978-82. (Excludes 31 recoveries off map.)

TABLE 4. Hunting recovery of banded grouse relative to driveable roads on the Sandhill-Wood County study areas, 1978-82.

Area		Distance From Driveable Road (m) 400 or less	401-800	801+
Sandhill (268)*	Percent birds	83	14	3
	Percent of area	83	12	5
Wood County (106)	Percent birds	74	22	5
	Percent of area	43	30	27

* Number of birds recovered in parentheses.

TABLE 5. Recovery rates of sex-age classes of banded ruffed grouse subsequently shot and reported by hunters during the same year of banding on the Sandhill-Wood County study areas, 1978-82.

Sex and Age Classes	No. Banded	No. Shot	Recovery Rate (%)
Adult			
Male	45	20	44
Female	45	17	38
Total	90	37	41
Juvenile			
Male	304	138	45
Female	280	113	40
Unknown	22	3	14
Total	606	254	42

POPULATION CHARACTERISTICS AND PRODUCTIVITY

Sex and Age Ratios

The ratio of males to females was different ($P = 0.04$) between live-trapped and hunter-shot grouse (Table 6), but the sex ratio between juveniles and adults in live-trapped and hunter-shot grouse was not different ($P>0.05$) on our study areas. A greater ($P<0.05$) occurrence of males in live-trapped and females in hunter-shot birds was also observed. The juvenile:adult sex ratio was not different ($P>0.05$) and juveniles constituted 81% and 82% of live-trapped and hunter-shot birds, respectively. DeStefano (1982) found 90% juveniles in live-trapped grouse at Navarino and a sex ratio of 1.2 males/female in adults and 1.0 in juveniles. A somewhat higher ratio of 1.3 males/female among live-trapped juveniles was found in southwestern Wisconsin (Rodgers 1980). In an earlier study (Hale and Dorney 1963), juveniles comprised 72% of fall-shot grouse in central Wisconsin, and the sex ratio was 1.1 males/female among adults and 1.0 in juveniles.

TABLE 6. Sex and age composition of summer and fall trapped and hunter-shot ruffed grouse on the Sandhill-Wood County study areas, 1978-82.*

Male:Female Ratio				
Adult	Juveniles	All Birds	Juvenile: Adult Ratio	Percent Juveniles
Live-trapped				
1.3 (125/99)	1.0 (442/429)	1.1 (570/525)	4.3 (968/224)	81
Hunter-shot				
0.8 (51/60)	0.9 (223/248)	0.9 (274/308)	4.4 (494/111)	82

* Number of birds in parentheses.

Color Phase

Red, intermediate, and gray color phases constituted 51%, 42%, and 6%, respectively, of 1,142 live-trapped and hunter-shot grouse on our study areas (Table 7). This compares to 56% red phase grouse in southwestern Wisconsin (Rodgers 1980), 50% at Navarino (DeStefano 1982), 71% in Iowa (Porath and Vohs 1972, Little 1984) and 44% and 27-30%, respectively, in southeastern and northern Minnesota (Gullion 1984). In contrast, while only 6% of the birds were gray phase on our study areas, Gullion (1984) reported 10% in southeastern Minnesota and 25-28% in more northern latitudes. Occurrence of red color phase was greater ($P<0.05$) in females than males on our study areas. Rodgers (1980) reported similar results in southwestern Wisconsin. No difference ($P>0.05$) between the tail coloration of adult and juveniles was detected on our study areas.

TABLE 7. Color phase of live-trapped and hunter-shot grouse by sex and age on the Sandhill-Wood County study areas, 1978-82. (Samples were combined since proportions in the various categories were nearly identical.)

	Sex	No. Birds	Percent Red	Percent Intermediate	Percent Gray
Adult	Male	135	49	39	12
	Female	121	59	35	6
Juvenile	Male	436	47	44	9
	Female	450	55	43	2
All Birds		1,142	51	42	6

Weights

Mean weight of males was greater than females in both juveniles at 17+ weeks of age ($P<0.13\%$) and adults ($P<0.01$) (Figs. 4, 5). As expected, juvenile weights increased dramatically as birds developed between 7 and 17+ weeks of age, but adult weights also increased considerably from July to October. Mean weights of juveniles were similar until 12 weeks of age, after which time weights of juvenile males exceeded juvenile females through 17 weeks. At 17+ weeks (from early September-October) mean weight of juvenile males was 571 g compared to 519 g for juvenile females. Mean October weights for adult males and females were 646 g and 544 g, respectively.

Hatching Chronology

Eighty-one percent of 568 live-trapped juvenile grouse were hatched between 25 May and 7 June and 93% before 15 June (Fig. 6). In an earlier study at Sandhill (Kubisiak 1978), 74% of 134 broods observed on flushing surveys were estimated to have hatched before 15 June. Hale and Wendt (1951) found 90% of 69 broods were hatched before 16 June in northern Wisconsin. In southwestern Wisconsin 80% of 86 juveniles were estimated to have hatched between 12 and 24 May (Rodgers 1980).

