MONTANA STATE UNIVERSITY

The ecology of the greater prairie chicken as related to reintroductions
by John Edward Toepfer

A thesis submitted in partial fulfillment of the requirements for the degree o f Doctor of Philosophy in Biological Sciences
Montana State University
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Abstract:
This study was initiated in 1972 to examine nesting and brood rearing ecology of the prairie chicken in central Wisconsin. The study was expanded to include movements and habitat use of resident and transplanted birds and to evaluate pen-reared and transplanted wild birds in reestablishing a population in northwestern Wisconsin. Mean weights and breast circumferences of pen-reared birds were significantly less than those of wild birds. A total of 223 pen-reared and 60 wild prairie chickens were released from 1974-77 and 55 pen-reared, 29 transplants and 54 resident birds were radio-tagged. Ninety percent of the radio-tagged pen-reared birds were dead within a month. Over 80% of the losses of radio-tagged birds were attributed to predation. Pen-reared birds were more susceptible to mammalian predation than wild birds. Annual survival of wild, transplanted and pen-reared birds was 48%, 24% and 0.5% respectively. Pen-reared birds were more observable and attracted more raptors than wild birds. Flushing distances of pen-reared birds were half those of wild birds. Pen-reared birds remained within 2 km of their release sites and their movements were most like those of wild birds during summer. Movements of transplanted birds during April were characterized by an orientation period of 0-55 days when individuals made large wandering moves that at times exceeded 16 km. Daily movements and ranges of transplants were 2-20 times larger than those of resident birds. However, movements of birds transplanted in August were comparable to those of resident birds. Habitat analysis indicated that praire chicken habitat was a mix of undisturbed, disturbed grassland and agriculture. The critical habitat component was grass or grass forbs cover in the 25-100 cm height range that was used for nesting, roosting and brood rearing. Agriculture was used for feeding. Habitat information is presented on an annual, seasonal and weekly basis by day and night for two areas.

Additional information is presented on flocking, the relationship to the booming ground, nest, weight dynamics, seasonal survival, effects of removal on local populations, costs, survival and behavior inside the pen. Recommendations are given with regard to future reintroductions and habitat management.

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of a thesis submitted by

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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John Edward Toepfer was born on September 7, 1948 in Sheboygan, Wisconsin. He enrolled at Wisconsin State University at Stevens Point in September 1966 and received his Bachelor of Science degree in Wildlife Management in June 1970. He entered the University of Wisconsin at Stevens Point in August 1971 and received a Masters of Science in Natural Resources-- Wildlife in May 1976. He was employed as a field researcher by the University of Wisconsin Stevens Point from September 1975 through April 1978. From May 1978 to March 1980 he was employed as a Fish and Wildlife Biologist by the Delaware Division of Fish and Wildlife. He began studies towards a Doctor of Philosophy degree in Fish and Wildlife Management in March 1980.

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ABSTRACT

This study was initiated in 1972 to examine nesting and brood rearing ecology of the prairie chicken in central Wisconsin. The study was expanded to include movements and habitat use of resident and transplanted birds and to evaluate pen-reared and transplanted wild birds in reestablishing a population in northwestern Wisconsin. Mean weights and breast circumferences of pen-reared birds were significantly less than those of wild birds. A total of 223 pen-reared and 60 wild prairie chickens were released from 1974-77 and 55 pen-reared, 29 transplants and 54 resident birds were radio-tagged. Ninety percent of the radio-tagged pen-reared birds were dead within a month. Over 80% of the losses of radio-tagged birds were attributed to predation. Pen-reared birds were more susceptible to mammalian predation than wild birds. Annual survival of wild, transplanted and pen-reared birds was 48%, 24% and 0.5% respectively. Pen-reared birds were more observable and attracted more raptors than wild birds. Flushing distances of pen-reared birds were half those of wild birds. Pen-reared birds remained within 2 km of their release sites and their movements were most like those of wild birds during summer. Movements of transplanted birds during April were characterized by an orientation period of 0-55 days when individuals made large wandering moves that at times exceeded 16 km. Daily movements and ranges of transplants were 2-20 times larger than those of resident birds. However, movements of birds transplanted in August were comparable to those of resident birds. Habitat analysis indicated that prairie chicken habitat was a mix of undisturbed, disturbed grassland and agriculture. The critical habitat component was grass or grass forbs cover in the 25-100 cm height range that was used for nesting, roosting and brood rearing. Agriculture was used for feeding. Habitat information is presented on an annual, seasonal and weekly basis by day and night for two areas. Additional information is presented on flocking, the relationship to the booming ground, nest, weight dynamics, seasonal survival, effects of removal on local populations, costs, survival and behavior inside the pen. Recommendations are given with regard to future reintroductions and habitat management.

INTRODUCTION

The introduction of wild-trapped and pen-reared birds to establish populations into vacant habitat is a common wildlife management practice. Most of these efforts have been unsuccessful and costly in terms of money, manpower and wildlife resources. In addition to being characterized by limited success, such efforts have been poorly documented and have provided limited information on the behavior, movements and fates of released individuals. The information that is available has been based on casual observations and/or band or tag recoveries that are usually received a considerable length of time after the release.

Lewis et al. (1962) indicated that minimal movement from the release site was the key to a successful transplant. However, movements and survival of released birds may vary within and between species and may depend upon whether the birds were pen-reared or wild trapped. Previous studies have indicated that transplanted wild birds frequently wandered and made large movements away from the release site (Grange 1948, ptarmigan [Lagopus lagopus]; Hamerstrom and Hamerstrom 1951, Farmes 1955; Ammann 1957, sharp-tailed grouse [Tympanuchus phasianellus]; Patterson 1952, sage grouse [Centrocercus urophasianus]; Jacobs 1959, greater prairie chickens,

[Tympanuchus cupido pinnatus]; and Southern 1970, herring gulls [Larus argentatus]).

Other studies have found that most pen-reared or relatively non-mobile species such as flightless waterfowl generally stay near the release site (Frye 1942, Baumgartner 1944, Buechner 1950, bobwhite quail [Colinus virginianus]; Ammann and Palmer 1958, Lewis et al. 1968, White and Dimmick 1979, ruffed grouse [Bonasa umbellus]; Proud 1969, Little and Varland, 1981, turkey [Meleagris gallopavo]; Williams and Kalmbach 1943, Schladweiler and Tester 1972, immature waterfowl; Leopold et al. 1938, MacNamara and Kozicky 1949, Roby 1951, Burger 1964, Hessler et al. 1970, Hartman 1974, and Myers 1971 ring-necked pheasant [Phasianus cholchicus]. None of the above studies compared the behavior, survival and movements of pen-reared and wild birds released in the same area at the same time. Krauss et al. (1987) and Roseberry et al. (1987) more recently have compared survival and general behavior of wild and pen-reared pheasants and quail released in the same area.

Over the past 125 years, efforts to re-establish the prairie chicken and heath hen [Tympanuchus cupido cupido] have met with little or no success (Gross 1928, Phillips 1928 and Kruse 1973). Jacobs (1959) indicated that in Oklahoma dispersal from release sites was a major problem with prairie chickens transplanted during the winter and

spring. Because adequate numbers of prairie chickens were not readily available to overcome this dispersal problem, Kruse (1973) recommended the release of large numbers of pen-reared birds.

Toepfer (1976) showed that radio-tagged cock prairie chickens transplanted in April did move away from their release sites, and that they made daily moves that were 2.5 times greater than those of residents. However, daily movements of radio-tagged hens transplanted in April and a cock in August during the wing molt were similar to those of radio-tagged resident birds in the same study area. As a result of that study, a 2-step approach was recommended to re-establishing prairie chickens; transplant cocks in the summer and release hens the following spring.

The purpose of this study was to develop and evaluate procedures for re-establishing a greater prairie chicken population in vacant habitat of northwestern Wisconsin on the Crex Meadows Wildlife Area through the use of pen-reared and wild birds. Wild and pen-reared prairie chickens were radio-tagged and monitored during the period October 1974-July 1978. The prairie grouse populations in the area were censused from 1975 through 1987. Data collected 1972-76 on resident radio-tagged greater prairie chickens in central Wisconsin, were used to describe the general ecology of the prairie chicken in order to make comparisons among wild resident birds, wild transplants

and pen-reared prairie chickens.

The objectives of this dissertation were to compile in sections new and existing information on resident wild prairie chickens and relate it to the ecology of pen-reared and transplanted birds. Many of these sections can stand alone as treatments of the subject matter and as a result some duplication between sections was necessary. At times methods specific to a section have been included in the discussion to aid the reader.

STUDY AREAS

Data for this study were collected from 3 separate areas (Fig. 1): central Wisconsin provided information on resident prairie chickens 1972-76; prairie chickens transplanted in 1977 were captured on or near booming grounds located in western Minnesota; and information on pen-reared and transplanted wild birds was collected on and in the vicinity of Crex Meadows Wildlife Management Area located in northwestern Wisconsin.

Central Wisconsin

The Portage County Management Area and the adjacent Plainfield Area are located approximately 13 and 35 km respectively south of Stevens Point. These areas have been described in detail by Hamerstrom et al. (1957) and Hamerstrom and Hamerstrom (1973). The Portage County Area, the main study area for resident prairie chickens contained 18,616 ha, 23.5% of which was grassland habitat privately purchased and managed for prairie chickens by the Wisconsin Department of Natural Resources (Fig. 2). The terrain is level and sectioned into a checkerboard fashion by dirt roads and drainage ditches. Management practices included grazing and mowing after 1 August, chemical and mechanical brush control and the planting of food patches consisting of

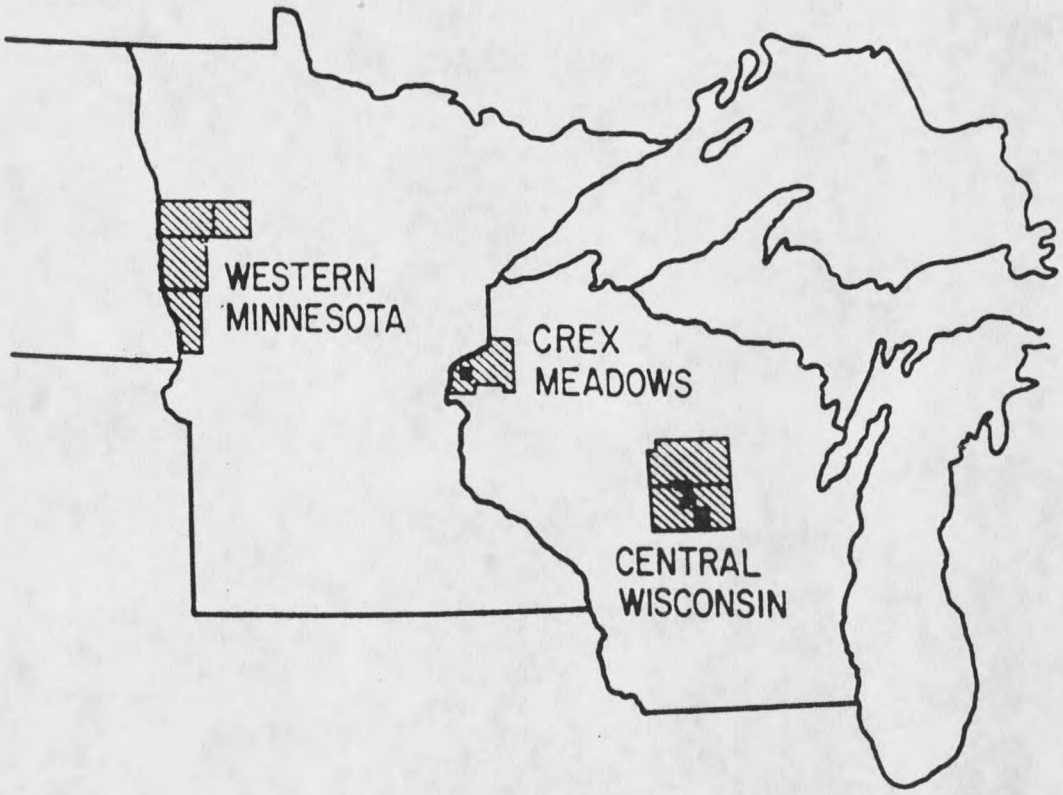


Figure 1. Location of Central Wisconsin, Crex Meadows Wildlife Management Area and Western Minnesota study areas.