Brood Size

Brood size based on captures of broods (1 or more chicks with or without a hen) was probably underestimated since single chicks constituted 60% of 314 captures between the earliest date of capture on 18 July and 6 September, the approximate date after which brood breakup begins (Fig. 7). After this date brood size was underestimated as brood breakup and dispersal commenced (Godfrey and Marshall 1969, DeStefano 1982). This phenomenon was verified further as 84% of 296 captures of broods between 7 September and 31 October (latest date captures were made) were single chicks. In contrast, DeStefano (1982) found the occurrence of single chicks accounted for only 22% of all captures before brood breakup (about 8 September) at the Navarino Wildlife Area in Shawano County. This increased to 59% of all captures after brood breakup began. Single, apparently unsucessful, adult hens without broods comprised a small proportion of the population since they constituted only 5% of the total captures of hens with 1 or more chicks, 1 or more chicks without

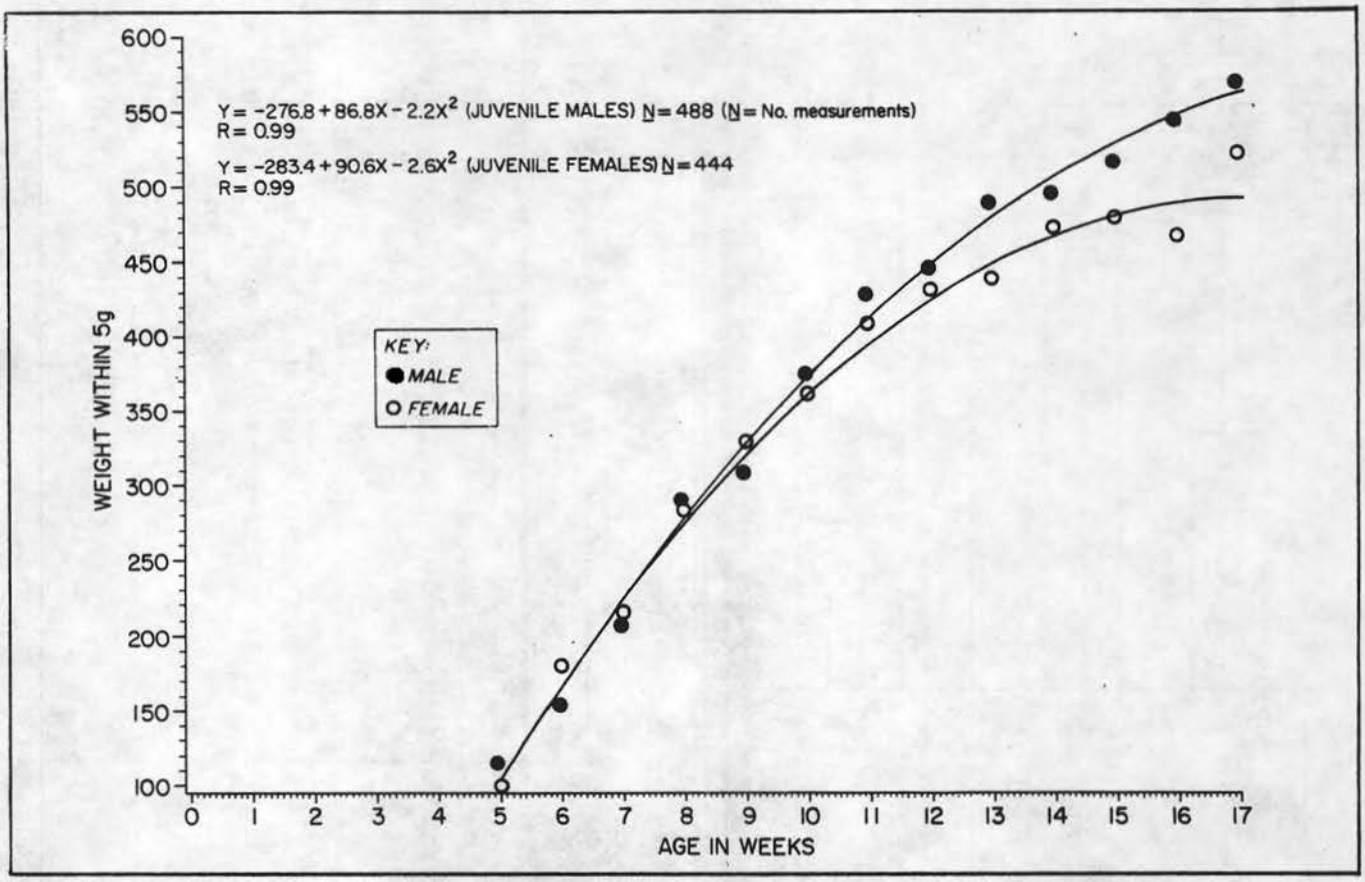

FIGURE 4. Weights of live-trapped juvenile grouse on the Sandhill-Wood County study areas, 1978-82.

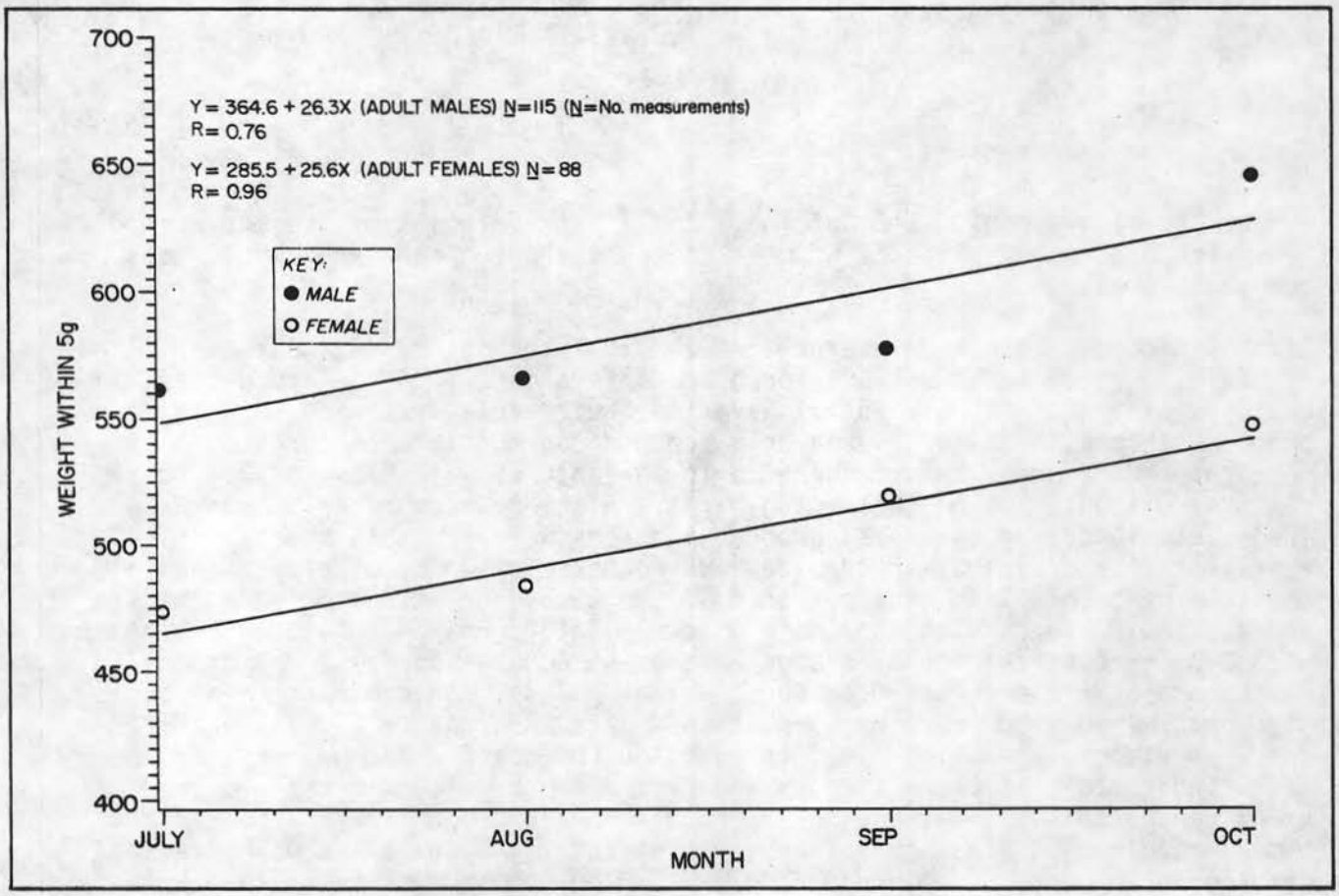

FIGURE 5. Weights of live-trapped adult grouse on the Sandhill-Wood County study areas, 1978-82.

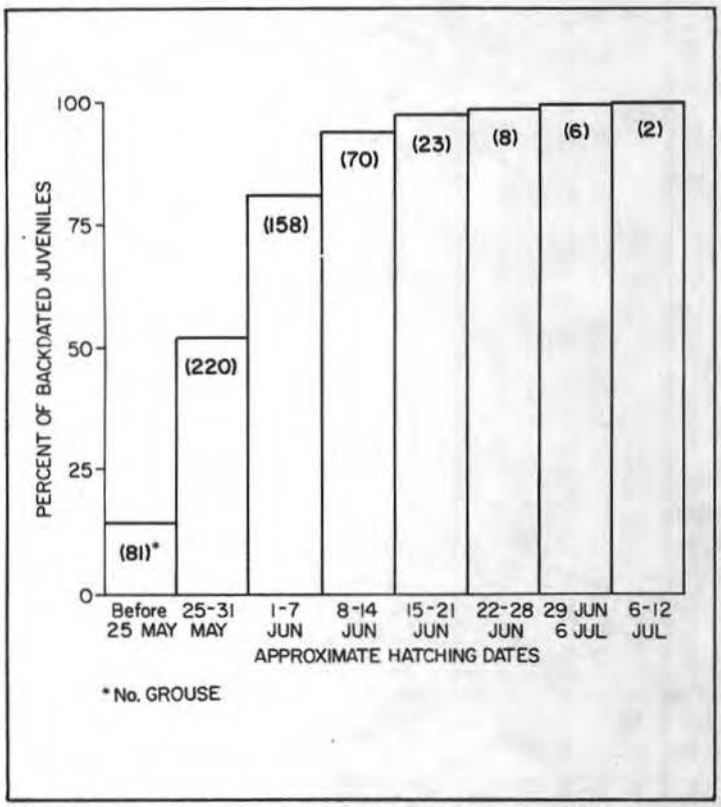

FIGURE 6. Approximate hatching dates of live-trapped grouse on the Sandhill-Wood County study areas, 1978-82.