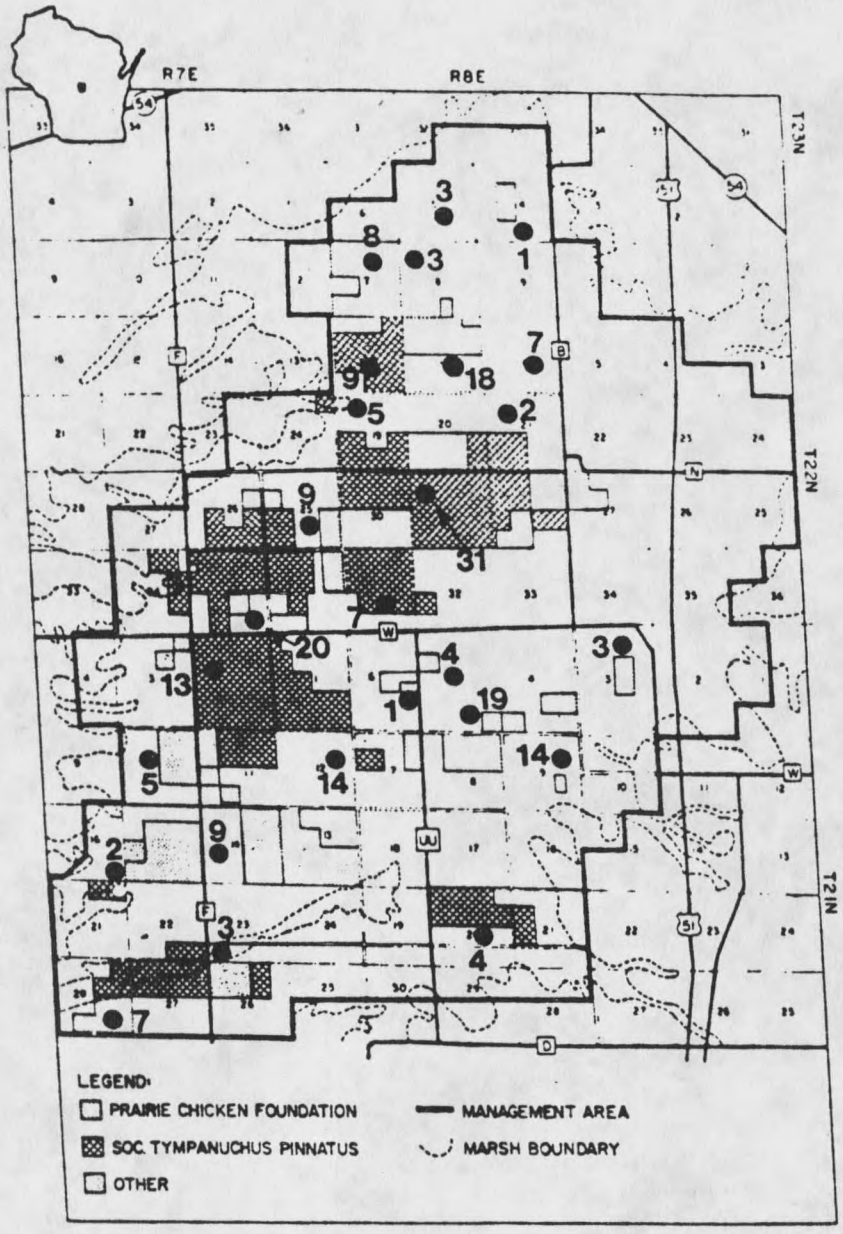


Figure 2. Distribution of grassland reserves and booming grounds with number of cocks, Portage County Management Area (central Wisconsin), 1972. (Taken from Hamerstrom and Hamerstrom, 1973).

buckwheat (Fagopyrum esculentum) and corn (Zea mays) to provide fall and winter food. Elevated wooden platforms, 1.5 m in height, contained cob corn in winter and provided emergency food in case the corn food patches failed or were destroyed by feeding deer.

During the study period 1972-76, private land was used primarily for beef production along with the cultivation of hay, small grains, corn, some mint (Mentha sp.) and potatoes (Solanum tuberosum). General habitat types consisted of 58% grassland, 17% cropland and 25% woodland, brush and wetlands. Dominant grass species were quackgrass (Agropyron repens), bluegrass (Poa pratensis) and timothy (Phleum pratense). Dominant forbs were: goldenrod (Solidago spp.), butter and eggs (Linaria vulgaris), and strawberry (Fragaria spp.). Willow (Salix spp.), meadowsweet (Spirea spp.), aspen (Populus spp.) and oak (Quercus spp.) were the dominant woody species.

A 1971 cover type map of this study area, the distribution of grass reserves and census information during 1950-72 were presented by Hamerstrom and Hamerstrom (1973). Since 1972 the prairie chicken population on the area has ranged from a low of 126 cocks on 21 booming grounds in 1974 to a high of 550 cocks on 41 booming grounds in 1981 (R. K. Anderson pers. comm.).

Northwestern Wisconsin

The Crex Meadows Wildlife Management Area (Crex), owned and managed by the Wisconsin Department of Natural Resources, is located 1.6 km north of Grantsburg in western Burnett county Wisconsin. The Crex Management Area of 10,820 ha contained a centrally located 4.3 X 2.3 km refuge (Fig. 3). The terrain is level to gently rolling. The 970 ha refuge contained 240 ha of marsh, 320 ha open water, 280 ha upland brush prairie and 3 agricultural areas totaling 110 ha. The 3 cropland areas consisted of alternating, 10 m wide strips of corn, buckwheat and rye. The refuge and immediate area contained at maximum 445 ha of open treeless grass habitat during a year with normal precipitation.

The entire management area contained approximately 1,599 ha (14.7%) of brush prairie, 848 ha (7.8%) of prairie grassland and 3,480 ha (32%) of oak-pine-aspen forest, lowland brush, roads and dikes (Fig. 3). Most of the open areas consisted of open water (1,102 ha, 10.1%) and wetland marsh areas (3,745 ha, 34.3%). Marsh areas were dominated by blue-joint (*Calamagrostis canadensis*) and sedges (*Carex* spp. and *Scirpus* spp.). Dominant upland species were big bluestem (*Andropogon gerardi*), little bluestem (*Andropogon scoparius*), puccoon (*Lithospermum canescens*), phlox (*Phlox pilosa*), blazing star (*Liatris* spp.), sunflower (*Helianthus rigidus*), lupine (*Lupinus perennis*), oak brush (*Quercus ellipsoidalis*), hazelbrush

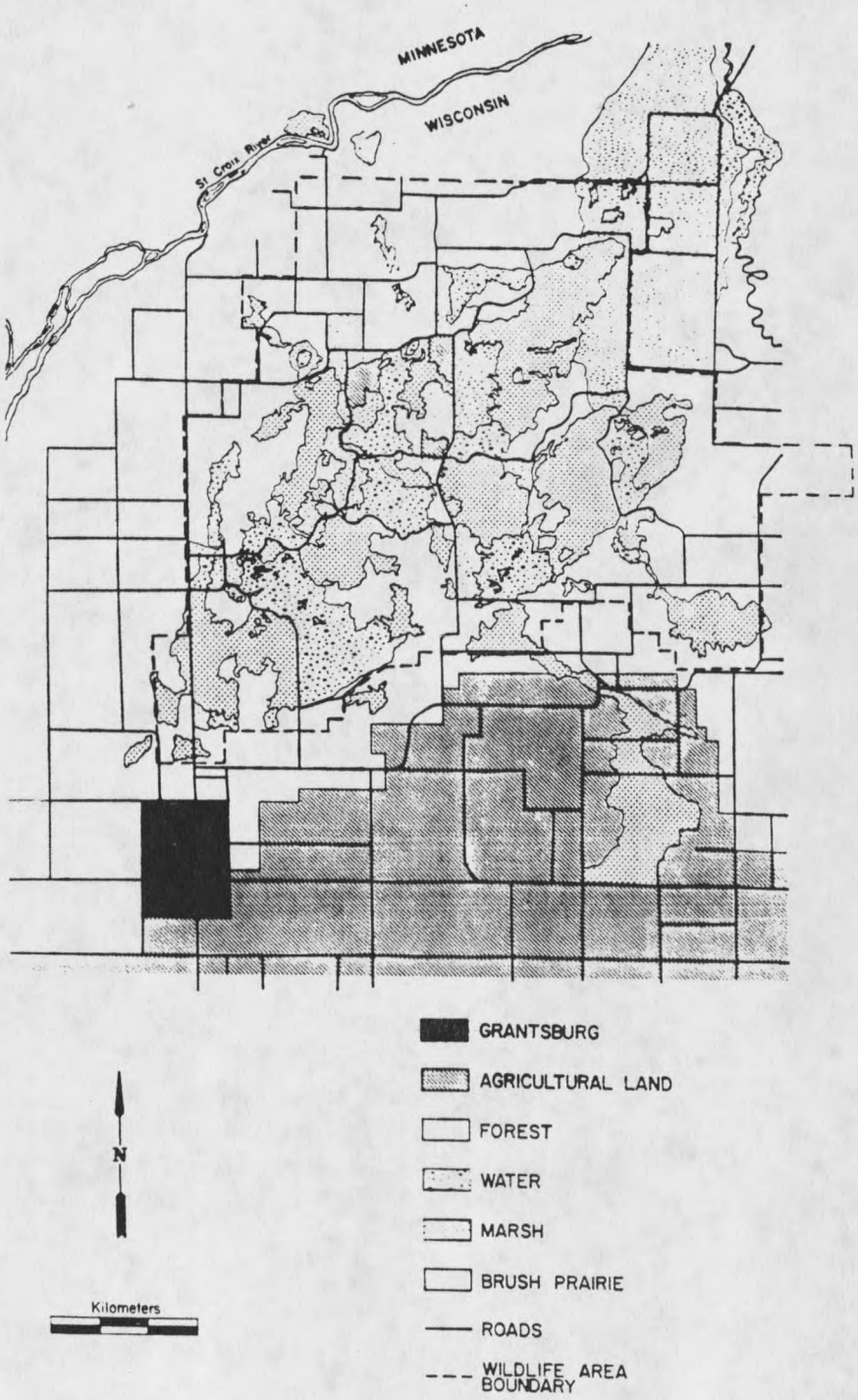


Figure 3. General cover map of Crex Meadows Wildlife Management Area, Wisconsin.

(Corylus americana) and sweet fern (Comptonia peregrina). Upland habitat has been described in greater detail by Vogl (1964) and Beck and Vogl (1972), and characterized as a brush prairie. Most of the upland area surrounding Crex consisted of mixed forests of oak, jackpine (Pinus banksiana) and aspen (Populus spp.). Private agricultural lands near the study area were planted to corn, rye, oats, soybeans (Glycine max) and alfalfa.

The primary management objective of the Crex Wildlife Management Area was to restore and maintain, through clearing and controlled burning, marsh and prairie habitat for waterfowl and prairie grouse. Three wooden platform feeders, 2 m high, were located in the refuge to supplement winter food for prairie grouse. These feeders were provided to offset the loss of standing corn to fall concentrations of feeding waterfowl and deer.

Historically, the greater prairie chicken and sharp-tailed grouse were plentiful in the Crex area during the early 1900's. Gross (1932) estimated that there were at least 1,000 prairie chickens and 4,000 sharptails in Burnett county in 1929. However, the loss of grasslands to changing landuse practices, natural succession and afforestation caused prairie chicken and sharptail numbers and distribution to decline. The sharptail population at Crex declined to less than 10 birds in 1947 and the last prairie chicken observed was a single bird in March 1947 by

N. R. Stone. The last prairie chicken sighted in Burnett county was another single bird, observed 11 km south of Crex in January 1948 (N. R. Stone, pers. comm.). Today the prairie chicken is a threatened species in Wisconsin (Hine, 1974a) and the sharptail, while still a game species exists in scattered remnant populations associated with wildlife management areas (Vanderschaegen 1977).

Western Minnesota

The Minnesota study areas were located in Mahnomen, Clay, Norman and Wilken counties in western Minnesota (Oney 1974). The area was primarily agricultural land with corn and sunflowers being the main crops. Svedarsky and Wolfe (1980) reported that this area contains at least 20,737 ha of scattered grassland tracts (average size 134 ha) owned and managed by The Nature Conservancy (2,729 ha), Minnesota Department of Natural Resources (13,107 ha), and U. S. Fish and Wildlife Service (4,901 ha, primarily Waterfowl Production Areas). The prairie chicken population in this region ranged from a low of 628 cocks on 57 booming grounds in 1975 to a high of 684 cocks on 57 booming grounds in 1976, (T. Wolfe pers. comm.).

METHODS

Source of Birds

Because prairie chickens of varying degrees of "wildness" were used in this study the following definitions are presented: (1) pen-reared bird--hatched and raised in a pen, (2) resident prairie chicken--a natural resident of the central Wisconsin study areas, (3) Crex resident--transplant that established at Crex Meadows, (4) Minnesota transplant--trapped in western Minnesota and transplanted to Crex, (5) Wisconsin transplant--trapped in central Wisconsin and transplanted to Crex and (6) semi-wild--wild bird held in a pen for at least 4 months.