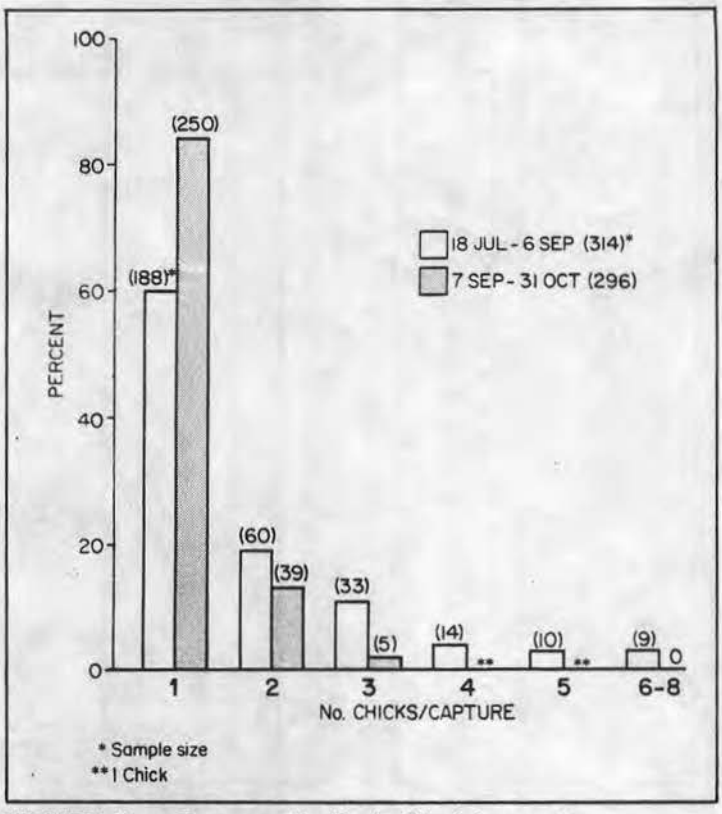

FIGURE 7. Seasonal distribution of captures of one or more grouse on the Sandhill-Wood County study areas, 1978-82.

a hen, and single hens. In addition, single hens were 13% of the captures of hens with 2 or more chicks, 2 or more chicks without a hen, and single hens on our study areas.

Size of broods with a hen were greater ($P<0.01$) than broods without hens (Table 8). Rusch et al. (1984) found no difference ($P>0.5$) in brood sizes in captures with and without hens at Navarino, but sample size was small in broods with hens, and their data only represented multiple captures of 2 or more chicks. Brood size averaged 3.5 in 10 captures with hens and 3.4 in 51 captures without hens on their study area. Since most captured broods were incomplete in our study areas, broods with hens were probably more representative of actual brood size. Using these data, brood size based on captures of broods with hens averaged 3.2 in 83 broods with 1 or more chicks and 4.2 in 18 broods with 2 or more chicks. This compares to 4.0 chicks/brood with 2 or more chicks for 31 broods in Shawano County and 4.1 for 8 broods in Waushara and Marquette counties (Rusch et al. 1984). In contrast, mean brood size determined from prevoiously published data (Rusch et al. 1984) was somewhat higher, averaging 4.9. In addition, broods flushed on our study areas indicated that brood size is underestimated by a considerable degree using conventional live-trapping techniques. Mean brood size was 6.1 in 214 broods recorded on flushing surveys or incidentally by wildlife work crews between 18 July and 6 September from 1952-82 on our study areas. In comparison, mean brood size was 7.4 in 703 broods flushed in July and August from 1950-57 in northern Wisconsin (Dorney and Kabat 1960).

TABLE 8. Brood size of live-trapped grouse on the Sandhill-Wood County study areas, 1978-82.

Season	Birds/brood with 1 or more chicks ± SE (no. broods) With Hen	Without Hen
18 Jul - 31 Jul	3.8 ± 0.8 (9)	1.8 ± 0.2 (51)
1 Aug - 6 Sep	2.9 ± 0.5 (17)	1.8 ± 0.1 (216)
Summer-long	3.2 ± 0.4 (26)	1.8 ± 0.1 (267)

Movements of Banded Grouse

Movements of banded grouse based on recaptures during the same or subsequent trapping period indicated juveniles were considerably more mobile than adults, but most birds (90%) were recaptured within 1,000 m of the banding site on our study areas (Table 9). Recaptures during trapping were treated separately since these data represent incomplete movements for most birds. Of 78 juveniles recaptured during the same trapping period, 88% were recovered within 1,000 m of the banding site, and all 20 adults were recovered within 500 m. Recaptures of banded grouse during subsequent trapping periods illustrated a similar pattern with 18 of 22 juveniles recaptured within 1,000 m and all 7 adults within 640 m of the banding site.

Movements of banded grouse recovered by hunters or found dead have provided additional evidence of the greater mobility of juveniles on our study areas (Table 10). Of 301 juveniles recovered in the same fall or following spring, 38% were recovered more than 1,000 m from the banding site compared to 9% of the adults. In addition, 22% of the juveniles were recovered more than 2,000 m from the banding site. Among juveniles, mean distance moved was greater ($P<0.01$) in females, suggesting they were more mobile. Maximum recovery distances were 11,600 m in 58 days for a juvenile female and 9,400 m in 83 days for a juvenile male. Similar results were observed in recoveries of grouse in subsequent years, except that more juveniles (61%) were recovered more than 1,000 m from the banding site. A similar pattern of juvenile mobility was observed by DeStefano (1982) at Navarino and Hale and Dorney (1963) in northern Wisconsin. At Navarino, mean capture-to-kill distances were 590 m for 9 adult males, 610 m for 5 adult females, 1,340 m for 80 juvenile males, and 2,290 m for 60 juvenile females. Maximum straight-line recovery distances were 8,000 m in 38 days for a juvenile female and 5,600 m in 147 days for a juvenile male. Forty-one percent of 150 juveniles banded in northern Wisconsin were recovered more than 800 m from the banding site in the same fall compared to 7% of 27 adults. Of the juveniles, 26% were recovered more than 1,600 m from the banding site, and 14% more than 3,200 m from the banding site.

Plotted recoveries of the various sex and age classes of banded grouse either shot or found dead more than 1,000 m from the banding site also illustrated that juveniles dispersed throughout the study areas (Figs. 8-10). Recoveries included 3 adult females and no adult males. However, direction of dispersal was not random ($P<0.01$) on our study areas (Table 11). But this result may be biased by those movements which are influenced by the configuration of habitat (continuous forest, large open marsh or water areas) which surrounded banding sites and also affected dispersal. Grouse dispersed through all habitats, and some movements occurred across large (greater than 1,000 m wide) open wetlands where birds could use ditch banks or other habitats suitable as temporary resting sites. Few recoveries were recorded on small upland islands surrounded by wetlands and other areas with suitable grouse habitat, but less accessible to hunters. In contrast, Gullion (pers. comm.) suggested that juvenile dispersal was random on the Mille Lacs Wildlife Area in Minnesota. Grouse movement did not appear to be influenced by hunting on this area -- that is, birds did not move from heavily hunted areas or to areas with populations depressed by hunting. Direction of dispersal occurred as expected ($X^2 = 3.016$; 3 df) but a circular distribution analysis was not performed. However, a large marsh (1,500 m wide) appeared to be an effective barrier to grouse movement and a small marsh (240-560 m wide) also appeared to restrict movement between uplands to some degree at Mille Lacs (Gullion, pers. comm.).

Mean recapture or recovery distances of juveniles increased substantially after 6 September on our study areas, suggesting the onset of dispersal. Mean distance moved averaged 202 m for 82 juvenile males and 140 m for 56 juvenile females recaptured from late July to 6 September. During this period, 65% of the juvenile males and 64% of the juvenile females were recovered within 200 m of the banding site. In contrast, recovery distances increased considerably after 6 September, averaging 1,108 for 194 recoveries of juvenile males and 1,602 m for 157 juvenile females. Only 6% of the juveniles were recovered within 200 m of the banding site after 6 September. DeStefano (1982) observed a similar phenomenon at Navarino where movements of juveniles increased considerably after initiation of dispersal (13 September). Mean recapture distance was 120 m prior to dispersal with 80% of the recaptures occurring in the same trap. Thereafter mean recapture distance increased to 540 m during dispersal.

From our data, it appeared that juvenile males began dispersing before juvenile hens, a pattern also observed by Gullion (1984) in Minnesota. The sex ratio of males to females among juveniles captured from 7 September to 23 September averaged 1.4 compared to 1.1 during the remainder of the trapping period until 7 October. Thereafter the ratio of males to females among juveniles was 0.6. In contrast, sex ratios of juvenile grouse were similar between 10 September and 7 October in southwestern Wisconsin (Rodgers 1980).

Survival

Few birds survived more than one year, and unless shot or found dead, the fate of banded birds was largely undetermined. On areas open to hunting, most banded birds did not survive beyond the first fall. Of 712 birds banded on areas open to hunting, 333 (47%) were recovered. Of these 291 were recovered the same year as banded. Another 32 were shot the following year, while 6 were taken in the third, and 2 in the fourth. Only 4 birds were recaptured the first year following banding and 2 the second year. Of 428 birds banded on the Sandhill unhunted area, only 55 (13%) were recovered. Only 22 were recaptured the following year and 7 the second year. Greatest longevity recorded in juveniles included a male banded in 1978 and recaptured in 1981. Greatest longevity recorded for adults included a male banded in 1979 and shot in 1982 and a female banded in 1979 and recaptured in 1981.

TABLE 9. Movements of banded ruffed grouse recaptured on the Sandhill-Wood County study areas, 1978-82.

Recaptures after 7 days within the same trapping period.

Sex-Age Class		Distance Moved (m)					
		Mean	(SE)	Range	0-1,000	1,001+	Total
Adult	Male	44	19	0-220	14	0	14
	Female	83	92	0-500	6	0	6
Juvenile	Male	556	123	0-3,640	36	7	43
	Female	302	193	0-3,500	29	2	31
	Unknown	200	91	0-440	4	0	4
Total					89	9	98

Recaptures in trapping period of subsequent year.

Sex-Age Class		Distance Moved (m)					
		Mean	(SE)	Range	0-1,000	1,001+	Total
Adult	Male	60	60	0-300	5	0	5
	Female	320	320	0-640	2	0	2
Juvenile	Male	480	178	0-1,400	8	3	11
	Female	489	216	0-2,000	10	1	11
Total					25	4	29

TABLE 10. Movements of banded ruffed grouse recovered by hunters or found dead on the Sandhill Wood County study areas, 1978-82.

Recoveries in the same fall or following spring.

Sex-Age Class		Distance Moved (m)							
		Mean	(SE)	Range	0-1,000	1,001-2,000	2,001-3,000	3,000+	Total
Adult	Male	349	42	200-800	23	--	--	--	23
	Female	595	101	200-1,400	17	4	--	--	21
Juvenile	Male	1,238	120	200-9,400	105	23	17	13	158
	Female	1,744	215	200-11,600	82	23	5	24	134
	Unknown	2,888	776	200-6,400	3	0	2	4	9
Total					230	50	24	41	345

Recoveries in subsequent year.