Pen-reared greater prairie chickens, 8-15 weeks old (207 in September 1974 and 249 in 1975) were made available by Arnold Kruse, U. S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center, Jamestown, North Dakota. These birds were produced from matings between wild South Dakota cocks and pen-reared hens which had resulted from earlier matings of wild birds from Nebraska, North Dakota and Minnesota. In 1975, 47 of the 249 birds sent to Crex were the offspring of penned wild South Dakota hens and cocks. The birds from Jamestown were transported by truck at night in cardboard boxes (56 X 46 X 13 cm), 1 per

compartment, 4 to a box. The birds were examined, banded and released into the holding pen the following morning.

In addition to the pen-reared immatures, 14 adult pen-reared birds (1 cock, 13 hens) and 9 semi-wild Wisconsin birds (1 cock, 8 hens) used for egg production at Jamestown in 1975 were returned to Crex in August. These 9 semi-wild birds were the remnants of 15 wild birds (5 cocks, 10 hens) trapped in central Wisconsin in March 1975.

Wild prairie chickens for transplanting were captured on booming grounds containing 10 or more cocks in central Wisconsin in 1976 and in western Minnesota in April 1977. Trapping was accomplished with rocketnets and bownets baited with corn and hen decoys (Anderson and Hamerstrom 1967). No more than 4 hens and 5 cocks were removed from any one booming ground.

In April 1977, 18 cocks were radio-tagged and released in place in western Minnesota, so 10 could be recaptured by nightlighting and transplanted in mid-June or during wing molt in August. All wild birds were transported the 400 km to Crex in cardboard boxes, 1 bird per box and were released at Crex within 12-24 hours of their capture.

Condition and Measurements

Most of the pen-reared and wild prairie chickens were weighed, measured and examined for injuries and missing or broken flight feathers. The pen-reared birds were processed upon arrival in the fall and again approximately

3 weeks before their release in the spring. Weights were taken using a dial-o-gram scale and were recorded to the nearest 0.1 g. Measurements included: tail length, pinnae length, breast circumference (live and dead birds) middle toe, bent tarsus, and total length (dead birds). Breast circumferences were measured by holding the bird upside down by the legs and placing a 30 cm length of monofilament with a bowline knot at each end around the breast perpendicular to and approximately 1 cm below the tip of the sternum. The monofilament was stretched taught with a spring scale to a tension of 2 kg, cut and the length measured. Precision of breast circumference measurements was 2.3+2.1 mm (n=74) and maximum error was plus 7 mm or less than 3% of the total length. All measurements were taken by the author.

Condition of the flight feathers (primaries and secondaries) of each bird was classified using the following criteria: Excellent, all of the flight feathers present; Good, only 1 primary and/or a secondary missing or broken on 1 or both wings; Fair, 2 primaries or secondaries missing or broken on 1 or both wings; and Poor, more than 2 primaries and/or secondaries missing from 1 or both wings. Individuals with wings in poor condition were not capable of sustained flight. The broken primaries on the wings of some birds in poor condition were pulled to encourage regrowth.

The age of pen-reared birds was known to within 3 days (A. Kruse pers. comm.). The age of wild birds, adult or immature was determined by primary feather molt and wear (Petrides 1942, Wright and Hiatt 1943, and Ammann 1944) and scapular molt (Toepfer unpubl. data). Each pen-reared and wild transplant bird was individually marked with 3 and 4 colored leg bands respectively. The age of residents trapped during the winter in central Wisconsin was determined by bursa depth (Gower, 1939 and Kirkpatrick, 1944). For purposes of this study immatures became yearlings and yearlings became adults on 15 September.

Holding and Release Pen

The pen was located in the southeast corner of the Crex refuge approximately 800 m west of the eastern refuge boundary adjacent to an agricultural food patch. The upland habitat around the pen consisted of grasses, mixed forbs and scattered shrubs. The pen was 45.7 X 39.6 X 1.8 m and made of 2.5 cm galvanized chicken wire, with 60 cm of chicken wire buried below the surface of the ground. The top of the pen was covered with 5.1 cm mesh, black flexible nylon netting. A 12-volt electric fence encircled the pen to prevent mammals from climbing up the sides. Wire spikes made of number 9-gauge wire were placed on the top of each support pole to prevent raptors from perching on the pen. A center partition made of chicken wire divided the pen in half lengthwise. Eight strips (4 per half) of nylon

netting (1.2 X 19.8 m) were hung from the top of the pen to discourage birds from flying the full length of the pen and injuring themselves on the wire ends.

Cover inside of the pen consisted of native grasses and low shrubs. Three strawbale huts with 9 X 15 dm wooden tops were placed in each half of the pen to provide shade and protection from wind and rain. Fifteen, 9 X 15 dm huts made of red pine (Pinus resinosa) boughs were added to increase cover when natural cover became reduced in late October. Four 3 X 6.1 m shelters made of red pine boughs were added in December when snow covered the huts and natural cover.

In 1975, black nylon netting and streamers were placed along the sides of the pen to make them more visible and protect birds from hitting the wire sides. Number 9-gauge wire was crisscrossed, 30 cm above the top of the pen to reduce the maneuverability of raptors and prevent them from catching birds as they flew up the sides of the pen at night. Two Swedish goshawk traps (Meng 1971) baited with pigeons were used from December 1974-July 1976 to capture great horned owls.

In 1974-75, cocks and hens were kept in separate sides of the divided pen. Cocks and hens were not separated in 1975-76, but the pen remained divided. Pen-reared birds were held inside the pen from 1-11 months prior to release.

Food and Maintenance

While in the pen, birds were provided with commercial game bird finisher and maintenance pellets and a mixture of corn, oats and buckwheat. Food was placed in covered wooden feeders and water in metal troughs. The birds were checked, fed and watered daily.

Releases

From September 1974-September 1977, 236 pen-reared and 60 wild chickens were released on the Crex Meadows Wildlife Area. Pen-reared birds were released in October 1974, April 1975, August and September of 1975 and April 1976. Wild birds were transplanted from central Wisconsin in April 1976 and from western Minnesota in April, June and August 1977. Four radio-tagged hens that moved away from Crex (1 in 1976 and 3 in 1977) were recaptured by nightlighting and returned to the release area.

The releases of most of the pen-reared birds during April were gentle in that the sides of the holding pen were rolled up and birds were permitted to come and go at will. Food was maintained inside the pen as long as the birds continued to use it. In August and September 1975 and April 1976 a number of birds were released about 1.6 km northwest of the holding pen to increase the distribution of the pen-reared birds. Wild birds in 1976 were released from wooden holding boxes (15.2 X 30 cm) buried just to

ground level. In 1977, hens were released on the booming ground established by wild cocks from the 1976 release.

Predator Suppresssion

In September of 1975 and April 1976, mink (Mustela vison) were trapped with leghold traps and smoke bombs were placed in dens, within 0.4 km of the holding pen. Raptors were live trapped with Swedish goshawk traps and bal-chatris. All trapped raptors were banded and released at least 100 km from the Crex area.

Census

Booming and dancing ground surveys (Grange 1948, Partch 1949 and Hamerstrom and Hamerstrom 1973) were conducted each spring during April and May during 1975-78. The later 1979-87 surveys were conducted during a 3-6 day period during the last week of April or the first 2 weeks of May. Numbers of prairie chicken and sharptail cocks on each display ground were counted at least twice, but usually 3 or more times during the survey period. Efforts were made to check all prairie chickens for bands.

An annual brood survey was conducted during August and early September 1975-77 by driving the roads and scanning the edges of open areas with a 10-60X spotting scope. Winter counts were made at feeding areas.

Radio Telemetry

Radio transmitters (SM1 Type) in the 151 MHz frequency range were purchased from AVM Instrument Company, Dublin, California. Transmitters were powered by either a 1.35v, 7.3 g (Hg-640) or a 13.2 g (Hg-1) mercury battery. The completed transmitter packages were a modification of the backpack unit described by Dumke and Pils (1973) and weighed 24-28 g (2.7-3.5% of the bird's body weight). Modifications included a 29.7 cm whip antenna covered with black tubing and a 5 cm diameter neck loop in the harness. The harness was made of brown or black 18 gauge thermoplastic stranded wire. The smaller packages were used on the pen-reared birds and on wild birds transplanted in 1976. The larger package was used in 1977 and on all residents radio-tagged in central Wisconsin. Estimated life of the 2 transmitter packages was approximately 270 and 400 days. Radio packages were placed on pen-reared birds at least a week before they were released to give them time to adjust to the placement of the radio package.

Most radio locations were obtained from the ground using triangulation with an AVM Model LA12 continuous band receiver connected to a single 3.4 m high, 8-element (Hy-Gain) yagi antenna mounted on a vehicle. Ground-to-ground range of the system was 0.8 km. Average accuracy using signal nulls for known transmitter locations and angles of intersection of triangulation lines between 60 and 120

degrees was 27.8+15.4 m (n=78) at 262-1016 m (Mean 479.8+189.2 m). When locating a radio-tagged bird efforts were made to improve accuracy by approaching within 500 m and keeping the triangulation angle as close to 90 degrees as possible (Heezen and Tester 1967). Sets of triangulation lines were considered valid only if they were taken within 5 minutes of each other.

A 3-element hand held antenna was used to find individuals at close range and recover dead birds. Radio-tagged birds that could not be found on the ground were located with an airplane using a receiver, switch box and a 3- element antenna clamped to each wing strut. Ground to air range at an altitude of 1,000 m was 5.6 km. Airplane locations were usually verified with the ground equipment.

An effort was made to locate each radio-tagged bird at least once a day, and at least twice a week at night. The exception was in 1973 in central Wisconsin when birds were located weekly during the summer, fall and early winter.

Movements

All radio locations were plotted on acetate overlays of large scale aerial photographs (1:660) of the study areas. Each location was classified as to the date, time (CST), straight line distance to the last location, release site (transplants and pen-reared birds), nearest booming ground, home or regular booming ground, and nest for hens; also

recorded were the type of movement, habitat, disturbance type, height class and activity. When 2 or more locations were obtained per day 1 was randomly selected for calculating the distance between consecutive daily locations (Robel et al. 1970).

The distance between locations were stratified into 4 types of daily movements: the distances between a daylight and a subsequent night location (DN), and/or the distance between a night location and a subsequent daylight location (DN), within day movements (WD) and the distances between consecutive daily locations (DBC).

The distance to nest was measured to the first nest before nesting and last nest (renest) after nesting. The home booming ground for the cocks was the one they displayed on and for hens it was the one nearest their nest. If a hen shifted to a different booming ground for renesting, the postnesting measurements were made to the last nest and to the home ground nearest the last nest. A booming ground index was calculated by determining the number of booming grounds that a radio-tagged bird became associated with (within 1 km of for at least 2 days).

Random points (8,000) were generated within the legal boundaries of the study area in central Wisconsin and 4,000 random points were generated within a 5 km radius of the booming ground at Crex using a Mircosoft Fortran Program after Press et al. (1986). The random points were used to

compare the distribution and mean distances of radio-tagged prairie chickens from the nearest booming ground, their home booming ground and hens from their nests. The distances from random points were measured to 20 booming grounds to approximate the relationship to the home booming ground or nest in hens (i.e. to fixed points). The orientation of radio-tagged birds to a booming ground or release site was evaluated by dividing the area into 4 quadrats relative to a known point and assuming an equal distribution.

Home Range

Radio locations were coded in an X and Y coordinate system using the Universal Transverse Mercator Grid (UTM) (Avery and Berlin 1977). In this format the locations were analyzed using TELDAY (Lonner and Burkhalter 1983) to determine home range and range sizes. Home range is that area as defined by Burt (1943) and Baker (1978) and its area calculated by connecting the outer most points to form convex polygon (Mohr 1947 and Hayne 1949). Range was calculated in the same manner as home range, but refers to area covered by wandering transplants before they localized and established a regular movement pattern.

Habitat Use

Habitat types were classified using covertype maps drawn from aerial photographs. Ocular percentage estimates

were used to place cover into 7 general habitat categories: Grass, Forbs, Agricultural (cultivated crops and alfalfa), Shrubs, Wetland, Trees, and Other plus paired combinations of these categories (i.e. Grass 80-100%=Grass, a mixture of 50-75% Grass and 25-50% Forbs=Grass/Forbs). A shift in composition favoring Forbs (greater than 50%) was classified as Forbs/Grass habitat. These general categories were then visually classified according to the dominant plant species on the same percentage basis as the general habitat categories. Disturbances were classified as to the type and time since the last disturbance to the nearest half month, after which they were placed into 1 of 6 categories: disturbed, disturbed within 1-6, 7-12, 13-24 months and undisturbed for 24-36 months.

Vegetation height classes were based on the height of a standing prairie chicken. Class I up to the belly of a bird (0-8 cm), Class II up to the eye of a bird (9-25 cm), Class III above the birds head (26-50 cm), Class IV (51-100 cm), Class V (1-2 m) and Class VI (over 2 m). At times Classes IV, V and VI were combined into a Class IV+ category to simplify analysis. These height classes were applied to the maximum screening height of the vegetation. In instances where 2 classes were found in a mosaic pattern, they were classified with regard to the dominant form i. e., mixed Class III vegetation with patches of Class I were classified as III. In addition to the major categories,

habitat, disturbances and height were classified as an edge type, when a location was within 40 m of a different type. This was done to compensate for the limitations in telemetry accuracy and reduce the possibility of placing the location in the wrong habitat type.

Two measurements were made from the booming grounds to characterize open space. One measurement was made from each booming ground to the nearest tree in each of the four quarters. A second series of measurements were made to the nearest woodlot or screening row of trees at least 400 m in length in each of 8 directions (N, NE, E, SE, S, SW, W, NW). Eight samples were used because 4 did not adequately represent the area of open space surrounding each booming ground. Measurements to the nearest trees calculated the density of trees using the point quarter method (Cottam and Curtis 1956). The 4 and 8 distances measured were averaged and the mean radius was used to calculate the circular treeless and open area around each booming ground. Aerial photgraphs were used to obtain measurements from trees and treeline to each booming ground in central Wisconsin 1972-76, the display grounds at Crex 1977-84 and to random points in each area for every year.

Cover present at each nest was classified relative to the vegetative height class of residual cover. Concealment of the nest was evaluated on an arbitrary scale of excellent, good, fair or poor. Species composition at each

nest was determined by recording the species of the 2 nearest plants at 10 cm intervals along 2, 1 meter lines, 1 running north and south and the other east and west through the center of the nest. Species composition around the nest was determined by recording the species of the 2 nearest plants every 0.5 m along a 30 meter tape running north and south and east and west throught the nest. Species composition of night and day roosts was determined in the same manner as vegetation within a meter of a nest.

Periods and Seasons

Data were stratified into seasons and periods as determined by weather and changes in behavior to permit comparisons between the different types of birds. The periods were: Prenesting-- 1 April to start of egg-laying, or time period between first and second nest; Egg-laying-- determined by back-dating and assuming 1 egg was laid each day (observed rate was 1.2 days per egg, n=3 nests, 16 eggs); Post-nesting--after nesting until 15 September, with or without a brood; Brood Rearing-- stratified into weekly periods based on the age of the chicks; Orientation-- when a transplanted bird made irregular movements over a relatively large area; Adjustment-- when a bird made relatively small or no movements after its release; Post-orientation-- when a transplanted bird established a new range with regular movement patterns and became a resident of the area.

Comparisons between survival of cocks and hens were made by selecting a general time period to represent the behavioral periods of the hens: Breeding Season, 22 April-15 September, Prenesting 1-30 April, Egg-laying 22 April-15 June, Incubation 1 April-30 June and Brood rearing 10 June- 15 September. Seasons were: Summer--after the cocks abandon the booming grounds, Fall--when the cocks returned to the booming grounds usually after the first hard frost in September, Winter--when 7 cm of snow had accumulated and ground foods were covered, Spring--when the cocks began using the booming grounds in both the AM and PM and when ground foods were once again available. Data were stratified into those periods when pen-reared birds were being studied, and into weekly periods. The daylight hours were stratified into 3 equal periods (AM, MIDDAY, PM) starting 1 hour before sunrise and ending 1 hour after sunset.

General

All observations of prairie chickens and sharptails were recorded in the same manner as radio locations. Additional observations were made regarding penned behavior, display, response to raptors, interactions between prairie chickens and sharptails, flocking, flushing and flight distance and height of flight. All observations at the release pen were made from a parked automobile and

on booming grounds from blinds. The distances at which birds flushed were measured by pacing. Flushing distances were classified as to vegetative height class, cause of flush and distance from the pen. The responses of birds to raptors were classified in the same manner as Berger and Hamerstrom (1963). All observations of raptors at the pen and in the vicinity of radio-tagged birds were recorded. Flocks of prairie grouse were tallied as to the minimum number of prairie chickens, sharptails and unknowns (prairie grouse).

To ascertain the difference between wariness of pen-reared and wild birds, a daily observability index was computed by dividing the number and type of non-displaying birds observed by the number of hours in the field. This same information was calculated for wild birds observed in central Wisconsin for 1972 and 1973 and for the wild birds at Crex in 1977 and 1978.

Observability indexes were adjusted for differences in density. The area for density in central Wisconsin was calculated by connecting the outer most booming grounds to distributions of pen-reared and wild birds at Crex. Density was then calculated by dividing this area by twice the number of displaying wild cocks to account for hens. Fall density was calculated by doubling spring density to adjust for the summers production. The number of pen-reared birds was known, and density was adjusted based on

estimated mortality rates. Densities calculated in this manner have a biological basis and are more realistic than those calculated using areas created by arbitrary study areas.

Diurnal exposure to raptors was calculated by recording the number of raptors observed per hour on the booming ground, at the release pen and within 200 m of a radio-tagged prairie chickens.

Statistics

All information collected was computerized and analyzed using SPSSX (Statistical Package for Social Science) (Nie et al. 1975). Chi Square, Student t test, analysis of variance, Pearson correlation coefficent, and Spearman's rank correlation (Snedecor and Cochran 1980), have been used to make statistical (mathematical) comparisons. Weighted annual means were calculated by equalizing sample sizes relative to differences in sample sizes between the seasons and day and night. Means, ranges and P values are presented in parentheses. In all cases the $\pm$ symbol equals 1 standard deviation and CSq equals ChiSquare value.

Scientific names of birds are based on the Sixth edition of the American Ornithologists' Union check-list of North American birds (1983). Mammal names are based on Honacki et al. (1982) and plant nomenclature followed Scott and Wasser (1980).

RESULTS AND DISCUSSION

Behavior in Pen

General

The 9-12 week-old prairie chickens readily adjusted to the pen at Crex since they fed, drank and dusted the same day they were transferred from Jamestown. In both years the penned birds initially flushed when a vehicle arrived at the pen, but became habituated after approximately 1 week when they became alert to its arrival, but did not flush. A different vehicle, usually caused the birds to flush until they became accustomed to it. The birds responded to a man walking into the pen by either flushing, running to cover, or moving to the opposite end of the pen. After 2 weeks it was possible to walk slowly into the pen without flushing any birds, but only if the birds were allowed to move to cover or to the far end of the pen.

Single birds in the open or surprised in cover usually flew back and forth across the pen often flying into the wire sides, absorbing the impact with their feet and/or open wings. The black strips of netting hanging from the top of the pen were avoided by flying parallel to them or by landing and running under them. Most birds usually flew a short distance and then ran to cover or to the far end of the pen. The remainder of the birds rarely flushed as long

as the disturbance was at the opposite end of the pen. Most of the collisions with the pen occurred during these contagious flushes and flights. After the birds had flushed once, it appeared they preferred to run rather than flush. Individuals in poor wing condition ran to cover and made no effort to fly until cornered. Because of the large number of birds flying in a small area it was not uncommon to see birds collide during the contagious flushes. Birds were more likely to flush during the morning or evening activity periods than during midday when they were day roosting in taller cover.

Two general types of flight behavior were noted while the birds were held in the pen. The first was a leap or jump straight up into the top netting with a bounce down to the ground. Some individuals would flush in this manner 2-3 times in rapid succession before running to cover. The second type involved a short flight parallel to the ground to the opposite end of the pen ending in a normal landing or a collision with the wire side. At times birds would angle too far up, hit the top netting and flip over backwards to the ground. Both types of flushes and flights appeared more hesitant than those observed in wild birds. Flushing and flight behavior changed over winter (Table 1). The incidence of flushing straight up decreased, the lateral flight and landing increased, while lateral flights into the sides decreased. This change in flight behavior

Table 1. Seasonal changes (%) in flushing and flight behavior of pen-reared prairie chickens inside the pen at Crex Meadows Wildlfe Area, Wisconsin, 1975-76. Number of observations in parentheses.

Season	Lateral flight and land	Lateral flight and hit side or top	Flush straight up and hit top	Total Observations
Summer	1.5 (1)	6.1 (4)	92.4(61)	66
Fall	18.2(33)	60.8(110)	21.0(38)	181
Spring	93.7(59)	1.6 (1)	4.8 (3)	63
Total	30.0(93)	37.1(115)	32.9(102)	310

was due to at least 3 factors: (1) adverse conditioning due to hitting the sides of the pen, thereby suppressing the the natural tendency to flush and outfly danger, (2) survival favoring those individuals that could not fly or learned not to fly and (3) deterioration of the wings due to hitting the wire. All are factors related to the small size of the pen. These are dramatic changes for prairie chickens since wild birds either leap up or flush laterally typically flying 200-1500 meters.

Feeding

The pen-reared prairie chickens preferred the commercial game bird pellets and buckwheat in the grain mixture during the late summer and fall. In winter they ignored the commercial pellets and ate the corn and buckwheat while leaving the oats and rye. Additional items found in crops of dead birds included hazel catkins, pine needles, oak buds, grass leaves, rose hips, willow buds, and insects. The birds regularly drank water from the metal troughs during the summer and fall. I have observed wild prairie chickens drinking free water on only 1 occasion and that from a rain puddle on a warm day in May. In winter the penned birds were observed on several occasions eating snow, presumably to obtain water. The regular use of free water by pen-reared prairie chickens was probably an acquired habit necessitated by the heavy use of the dry game bird pellets.

Use of Cover

The immature prairie chickens used available natural cover inside the pen for both day and night roosting during the summer and fall. The red pine huts were used for perches, hiding and for both day and night roosting as the natural cover disappeared due to the birds activity. The strawbale huts were used occasionally for roosting and the tops were used for loafing. Snow roosting, both day and night, was observed but was not common as the activities of the birds caused the snow to become too hard for burrowing. As a general pattern of cover use, the penned birds fed and loafed in the open short cover (0-8 cm), and day and night roosted in the taller brush and grass or in the pine huts (10-50 cm).

The general activity pattern was to feed in the morning and evening, and day roost during the midday hours (10:00-15:00 hrs). This activity pattern varied with the seasons. During spring, cocks displayed in morning and evening and fed in late morning or early midday or late afternoon. In the fall, cocks displayed only during the morning on clear, calm mornings. During stormy or very cold days in winter the birds fed only in the morning. Some individuals fed only once a day during all seasons.

Confinement may have reduced activity so the pen-reared prairie chickens did not need as much food as wild

birds. Svoboda and Gullion (1972) reported that penned ruffed grouse ate one-third the amount of food as wild ruffed grouse. Wild prairie chickens typically feed twice a day except during cold winter weather when they fed only once.

Dusting

Dusting occurred in the open sand areas during the midday hours. Individual dusting bowls were used repeatedly by the same and different individuals. When all available bowls were occupied individual cocks chased other cocks and hens out of dusting bowls for their use. In November 1975 several cocks attempted to mount birds lying on their sides in dusting bowls in a manner similar to copulating behavior of cocks in the spring. Dusting was more prevalent in 1974-75 than in 1975-76, perhaps due to chemicals having been placed in dusting bowls at Jamestown in 1975-76 to kill the lice.

Response to Predators

A measure of responses (positive or none) by immature pen-reared prairie chickens at Crex showed that they were able to distinguish raptors from non-raptors equally as well as wild prairie chickens (Table 2). There was no significant difference between the responses ($CSq=0.62$, $df=1$, $P=0.43$) nor in the specific reactions ($CSq=7.15$,

Table 2. Responses of wild prairie chickens on booming grounds (March-May) and pen-reared prairie chickens inside the pen to avian predators and other common avian species. Percentages are in parentheses.

	Positive Response		No Response	
Species	Wild	Pen-reared	Wild	Pen-reared
Female Harrier	109	38	11	3
Male Harrier	17	7	9	2
Unidentified Harrier	21	0	1	1
Rough-legged	17	23	4	1
Goshawk	18	1	0	0
Redtail	7	2	0	0
Unknown	1	1	0	0
Total Raptors	190(88.4)	72(91.1)	25(11.6)	7(8.9)
Crow(s)	7	5	14	10
Goose	0	1	19	19
Geese	1	0	13	17
Mallard	2	1	16	15
Ducks	0	0	9	4
Crane(s)	2	0	14	7
Blue-winged teal	0	0	4	2
Total Non-raptors	12(11.9)	7 (9.9)	89(88.1)	64(90.1)
Total "long-necked"	5 (6.3)	2 (3.0)	75(93.7)	54(97.0)

df=4, P=0.13) of pen-reared birds in the spring and fall. The latter indicated that the pen-reared prairie chickens did not become habituated to raptors during the winter. Reactions of wild prairie chickens on booming grounds and the combined fall and spring reactions of pen-reared birds were also comparable (CSq=0.46, df=1, P=0.50).

The shape, direction and type of flight were all factors that appeared to influence the reaction of birds to avian species. Tinbergen (1939) reported that young turkeys displayed flight responses to a short-necked model pulled over them, but showed no response to a long-necked model. Davies (1962) felt that habituation could be important as some common shapes caused no reaction, while less familiar shapes usually produced responses. McNiven (1960) working with domestic chickens, mallards and pheasants obtained no responses to the long-neck or short-neck models, but did get positive responses to swooping movements of models regardless of shape. Both the pen-reared and wild prairie chickens rarely reacted (<7%) to the long-necked species flying overhead (Table 2).