Sex-Age Class		Distance Moved (m)							
		Mean	(SE)	Range	0-1,000	1,001-2,000	2,001-3,000	3,000+	Total
Adult	Male	362	92	200-900	8	0	0	0	8
	Female	629	163	200-1,200	7	2	0	0	9
Juvenile	Male	1,550	325	200-6,000	12	6	3	2	23
	Female	3,429	810	400-13,000	2	4	3	6	15
Total					29	12	6	8	55

TABLE 11. Direction of dispersal of juvenile grouse on the Sandhill-Wood County study areas, 1978-82.

Recovery Distance	No. Birds/Quadrant				
	Northeast (1-90)	Southeast (91-180)	Southwest (181-270)	Northwest (271-360)	Mean Angle (degrees)
Over 400 m (247)*	43	68	74	62	141
Over 600 m (215)	36	60	66	53	148

* Number of birds.

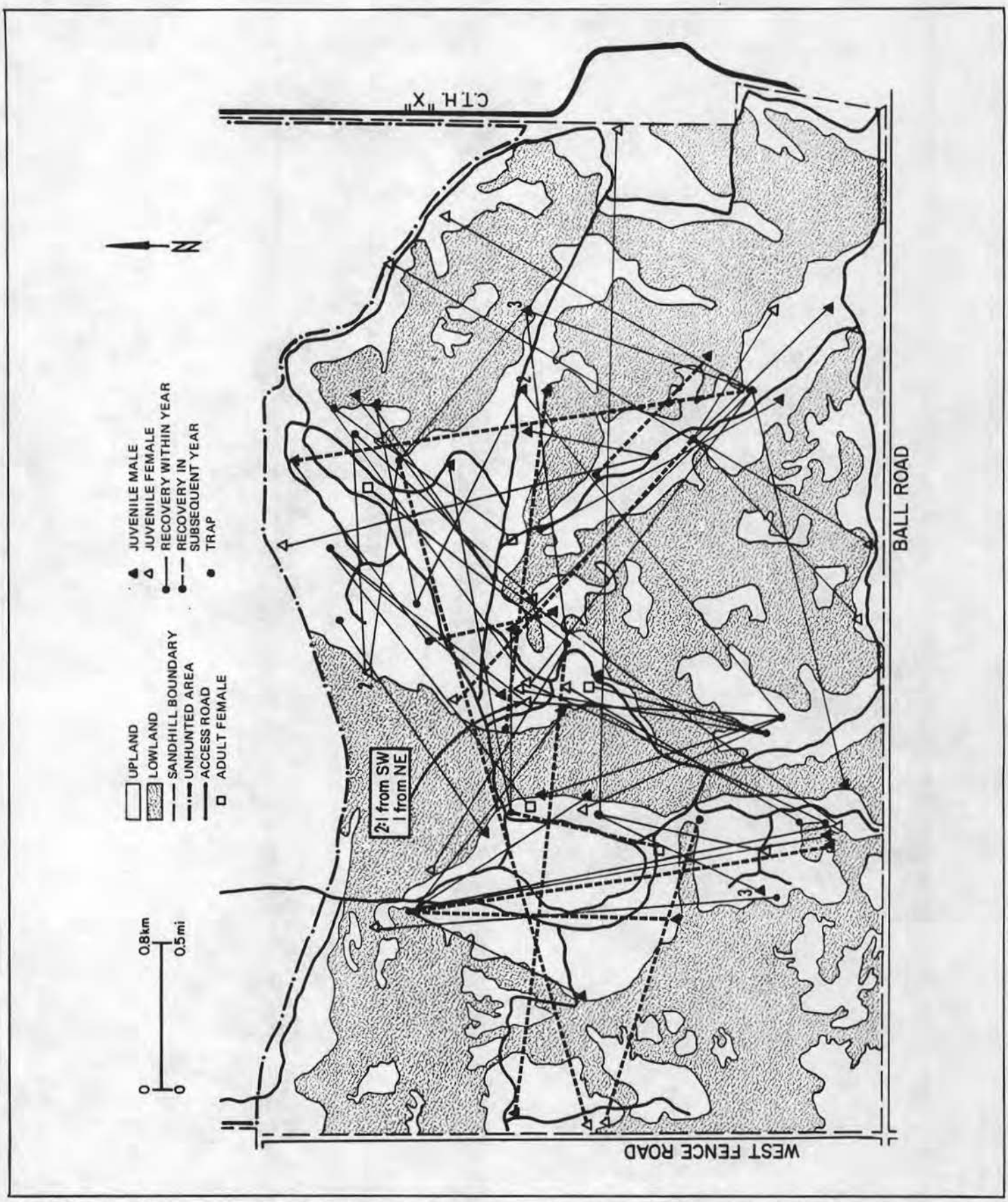

FIGURE 8. Distribution of banded grouse shot or found dead more than 1,000 m from the banding site on the Sandhill hunted area, 1978-82.