However, of all the non-raptors observed both the pen-reared and wild birds responded most often to the crow, a short-necked species, but not a threat to an adult bird. Crows often "swoop down" on prairie chickens in a manner similar to a hunting raptor and the birds were reacting to this flight pattern and reacted as if it were a raptor.

Prairie chickens are capable of discerning some species and even sexes as they do recognize crows as a non-raptor more often than not (66.6% versus 33.3%) and reacted more often to female harriers (90%) than males (65%) (Table 2). Berger et al. (1963) also found that prairie chickens on booming grounds reacted more often and in a stronger manner (flushed) to female than male harriers. The female harrier is larger than the male and a greater threat to an adult prairie chicken. This type of discrimination was probably learned and reinforced with experience. Wild prairie chickens also reacted to kestrels in a manner similar to crows (68.8% versus 31.2%), (Berger et al. 1963). They probably recognized flight patterns and were mistaking the kestrel for a larger falcon. Recognition of raptors and non-raptors was not perfect and mistakes were probably a matter of some or all birds reacting before the threat is confirmed.

The flight path of a raptor can also influence the reaction of prairie chickens. A raptor flying parallel to them will cause them to look up or become alert, and if the raptor continues in one direction the birds will resume their activity. However, if the raptor turns and moves towards the birds they will freeze or crouch and when the raptor approaches too close the birds will take flight usually in the direction away from raptor's approach. Crouched birds will often wait for the raptor to pass over

and then take flight in the opposite direction. Some birds will crouch and hold even while the raptor is present. On one occasion a goshawk was observed perched on a fence post with 3 wild cocks crouched in short grass (1 cm) within 5 m of the hawk; 1 cock was crouched directly below the hawk. The birds remained crouched for approximately 10 minutes until the hawk left.

Even though pen-reared prairie chickens recognized and reacted to potential avian predators, they did not respond in the same manner as wild birds. Pen-reared birds were less likely to flush and showed a greater tendency to freeze or run to cover than wild birds ($CSq=24.5$, $df=4$, $P=0.001$) (Table 3). Wild birds were observed running to cover on booming grounds only once during this study.

Melzack (1960) found that after more than 2000 presentations of hawk and goose models to mallard ducklings, "overt fear responses", flushing, squatting, and running were replaced by "non-emotional orienting responses" (head alert, looking up). He felt that habituation of the fear response to the hawk shape was the result of a change in organization of behavior in which the emotional disruption is replaced by non-emotional orienting responses.

Pen-reared prairie chickens did exhibit a reduction in overt fear response (flushing) when compared with reactions of wild birds on booming grounds ($CSq=22.7$, $df=4$, $P=0.001$).

Table 3. Comparison of types of responses to raptors between wild and pen-reared prairie chickens. Percentages are in parentheses.

Type	Type of Response					
	Flush	Squat	Alert/ Freeze	Run Cover	No Response	Total
Pen-reared						
Fall	7(20.6)	16(47.1)	4(11.8)	3 (8.8)	4(11.8)	34
Spring	8(17.8)	12(26.7)	13(28.9)	9(20.0)	3 (6.7)	45
Total	15(19.0)	28(35.4)	17(21.5)	12(15.2)	7 (8.9)	79
Wild[a]	157(73.0)	26(12.1)	6 (2.8)	1 (0.5)	25(11.6)	215

[a] Wild birds on booming grounds in spring.

This modification in the type of response to raptors was probably acquired by birds as a result of their penned environment and not the result of habituation. Reduction in the flush response was probably due to survival favoring the behavioral and physical non-flyers and a negative feedback as the birds learned to run rather than fly into the sides.

The presence of cover in the pen may have allowed the pen-reared prairie chickens to avoid habituation. Observations of responses by (8-12 week-old) penned Japanese green pheasant (Phasianus cholchicus rubripes) to raptors indicated that they reacted to raptors in a positive manner as long as cover was available. The loss of cover, due to trampling and feeding activities, resulted in the total habituation (no responses) of the young pheasants to raptors flying within 200 m and above their pens. Lack of cover prevented the birds from hiding, thus encouraging habituation. Removal of cover is a common practice used in the raising and holding of large numbers of birds in pens and is done to prevent disease. However, the elimination of cover may play a critical role in the habituation of penned birds to raptors.

There was little opportunity to observe the responses of pen-reared prairie chickens to mammalian predators. On 20 April 1976, a mink was observed moving along the edge of the pen and the birds did not react when it ran within 7 m

of several groups of birds. On 2 other occasions a raccoon (Procyon lotor) and a red fox (Vulpes vulpes) walked along the edge of the pen within 4 m of the birds inside, and the birds became alert and a few moved to cover. However, none of the mammalian predators made an effort to get at the birds inside the pen. Berger et al. (1963), Hamerstrom et al. (1965) and Sparling and Svedarsky (1978) indicated that prairie chickens show a greater concern for raptors than mammals. Wild prairie chickens flush or crouch only when mammalian predators walk or run through the booming ground.

In the winter 1975 a short-tailed weasel (Mustela erminea) lived for a short time inside the pen, presumably feeding on mice attracted to the food. On 2 occasions it was observed moving through groups of birds. The birds were aware of the weasel, but only those in its immediate path moved out of its way. The weasel killed no birds and was eventually live trapped and removed.

These observations suggest penned environment does not alter or change the ability of the pen-reared prairie chickens to recognize avian or mammalian predators, but it does alter the way in which they respond to potential threats (freezing or running rather than flushing). The continuation of this type of behavior after release would make the pen-reared prairie chickens susceptible to predators, particularly mammals.

Some of the pen-reared prairie chickens also responded

to a man by running rather than flying and could be pursued and forced to flush only when he approached closer than 1 m. All evidence indicated that the surviving pen-reared prairie chickens were able to recognize potential predators, but were conditioned by the size of the pen to respond to potential predators by running rather than by flying. Wild prairie chickens usually responded to avian and mammalian predators by crouching and then flushing once the predator got too close.

Mortality Inside the Pen

Sixteen of 456 birds died enroute from Jamestown to Crex; 14 of 207 in 1974 and 2 of 249 in 1975. The losses were less in 1975 because the birds were moved at a younger age and in 2 separate groups a month apart.

Overwinter mortality (September-April) of pen-reared birds, while inside the pen was very high, 55.4% in 1974-76 and 32.4% in 1975-76. Table 4 summarizes the September to April losses inside the holding pen by probable causes. Birds that died from exposure were younger individuals that hatched in mid-July and were probably too small to tolerate the cold temperatures that occurred at night in late September. The 41 birds killed by raptors were killed after 1 December 1974, when the birds were more conspicuous due to snow cover.

From 1 December 1974 to 1 January 1975, birds were found dead on 11 separate occasions in intervals of 1-6

Table 4. Distribution of mortality by probable cause for pen-reared prairie chickens while inside the pen, Crex Meadows Wildlife Area, Wisconsin, 1974-75 and 1975-76. Percentages in parentheses.

	Year		
	1974-75	1975-76	Total
Probable cause			
Raptor	41(38.3)	1(1.3)	42(22.5)
Broken neck	3 (2.8)	46(57.5)	49(26.2)
Exposure	39(36.4)	6 (7.5)	45(24.1)
Mink	20(18.7)	0 (0.0)	20(10.7)
Unknown	0 (0.0)	20(25.0)	20(10.7)
Other	4 (3.7)	7 (8.8)	11 (5.8)
Total	107(100.0)	80(100.0)	187(100.0)

days with the usual interval 2-3 days (N=7). The average number of birds killed per incident was 4.1 (range 1-12). All of these birds were scraped, scratched, bloodied and most beheaded with the head lying near the body. The only sign found inside the pen were feathers and blood on the top netting. It is speculated that owl(s) flew and walked on the top of the pen and caught a bird as it fluttered up the sides of the pen and then tried to pull the bird out, pulling off the head in the process. This type of predation has been observed by personnel at the pheasant game farm at Poynette, Wisconsin. The trapping and removal of 13 great horned owls along with the addition of pine cover inside the pen reduced these losses as only 6 birds were found dead between 1 January and 27 April 1975. There was only 1 suspected loss to owls in 1975-76. However, the increase in the number of birds found dead with broken necks in 1976 (Table 4) was believed to be the result of raptor harassment during the fall. Individuals with broken necks were found unmarked, lying next to the sides of the pen and appeared to have hit the wire while flying.

On 28 April 1975, 21 birds being held for breeding were killed by a mink that entered an interior holding pen, that did not have wire underground. The birds that died from unknown causes were found after the snow had melted in the spring.

Cocks suffered higher mortality inside the pen

than hens (49.4% versus 38.2%). This discrepancy was greatest in 1975-76 and the difference was greatest in birds in excellent and good condition (Table 5). The fact that hens in good and excellent condition had the highest survival suggests some type of behavioral advantage for the hens. Total survival of cocks and hens and survival relative to wing condition was comparable in 1974-75 when cocks and hens were segregated. The difference in survival between the sexes in 1975-76 was probably a function of the cocks and hens being together and that cocks dominated hens. The dominance by cocks and display activity made the hens less vulnerable as they remained in or near cover to avoid cocks.

Survival inside of the pen was inversely related to wing condition (Table 5). Individual pen-reared prairie chickens with poor or fair wing condition were more likely to hold or run to cover than birds in excellent or good wing condition. The birds in excellent and good wing condition were 1.5 times more susceptible to mortality than birds in poor and fair condition, and the incidence of mortality associated with flying (broken neck, raptors) was 2.5 times greater. Thus selection inside the pen favored individuals that were poor flyers or those individuals that learned to run rather than fly from danger.

The aggressive nature of individual prairie chickens inside the pen also appeared to influence survival and

Table 5. Overwinter survival (%) of pen-reared prairie chickens inside holdingpen relative to wing condition in late summer, Crex Meadows Wildlife Area, Wisconsin, 1974-76. Number of birds in parentheses.

	Wing Condition		
	Excellent/Good	Fair/Poor	Total
Cocks			
1974-75	38.3 (47)	68.0(25)	48.6 (72)
1975-76	46.3 (82)	81.1(16)	52.0 (98)
Total Cocks	43.4(129)	73.2(41)	50.6(170)
Hens			
1974-75	30.0 (30)	64.0(25)	45.5 (55)
1975-76	65.8(117)	85.7(14)	67.9(131)
Total Hens	58.5(147)	72.8(39)	61.8(186)
Total	51.8(276)	72.5(80)	56.2(356)

status. In the fall 1975, 14 cocks and 2 hens were classified as aggressive individuals because they regularly chased and dominated others. Twelve of the aggressive cocks and both hens survived to spring; 9 of the 12 aggressive cocks became regular displayers, and 4 held interior territories.

Survival of this aggressive cohort was much higher than survival of the other birds (87.5% versus 67.6%), as was territory procurement (75.0% versus 44.0%) and the incidence of holding interior territories (44.4% versus 11.1%). Physically, the aggressive cocks were significantly older, 279 days (n=11) versus 264 days (P=0.03, n=40), had smaller pinnae, 7.3 cm (n=9) versus 7.6 cm (n=15)(P=0.041), and shorter tails, 9.4 cm (n=9) versus 9.6 cm (n=15)(P=0.021), and weighed more in April, 907.6 g (n=11) versus 888.1 g (P=0.216, n=40).

Wings on all of the aggressive individuals were in excellent or good condition compared to 69% for the other cocks. This latter relationship was contrary to the general pattern of survival inside the pen, where survival was inversely related to wing condition and presumably the ability to fly. These aggressive individuals had a higher survival rate than even the birds in fair and poor condition (non-flyers) (Table 5). In some unknown way the aggressive nature and related behavior modified the disadvantage of being able to fly. The greater weight of

the aggressive cohort was probably due to the better wing condition. The smaller pinnae and tails could have been a phenotypic expression of the aggressive nature of these birds but could be a function of a small sample size. The older age could suggest that these individuals were better conditioned to survive in the pen because of more experience or dominance by presence. However, these birds were on average only 2 days older than the other birds in the fall (66 versus 64 days). The older age in the spring was due to a higher over winter mortality rate in the younger cohorts.

These aggressive individuals were for some reason more adaptable to a penned environment and data suggested that an aggressive nature enhances survival inside the pen. Moss and Watson (1980a and 1980b) have recently hypothesized that changes in aggressiveness may be important in regulating red grouse (Lagopus lagopus) numbers in Scotland. The data here, though sketchy, indicate that aggressiveness and status could be important in prairie chicken population regulation and should be explored further, particularly the relationship away from the booming ground.

Display and Aggressive Behavior

Wild prairie chickens in central Wisconsin have been observed displaying every month of the year except July and August. Adult cocks return to the booming grounds in

mid-September to re-establish their territories about the time of the first hard frost. The first displaying by pen-reared prairie chickens in 1974 was observed on the afternoon of 7 December by a single cock which displayed intensively once. This particular cock was observed displaying on a regular basis even on the snow, from 12 January-May 1975.

Daily observations at the pen were made in the morning from a parked auto during 4-21 April to identify individuals that displayed and held territories. On 1 March 1975, 8 cocks displayed and defended territories. Five of the territories were located along the divider fence facing the half of the pen containing the hens. Two of the territories were interior or surrounded on all sides by other cocks (Hamerstrom and Hamerstrom, 1973). The number of territorial cocks increased to 11 by 17 April. Thirty-five (76%) of the 46 cocks were non-territorial; 13 displayed only once while the remaining 33 were never observed displaying.

Display and aggressive fighting between cocks was first observed on 5 October 1975 and occurred regularly on clear mornings throughout the fall. One cock displayed regularly from the first week of December through the end of April. The earlier display in 1975-76 was the result of more time spent making observations at the pen.

The number of cocks holding territories in 1976

increased from 20 on 19 March to a maximum of 22 on 20 April. Nine of these territories, 4 in one half and 5 in the other, were along the divider fence and 7 of the 22 territories were classified as interior. Thirty-six (72%) of the 50 cocks were non-territorial and 7 of the 36 were observed displaying once, 6 cocks twice, and 7 displayed 3 times.

Non-territorial Cocks

The percentage of non-territorial cocks was similar for the 2 years (72% versus 76%). However the density of cocks appeared to influence the number of cocks that displayed. In 1975 a single cock displayed in the hen half of the pen and defended a territory through the center divider fence with at least 2 cocks in the other half of the pen. This cock was transferred to the cock half of the pen on 4 April; this move apparently altered his status as he never displayed or defended a territory again. Five additional non-displaying cocks were moved from the main cock pen (high density) to a smaller unoccupied partition of the pen (low density), and all eventually displayed and established territories, 3 within 2 days of being transferred. One cock was transferred back into the main pen and at which time he became a non-displayer. It appeared that high density conditions or the presence of certain individuals altered the status and/or suppressed display in some individuals. Likewise, removal from a high density

situation appeared to stimulate displaying in non-displayers. The sample sizes are small, but it suggests that there is a direct relationship between density and the percentage of non-displayers.

Non-territorial cocks usually sat on top of huts or hid in cover to avoid being chased by the displaying territorial birds. Those birds that did not hide congregated in groups in areas away from the displaying territorial cocks. Individuals or groups of birds that wandered into an occupied territory were chased out by the resident cock. Non-territorial cocks responded to these encounters by running or hiding from the chasing cock. This type of behavior has been observed in immature wild cocks attempting to establish onto a booming ground in the early spring.

A number of non-territorial cocks would display occasionally inside existing territories, away from the displaying territorial cock, but would usually stop when the owner of the territory approached or gave chase. Initially, these non-territorial holders would display with pinnae part way up, with no foot stomp and with air sacs only partially inflated (lethargic display). New territories were established when a transient displayer held his ground and defended an area. These new territories were smaller, outer portions of larger existing territories. A similar pattern of territory establishment

has been reported for sharptails (Moyles and Boag 1981). Hens, when mixed with cocks in 1975-76 remained in cover or moved about freely, but tended to congregate in areas where the displaying cocks were less active.

Superficially, displaying immature pen-reared prairie chickens cocks appeared to exhibit all the normal display characteristics of wild birds. However, several of the display patterns were modified in intensity. Territorial fighting and flutter jumping did not appear to occur as frequently as in wild birds. Flutter jumping was observed occasionally inside the pen and when it occurred, the jumps were lateral rather than vertical. The height of the pen and the constant presence of hens provide the most logical explanation for this reduction and modification in flutter jumping. In wild birds, flutter jumping is a response to the arrival of hens. Cocks may initiate this type of behavior to attract hens to their territories (Hjorth 1970).

The reduced fighting probably indicated group stability and that social status of individual cocks was established before the birds began to display. It is quite probable that individual cocks establish their status in groups or flocks when not displaying and that this status carries over into the establishment and maintenance of territories on booming grounds.

Aggressive encounters, where 1 individual pecked or

chased another causing the latter to move, were common inside the pen. These encounters were associated with comfort and space as these types and were rarely observed at the feeding or water troughs. Aggression occurred when birds were crowded, at dusting bowls or when individuals moved too close to a dominant individual.

Overall aggressive encounters inside the pen increased as the density of the birds in a known area increased ($r=0.86$, $n=657$, $P=0.001$). Cocks were aggressive towards hens and other cocks and hens were aggressive towards other hens. In 1,234 aggressive encounters, hens chased cocks only 4 times.

These aggressive individuals concentrated their activities near the center of the pen where the interior territories and center of the display ground were eventually established. It appeared that these central territories were the first to be established and were probably preferred areas on the display grounds. Rippen and Boag (1974), Moyles and Boag (1981) with sharptails, Robel and Ballard (1974) with prairie chickens and Wiley (1973) with sage grouse indicated that central territories were preferred by cocks.

It is likely that wild surviving adult cocks when they return to booming grounds in fall have first choice of territories. New recruits and immatures have to establish around this "core" of adults. This process of a core and

peripheral establishment is repeated in the spring with adjustments for mortality and additional spring recruits.

Aggression between cocks and hens has also been observed in winter feeding flocks in central Wisconsin (n=564). The number of aggressive encounters also increased as wild birds concentrate on a limited food source (known area) in winter ($r=0.82$, $n=498$, $P=.0.001$). Cocks dominated hens and other cocks, but hens were aggressive only towards other hens.

Most behavioral studies of prairie chickens have concentrated on the booming grounds because the birds are so easy to find and observe. However, the potential for the development of a hierarchy or establishment of dominance is greater away from the display grounds, if for no other reason than a higher percentage of time is spent away from the booming grounds. This is particularly true for hens which visit the display ground to mate. Hamerstrom and Hamerstrom (1973) estimated that cocks spend only about 10% of their lives on the booming ground.

Several authors have indicated that aggressiveness may be important in regulating grouse numbers (Robel 1970a and Moss and Watson 1980a and 1980b). Data presented here also indicate that aggressiveness and status are important in prairie chicken population regulation and should be explored further particularly the relationships as they exist away from the booming ground.

Condition

Background

Changes and differences in weights and measurements are often used to determine the health and condition of birds. However, little information is available comparing pen-reared and wild birds.

Information that is available is inconsistent with regard to the physical differences between the two types. Leopold (1944) found that domestic turkeys were heavier, but similar in measurements of wing, tail and length of tarsus. Greenwood (1975) and Kiel (1970) reported that game farm mallards were 11% and 26% larger, respectively, than wild mallards. The larger size of pen-reared mallards and turkeys is thought to be the result of domestication (Leopold 1944, Prince et al. 1968 and Sossinka 1982). Bump et al. (1947) presented information indicating that hand reared ruffed grouse females weighed less than wild females, while males weighed more than wild males. Gates and Woehler (1968) found wild pheasant hens in Wisconsin averaged 150 g more than pen-reared hens just before egg-laying; they felt their penned birds were a smaller strain of pheasant. Tester and Olson (1959) found just the opposite as both pen-reared cocks and hens were heavier than wild-trapped pheasants in Minnesota.

Unlike prairie chickens, ruffed grouse, pheasants and

turkeys are not regular fliers, and have lighter breast muscles. Mallards are fliers with dark breast muscle, but the larger size of game farm birds is probably due to domestication (Prince et al. 1968, and Sossinka 1982). Weller (1957) working with redhead ducks (Aythya americana) a non-domesticated flier, found hatchery reared birds lighter than wild birds of the same age.

The strongest information on the effects of reduced flying due to confinement comes from falconers. Michell (1959) reported that birds held for falconry need the right amount of food and exercise to remain in top flying condition and Beebe and Webster (1985) stated there is "no substitute for hard flying".

Muscles of birds, like mammals, increase and decrease with exercise and red muscle fibers atrophy faster than white fibers (Welty 1975). Hanson (1962) observed atrophy of the pectoral muscles and hypertrophy of the leg muscles in geese during the flightless period and, when geese shifted back to flying, the pectoral muscles increased in size. Available information indicates that flight exercise is very important in the development and maintenance of muscle tone and size and probably varies between species. Rearing in captivity should reduce muscle development, particularly in the more mobile flying birds. It is probably no coincidence that these same species have been the most difficult to rear in captivity and return to the wild.

Handling

A total of 891 wild prairie chickens were trapped during 1972-1977. Of these, 835 (488 cocks and 347 hens) came from central Wisconsin, 1972-76 and 56 from western Minnesota in 1977 (36 cocks and 20 hens). Only 9 birds died, presumably from shock while being held in burlap sacks. Table 6 shows the number of prairie chickens captured by season and sex.

Hens apparently tolerate the stresses of trapping and handling better than cocks as none died of shock. This same pattern was observed in pen-reared birds where 5 cocks of the 695 birds handled in the spring died of shock. None of the 14 that died of shock were underweight or appeared to be injured. However, 1 cock (sex determined internally) with full pinnae, had a full complement of hen (barred) tail feathers. Stress associated with the breeding season may compound handling stresses as 9 of the 14 cocks that died of shock held territories. In wild birds there was no apparent relationship between age and death due to shock (4 adults, 3 immatures and 2 unknowns).

Several researchers have indicated that the females of penned mallards, ruffed grouse, turkeys and pheasants are more resistant to stresses of weather extremes and starvation than males (Latham 1947, Jordan 1953, Tester and Olson 1959). The ability of each sex to tolerate these stresses also appeared to play a role in the ability to

Table 6. Number of wild prairie chickens trapped in Wisconsin and Minnesota, by season, sex and age, 1972-77.

		Cocks				Hens			
	Total	Adults	Immatures	Unknown	Total	Adults	Immatures	Unknown	Total
Winter	607	154	177	1	332	117	158	0	275
Spring[a]	246	82	59	22	163	53	25	5	83
Summer[b]	28	13	5	2	20	8	0	0	8
Fall	10	5	4	0	9	1	0	0	1
Total	891	254	245	25	524	179	183	5	367

[a] Includes 46 birds captured in Minnesota.
[b] Includes 10 birds recaptured in Minnesota.

handle the stresses of confinement. Six of the 15 wild birds (4 of the 5 cocks and 2 of the 10 hens) shipped to Jamestown in February 1975 died within 2 weeks of being placed into pens. These losses were attributed to the stresses of adjusting to the penned environment.

Hen prairie chickens tolerated the stresses of handling better than cocks, but were more likely to lose some or all of their tail feathers. Of 367 wild hens captured 38 lost all their tail feathers and 14 (3.8%) lost half. Of 521 cocks captured, only 15 (2.9%) lost half or all of their tail feathers. A possible explanation for this difference is that cocks have longer tail feathers than hens and superficially, individual tail feathers appeared to be stronger in cocks.

None of the 695 plus pen-reared birds handled lost more than a few tail feathers, as they were trapped in a large walk-in trap and did not struggle in the trap. Wild birds under nets flopped and ran until covered, hooded or restrained, increasing the chances of losing feathers or being injured. No birds were killed during trapping operations and those that died of shock, died in the holding sacks or while being banded.

Burlap sacks were convenient and safe for temporarily holding prairie chickens for processing. Burlap sacks also made access to the birds easier than from a box since the bird can be easily confined and manipulated from the

outside of the sack before being removed. Minimal handling of birds is recommended. They should be banded and radio-tagged before being placed in holding boxes and released directly from the boxes. Prairie chickens apparently are under less stress when held overnight in individual cardboard boxes. Prairie chickens in boxes have been shipped by air freight and held up to 36 hours without mortality. Birds should be shipped or transported at night when it is dark and cooler. Boxes should have air holes covered with cloth to permit air flow, but keep out bright light. Ligon (1946) describes transport boxes which work well, but are heavy and expensive.

Of the 872 wild prairie chickens trapped and handled, 2.4% (n=22) died of shock or were collected due to injuries. Injuries that occurred as a result of trapping were 5 with dislocated, 8 with a broken clavicle or humerus and 3 with internal injuries. Hamerstrom and Hamerstrom (1973) reported a trapping and handling mortality rate of 3.4% (64 out of 1885), but 33 were killed by predators while in unattended traps. Of 207 birds recaptured in this study none died; however 1 was collected due to injury. Natural injuries observed in wild trapped prairie chickens included 3 with healed leg injuries (probably broken), 3 with scars or cuts on the breast or abdomen, 2 missing an eye, another blind in one eye, and 4 missing parts or whole toes. All birds with natural injuries were captured in the

winter; none were underweight and all appeared healthy.