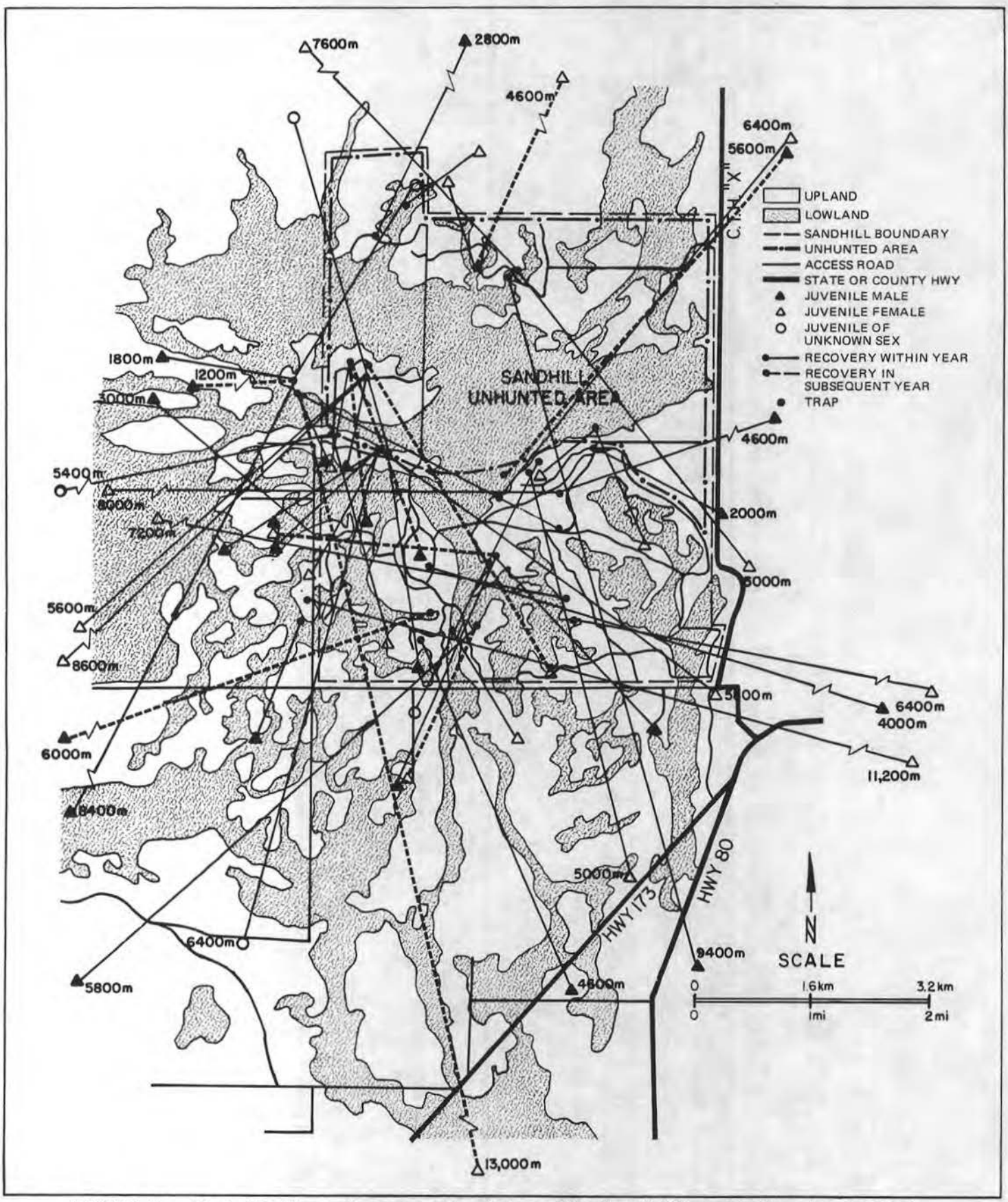

FIGURE 9. Distribution of grouse banded on the Sandhill hunted and unhunted areas and shot or found dead more than 1,000 m from where trapped, 1978-82.