General-- Pen-reared Birds

Of 143 birds examined on 26 September 1974, 32.2% had scraped heads and nares, probably due to contact with the wire tops and sides of rearing pens at Jamestown. The initial wing condition of birds examined was: 38.5% (n=55) excellent, 20.9% (n=30) good, 21.9% (n=20) fair and 12.6% (n=18) poor (Table 7). The birds in fair and poor condition were older individuals that had their primaries clipped to reduce flying in the wire topped pens. None of these birds had scraped heads, an indication that they could not fly well.

Hens were reexamined on 6 March and cocks on 4 April in 1975. Wing condition deteriorated over winter as all the outer primary tips were frayed and square from contact with the wire. One exception was a hen with a broken wing. Only 26% (n=12) of the cocks and 25% (n=9) of the hens wings were in excellent or good condition (Table 7).

In 1975, none of the birds received from Jamestown had scraped heads or nares. Wings were in better condition with 23% more birds in the excellent and good condition classes in 1975 than in 1974 (Table 7). The improved wing condition in 1975 was attributed to netting which was hung in flight pens to prevent birds from flying into the wire tops and sides. None of the birds had their flight feathers clipped in 1975 and birds were moved to Crex in 2

Table 7. Distribution of wing conditon by classes for live pen-reared prairie chickens examined in fall and spring, Crex Meadows Wildlife Area, Wisconsin, 1974-76. Percentages are in parentheses.

	Excellent	Good	Fair	Poor	Total
Fall 1974					
Cocks	29(33.7)	24(27.9)	23(26.7)	10(11.6)	86
Hens	26(45.6)	6(10.1)	17(29.8)	8(12.6)	57
Total	55(38.5)	30(20.9)	40(21.9)	18(12.6)	143
Spring 1975					
Cocks	4 (8.6)	8(17.4)	9(19.6)	25(54.4)	46
Hens	4(11.1)	5(13.9)	19(52.7)	8(22.2)	36
Total	8 (9.7)	13(15.9)	28(34.1)	33(40.2)	82
Fall 1975					
Cocks	74(71.2)	18(17.3)	8 (7.7)	4 (3.8)	104
Hens	93(68.9)	23(17.0)	14(10.4)	5 (3.7)	135
Total	167(69.9)	41(17.2)	22 (9.2)	9 (3.8)	239
Spring 1976					
Cocks	10(19.2)	26(50.0)	13(25.0)	3 (5.8)	52
Hens	12(15.6)	35(45.5)	17(22.1)	13(16.9)	77
Total	22(17.1)	61(47.3)	30(23.3)	16(12.4)	129

separate groups approximately a month earlier than in 1974. In general the birds received in 1975 were in better condition and wilder than the birds received in 1974 which may have been a result of less conditioning due to their younger age.

In 1976 the birds were reexamined on 1 April and once again the condition of the flight feathers deteriorated overwinter with 17% (n=22) excellent, 47.3% (n=61) good, 23.2% (n=30) fair and 12.4% (n=16) poor (Table 7). Approximately 3 times as many birds were in excellent and good condition in the spring of 1976 compared to 1975 (64.4% versus 26.6%), an improvement attributed to netting which hung along the side of the pen, better cover inside the pen and the better condition of birds when they arrived at Crex in 1975. However, the primaries were still frayed and square in all but 2 individuals, which had broken wings.

In 1974-75 only 4 of the birds with scraped heads failed to grow new crown feathers. This improvement was due to the flexible nylon netting used on the top of the Crex pen. Scraped nares usually healed, although the scab that formed on the nares was sensitive to the touch and easily removed. Tail and pinnae feathers did not deteriorate nor was development of the tail and pinnae hindered by being in the pen. In 1976, at least 25% of the 96 birds examined had worn breast feathers apparently the

result of abrasion from hitting the wire. Most (80%) of these birds were in excellent or good condition.

General-- Wild Birds

All of the wild prairie chickens transplanted in April had flight feathers in either excellent or good condition. While under the rocket nets, 5 hens lost all or a portion of their tail feathers. Most birds lost some body contour feathers, but none had obvious bare areas. However, 4 cocks and 3 hens had scrapes along the outer edges of their wings. One hen with a broken humerus was collected. Four cocks captured in April 1976 died from shock while being transported in burlap sacks.

Weight Dynamics

Seasonal. Weights of 801 wild greater prairie chickens captured during 1972-77 in Wisconsin and Minnesota, were greatest in early winter and then declined until snow melt in late March (Fig. 4). A second peak occurred in April followed by a decline to the annual low in late summer. This pattern of seasonal weight changes has been reported in other grouse species (Bump et al. 1947, Keith 1962, Robel and Linderman 1966, West and Meng 1968, Roseberry and Klimstra 1971, Ellison and Weeden 1979, and Robinson 1980). Limited information is available on weights of Wisconsin prairie chickens in the fall, but an increase would have to occur during the fall from the

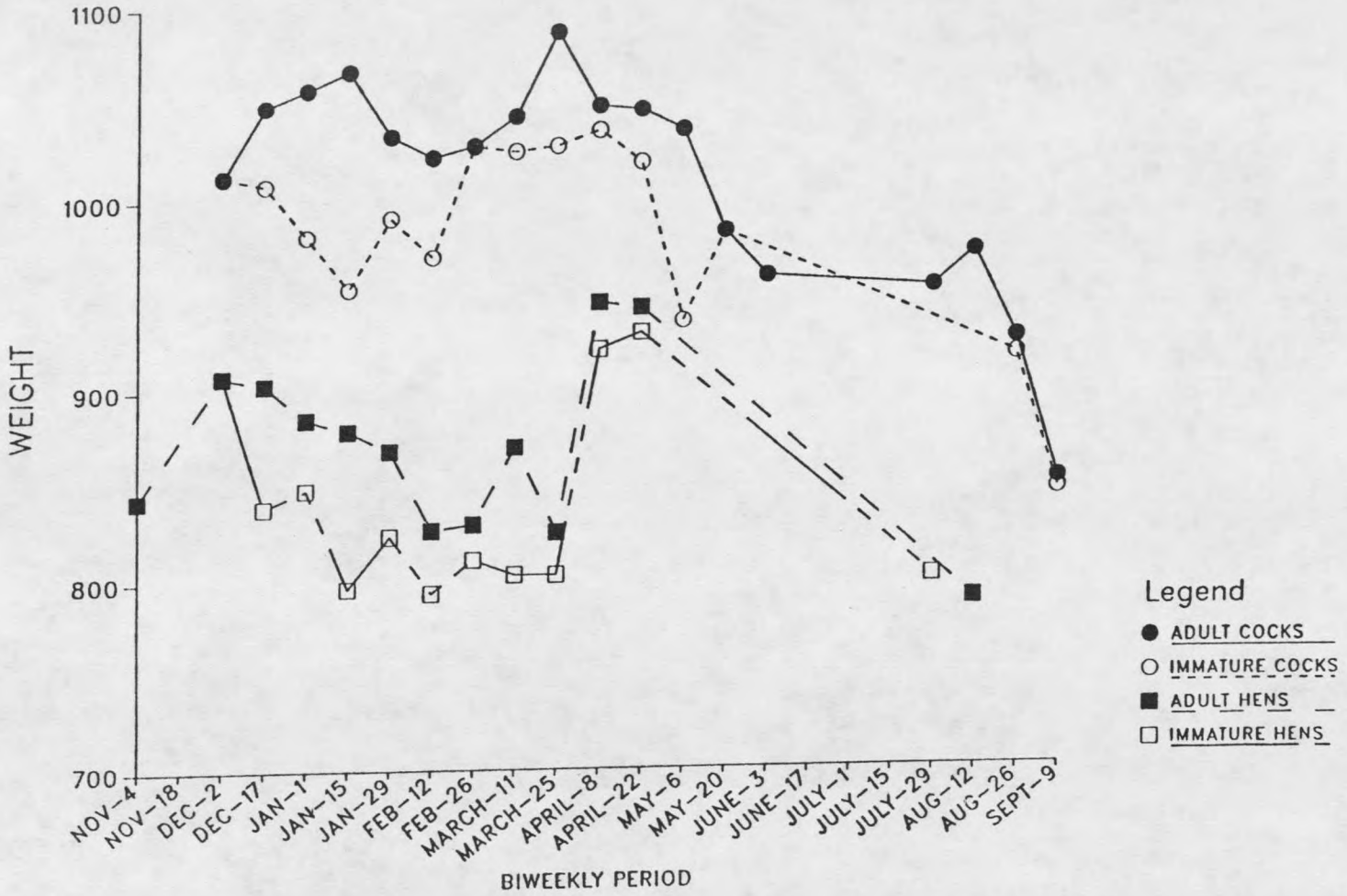


Figure 4. Mean biweekly weights (g) of wild prairie chickens by sex and age central Wisconsin, 1972-76 and western Minnesota 1977.

summer low to the early winter peak. Baker (1953) and Horak (1985) reported October and November weights of prairie chickens in Kansas that were between the summer lows and early winter peaks recorded in Wisconsin.

Adults and immatures followed the same general seasonal pattern, although mean weights of immatures were lower (Table 8 and Fig. 4). Maximum weights of cocks occurred in April, approximately 3-4 weeks before the breeding peak. Hens reached their maximum in late April, just before egg-laying. Mean weights of cocks were greater than hens throughout the year with adults of both sexes weighing more than immatures (Fig. 4). However, ranges of weights within and between sexes and ages overlapped, particularly the ranges of the hens and immature cocks (Table 9).

Immature prairie chickens did not reach full size until their second year of life, probably in late fall or early winter at approximately 18-19 months of age. Comparisons of winter weights of immatures captured during the same biweekly periods the following winter showed that immature cocks gained an average of 64.0 g (9.1%, n=18), while immature hens gained 48.2 g (6.1%, n=7). Comparable information for adults showed that mean weights changed less than 10 g for both cocks and hens (Table 10). West and Meng (1968), working with ptarmigan, found that only in their second fall were there substantial increases in

Table 8. Mean seasonal weights (g) of greater prairie chickens captured in Minnesota and Wisconsin, 1972-77. Number of birds in parentheses.[a]

	Cocks			Hens		
	Adult	Immature	P	Adult	Immature	P
Winter	1045.2±56.2(143)[bc]	989.1±69.1(170)[bc]	0.001	868.3±55.1(110)[bcd]	824.5±57.8(150)[bcd]	0.001
Spring	1042.5±59.2(56)[d]	1017.5±34.5 (33)[d]	0.031	943.7±50.4 (34)[bd]	904.9±69.4 (21)[bd]	0.043
Summer	945.9±39.8(12)[e]	913.0 (1)		788.1±5.7 (4)	800.2 (1)	
Fall	1012.1 (1)	1012.6±0.7 (2)		875.0±45.6 (2)	907.2 (1)	

[a] Includes 56 prairie chickens from western Minnesota

[bcd] Means with same subscript are mathematically significant (P>0.05).

[e] Significantly less than all weights of cocks (P>0.05) except winter immatures (P=0.236)

Table 9. Winter and spring weight (g) ranges for wild (1972-77) and pen-reared (1974-76) greater prairie chickens. Number of birds are in parentheses.

	Cocks		Hens	
Season	Adults	Immatures	Adults	Immatures
Winter				
Wild	915.0-1198.2(143)	783.5-1132.8(170)	732.0-995.2(110)	676.1-966.4(150)
Pen-reared	-	751.5-1007.6 (7)	-	625.9-933.3 (47)
Spring				
Wild	875.6-1166.0 (56)	880.5-1087.3 (33)	804.0-1007.0(34)	749.2-939.7 (21)
Pen-reared	-	732.3-1085.8(128)	-	605.5-856.0(165)

Table 10. Changes in mean weight (g) by sex and age for prairie chickens recaptured in subsequent winters, central Wisconsin, 1972-76.

		Weight						Weight				
Sex	N	Immature	Adult	Change	Percent	P	N	Adult	Adult	Change	Percent	P
Cock[a]	34	971.1	1028.6	+57.5	5.6	0.001	10	1046.7	1044.0	-2.7	0	0.925
Cock[b]	18	960.4	1024.4	+64.0	6.7	0.001	8	1042.6	1034.7	-7.9	1.0	0.789
Hens[a]	11	791.0	837.5	+46.5	5.9	0.001	11	869.3	869.2	-0.1	0	0.996
Hens[b]	7	787.9	836.1	+48.2	6.1	0.001	10	873.4	880.1	+6.7	1.0	0.718

[a] Same individual captured during same month.

[b] Same individual captured during same biweekly period.

individual weight. Beck and Braun (1978) and Linden (1984) showed that sage grouse and capercaillie did not reach full size until their second winter. However, the size differences between adults and immatures in these two species is much more obvious than in prairie chickens. Various body and feather measurements of prairie chickens also suggest that overall growth may not be complete by their first winter.

Winter. Seasonal changes in mean weights of prairie chickens were predictable and the result of behavioral changes influenced by environmental conditions and physiological requirements. The decline in winter was due to lower ambient temperatures and snow cover and reduced availability of food and increased energy demands. Reductions in food and cover caused daily movements and ranges to expand which, thus increased energy demands caused by lower temperatures.