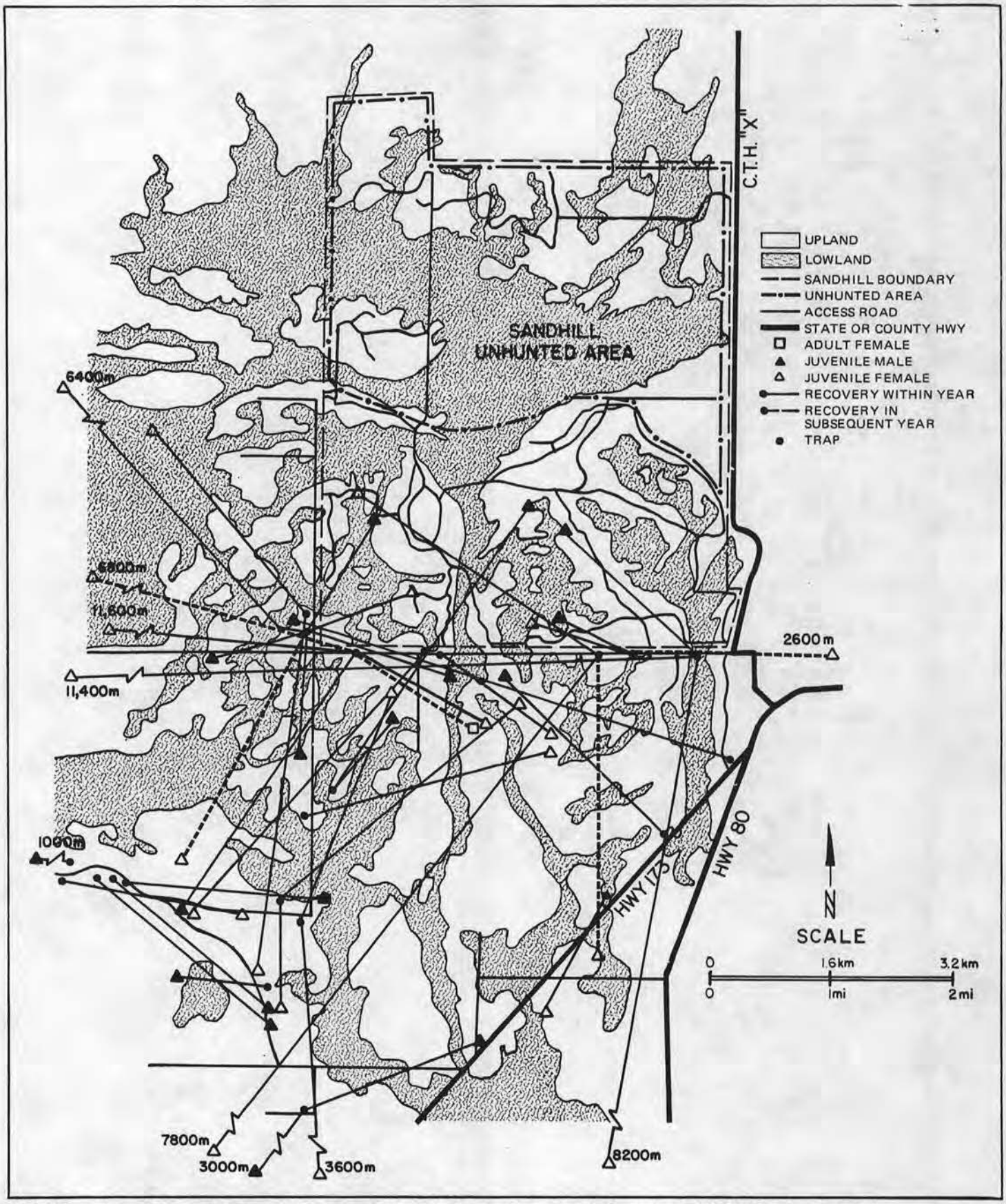

FIGURE 10. Distribution of grouse banded on the Wood County Wildlife Area and shot or found dead more than 1,000 m from where trapped, 1978-82.

SUMMARY AND MANAGEMENT CONSIDERATIONS

Mean recovery rates of banded grouse were 42% (range 20-54%) on Sandhill and were higher in most years than any reported in the literature. Highest recovery rates occurred in 1980 and 1981, averaging 46% and 54%, respectively. These high rates coincided with high grouse harvests and reduced or declining breeding populations. These recovery rates translate to an estimated harvest rate of 65% (range 31-83%) after allowing for mortality of banded birds before the hunting season, unrecovered cripples, and lost or nonreported bands. This study suggests that hunting mortality on Sandhill may be a major factor depressing grouse populations, but perhaps Sandhill is an exception to the general pattern observed in most of Wisconsin. It should be emphasized these results occurred on an area with excellent road access, exceptionally high hunter effort, high harvests sustained over several years, and a high proportion of hunters using dogs, particularly since 1980 (Kubisiak 1984).

Generally band recovery rates from other studies in Wisconsin are considerably below the level observed at Sandhill. Recovery rates from other areas were 29% (range 17-33%) on the Wood County Wildlife Area during 1978-82, 30% in Waushara and Marquette counties in 1982, 23% (range 18-31%) during 1978-81 at Navarino in Shawano County, and only 5% during 1976-78 in southwestern Wisconsin. This study also illustrated that nearly all banded birds were taken within 800 m of driveable roads, suggesting that most grouse hunting effort and success is similarly oriented. Juveniles were more mobile than adults and most birds were recovered within 2,000 m of the banding site. Although juvenile dispersal was not random ($P<0.01$), recoveries occurred throughout the study areas. Recovery data suggest little hunting occurred more than 800 m from driveable roads on the Wood County Wildlife Area, and therefore harvest rates may be lower in these areas. Juveniles comprised more than 80% of the population and few birds survived more than one year, providing further evidence for cropping the annual surplus by hunting. The fate of most banded birds was undetermined unless shot or found dead.

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CONVERSIONS

1 m = 3.280 ft
20 m = 1 chain
1 km = 0.621 mile

ACKNOWLEDGMENTS

We gratefully acknowledge the cooperation and contributions of many individuals during the course of this study. Special thanks are due W. Creed and K. McCaffery of the Forest Wildlife Research Group for their advice and technical assistance throughout the study and preparation of this report. C. Kabat and K. Klepinger, former and present Research Bureau Directors, J. Hale and J. March, former Chiefs of the Wildlife Research Section, R. Dumke, Chief of the Wildlife Research Section, and J. Haug, former Superintendent of the Sandhill-Meadow Valley Work Unit, gave administrative assistance or support in the field. L. Keith and D. Rusch of the University of Wisconsin-Madison also provided technical advice. T. Moser, P. Ruesch, B. Knudsen, S. Kendall, J. Bronsdon, M. Zeckmeister, J. Morton, K. Brockman, D. Dessecker, and members of the Sandhill Young Adult Conservation Corps assisted with field work or data analysis. D. Thompson, E. Lange, M. Staggs, and A. Lima provided statistical interpretations.

This research was supported in part by funds from the Federal Aid in Wildlife Restoration Act under Pittman-Robertson Project W-141-R. This report represents a Final Report for Study 221.

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