Declines in mean weights from the winter peak to the winter low were highest for immature cocks (95.7 g, 9.1%) followed by adult hens (58.6 g, 6.6%) immature hens (54.2 g, 6.4%) and adult cocks (44.8 g, 4.2%). The greater weight losses recorded for immature cocks were attributed to their smaller size, inexperience, higher mobility and their involvement in displaying, and maintaining territories as early as February.

Hens are smaller than cocks and must compete with them

when in mixed flocks. Beck (1977) reported that sage grouse segregated into flocks of adult cocks and flocks of the smaller hens and immature cocks. Schwartz (1945) reported unisexual flocks of prairie chickens in Missouri during the winter. In this study flocks captured in winter were usually bisexual.

Weights of individuals recaptured during the same winter showed the same pattern as determined from mean weights. One immature cock lost 126.7 g (11.6%) in 17 days in January and an adult cock lost 87.2 g (8.4%) in 45 days. Both of these birds survived to spring and displayed. An immature hen lost 79.1 g (9.7%) in 20 days in January and an adult hen lost 80.3 g (8.9%) in just 5 days in January. Both of these hens were recaptured the following winter.

Only 5 of 176 birds recaptured during the same winter gained weight (12-100 g in 16-45 days). All but one of these 5 birds survived to spring (2 immature cocks, 2 immature hens and 1 adult hen). The largest weight loss recorded occurred in 2 cocks which lost 457.1 g (45.0%) and 287.0 g (33.7%) in 19 and 24 days respectively. Both died of starvation. Most of the weight loss appeared to have been from the breast muscles as breast circumference declined (3.6 cm, 13.2%) in the former bird.

Grammeltvedt (1978) reported that during starvation grouse degraded their muscles, primarily the pectoralis. Hanson (1963) reported that loss of body condition in

winter involves loss of both fat and protein, as fat cannot be degraded under periods of food stress without the catabolism of proteins.

Comparisons of weights obtained during the 3 winters of major trapping (1974-76) showed no major differences between the sex and age classes (ANOVA, df=2, $P<0.204$) and within groups between periods (ANOVA, df=4, $P<0.164$). Declines in mean weights from early January to February were greatest in 1976 with changes being most pronounced for immature hens, followed by immature cocks and adult hens (Table 11). Immatures and adult hens appeared to be more sensitive to the rigors of winter than adult cocks.

With the exception of adult cocks, mean weights of survivors were larger in all 4 biweekly periods during the winter. This pattern was most pronounced for immature cocks and hens (Table 12).

Examination of survival and average weights during 1974-76 during biweekly periods between 30 December-25 February, showed that survivors weighed more in 5 out of 6 and 8 out of 9 periods in adult and immature cocks respectively, when periods with 8 or more individuals were considered. However, the average biweekly differences were small, 5.1-31.2 and 4.1-62.4 g for adults and immatures respectively. Numbers of hens known to survive were too small to permit yearly comparisons.

Reasons for increased weight loss observed in the

Table 11. Changes in mean weight (g) from January-February for prairie chickens by sex, age and year in Wisconsin, 1974-76. Number of birds are in parentheses.

	Adults			Immatures		
	Period			Period		
Year	12/30-01/14	01/29-02/11	Change	12/30-01/14	01/29-02/11	Change
Cocks						
1974	1068.6±63.2(36)	1049.7±54.7 (9)	-18.9	976.4±64.7(30)	999.7±50.8 (8)	+23.3
1975	1062.7±49.6(17)	1056.4±19.7 (4)	-6.3	987.2±69.8(29)	993.4±74.6(15)	+ 6.2
1976	983.1±11.2 (6)	1016.4±32.9(14)	+33.3	1021.2±50.5(13)	980.1±53.4(12)	-41.1
Mean			+ 6.9			- 3.9
Hens						
1974	882.3±65.2(11)	893.4±42.9(10)	+11.1	829.5±73.0(28)	830.1±57.5 (6)	+ 0.6
1975	895.4±57.9 (9)	882.3±40.3 (5)	-13.1	848.7±51.7(24)	825.7±34.7(11)	-23.0
1976	885.8±36.3(18)	848.8±42.7(18)	-37.0	871.5±39.3(16)	813.1±56.0(17)	-58.4
Mean			- 4.2			-26.9

Table 12. Biweekly mean weights (g) by sex and age for wild prairie chickens in winter relative to winter survival in central Wisconsin, 1974-76. Number of birds are in parentheses.

	Adults			Immatures		
	Not Observed in Spring	Observed in Spring	Change	Not Observed in Spring	Observed in Spring	Change
Cocks						
01/01-01/14	1066.2±63.3(38)	1036.1±54.4(21)	-30.1	985.8±66.2(47)	994.6±65.9(25)	+ 8.8
01/15-01/28	1058.6±63.7(10)	1073.1±46.7(12)	+14.5	929.1±61.7(15)	977.0±54.4(13)	+47.9
01/29-02/11	1048.0±48.9(11)	1022.6±35.4(17)	-25.4	989.4±73.6(22)	991.7±54.4(13)	+ 2.3
02/12-02/25	1011.4±52.1(17)	1042.8±39.5 (8)	+31.4	968.6±72.5(12)	970.9±55.7 (8)	+ 2.3
Total Cocks	1050.6±61.7(76)	1038.3±50.1(55)	-12.3	979.7±71.5(96)	987.8±55.1(59)	+ 8.1
Hens						
01/01-01/14	887.8±51.4(33)	881.2±41.5 (6)	- 6.6	843.2±59.9(54)	893.5±61.5(13)	+50.3
01/15-01/28	861.1±67.0(12)	908.1±47.2 (7)	+ 4.7	802.1±46.9 (8)	777.1±70.8 (5)	-25.0
01/29-02/11	869.2±46.9(25)	821.3±48.6 (9)	-47.9	821.3±48.6(28)	837.2±78.8 (7)	+15.9
02/12-02/25	829.2±71.1(10)	806.7±66.4 (4)	-22.5	789.6±42.4(16)	832.0± 4.0 (6)	+42.4
Total Hens	867.2±57.4(80)	878.8±53.7(26)	+11.6	825.0±56.6(106)	835.9±71.4(31)	+10.9

winter of 1976 are unknown (Table 11). Weather differences between the years may have a greater effect on hens and immature cocks since they were generally smaller and more mobile than adult cocks. This pattern could be expected in a feeding hierarchy with adult cocks on top.

It was assumed that birds not observed displaying by mid-April did not survive. This may not be completely valid as some of these immatures may have failed to recruit onto booming grounds, and were alive but not observed. However, over a 5 year period we recaptured only 1 banded cock (1%) that potentially could have been but was not observed on a booming ground the previous spring. This particular cock was observed on a booming ground the following spring and it was possible that he went unobserved.

A comparison of survival relative to median weights from 30 December-21 January indicated that survival of individuals above the median weight was higher for immature cocks (40.5% vs 27.3%), but lower for adult cocks (26.7% vs 44.1%). Both adult and immature hens above the median weight experienced higher survival, but sample sizes were small.

Stratification of weights into 50 g increments showed a weight threshold of approximately 959 g in cocks and 850 g in hens above which winter survival was enhanced (Table 13). Thus more of these adult cocks of intermediate weight

Table 13. Winter survival (%) of prairie chickens captured during the period 30 December-21 January, in central Wisconsin, 1974-76 by 50 g increments. Sample sizes are in parentheses.

	Cocks			Hens		
	Adults	Immatures	Total	Adults	Immatures	Total
Weight (g)						
1050 plus	38.6(17/44)	41.7 (5/12)	39.3 (22/56)	-	-	0 (0/1)
1000-1050	40.0 (8/20)	46.9(15/32)	44.2 (23/52)	0 (0/1)	-	0 (0/1)
950-1000	53.8 (7/13)	39.1 (9/23)	44.4 (16/36)	25.0 (1/4)	33.3 (1/3)	28.6 (2/7)
900-950	50.0 (1/2)	26.3 (5/19)	28.6 (6/21)	29.4 (5/17)	10.0 (1/10)	22.2 (6/27)
850-900	-	20.0 (1/5)	20.0 (1/5)	17.6 (3/17)	18.2 (2/11)	17.9 (5/28)
800-850	-	0.0 (0/2)	0 (0/2)	18.2 (2/11)	3.8 (1/26)	8.1 (3/37)
750-800	-	50.0 (1/2)	50.0 (1/2)	0.0 (0/3)	0.0 (0/9)	0 (0/3)
<750	-	-		-	14.3 (1/7)	14.2 (1/7)
Total	41.8 (33/79)	37.9 (36/95)	39.7 (69/174)	20.8 (11/53)	9.1 (6/66)	15.3 (17/111)

survived winter. Individuals in these intermediate weight classes are younger adults and were less likely to expose themselves to predation through pre-season display or other acts of dominance. Not enough individuals of known age were recaptured in winter to confirm this hypothesis, but the mean weights of adults, 2 years or older, were slightly larger than yearling adults (Table 10).

Because adult and immature hens weigh approximately 12-21% less than cocks (immatures 17-21% and adults 12.3-16.7%) and are dominated by cocks, some behavioral adjustments must be made for hens to survive winter. Schmidt (1936) indicated that hens often moved to more favorable food and cover conditions. In this study, radio-tagged hens had larger home ranges and moved farther from their home booming grounds than cocks, particularly the adult cocks.

Little doubt should exist that body condition (weight) is important to winter survival of both immatures and to adult hens. However, the relationship between weight and survival in adults suggested that immatures may be at a disadvantage because of incomplete growth and behavioral differences resulting in greater mobility and dominance. The quantity and distribution of winter food and cover are critical to survival as they directly influence daily movements and hence weight loss. Weight gains, during the fall to an early winter peak, imply that food and cover in

the fall are also very important.

Immature cocks that showed up on the booming grounds tended to be the larger individuals. Thus size may also play a role in acquisition and maintenance of a territory, and a higher rank would permit easier access to resources necessary to survive. Domination of hens by cocks emphasizes the importance of hen weight and the behavioral relationship between cocks and hens away from booming grounds, particularly when food is limited during the winter.

Spring. The rapid increase in mean weights observed in prairie chickens during the early spring corresponded to warming temperatures and the loss of snow cover, which increased the distribution, quantity and quality of food and cover. Movements decreased as cocks began to visit booming grounds, and hens established smaller flocks near the booming grounds where they fed, loafed and eventually nested.

This weight recovery was critical to both sexes to survive the reproductive effort. Siivonen (1957) felt that utilization of green plants high in protein in the early spring helped to restore body weight lost during winter. Foods high in protein were important because protein was utilized along with fat and any gains involved both fat and protein (Hanson 1962 and Grammveldt 1978). Fat reserves in grouse are apparently small and the breast muscle and other

sources of protein are as important as fat during food shortages (Brittas and Marcstrom 1982).

After snow melted, radioed prairie chickens continued to visit agricultural fields near their home booming ground, but they began to shift away from corn to other grains, particularly buckwheat, when available. However, they were also attracted to the green plants which started to grow early in cultivated fields because of warmer soil conditions created by the disturbed soil. Food habits documented by Baker (1953), and Korschgen (1962) and Tony (1980) showed that the use of grass and other leafy material increases in the spring.

Krapu (1974) found that wheat was inadequate as a staple food during egg production in pintails and more recently Baldessarae et al. (1983) has questioned the nutritional value of corn to wintering waterfowl.

Prairie chickens in Wisconsin were occasionally observed budding in shrubs and trees, but use of browse was very small when compared to use of corn and buckwheat. Hamerstrom et al. (1941) found that penned wild prairie chickens fed only browse lost weight but birds on browse plus grains or grain alone maintained weight. They concluded that to "have prairie chickens in quantity in the North Central States, winter grains are necessary".

Prairie chickens apparently do not prefer corn and will select other foods when available. Prairie chickens

shifted from standing corn or corn feeders to buckwheat when snow melted even though temperatures dropped below zero and corn was readily available during the winter in central Wisconsin and at Crex. If snow covered the buckwheat areas, they shifted back to corn. Schmidt (1936) thought buckwheat was a preferred food when available but corn and buds became the main foods after snow covered food on the ground. When both corn and soybeans were available they used the latter and when sunflowers were present they preferred them over both corn and soybeans (Toepfer unpubl. data). Hamerstrom et al. (1941) also thought prairie chickens preferred buckwheat and soybeans in winter, but preference varied between flocks.

Prairie chickens preferred standing corn to corn bait piles or corn on platforms. Flocks frequently ignored a bait pile or corn on a platform until corn in the field was gone. One possible reason for prairie chickens avoiding bait piles rests in their flocking or feeding behavior. Corn on bait piles or platforms was concentrated in a very small area which forced the birds to bunch up as they fed. However, when feeding in a standing corn field the birds can spread out and feed undisturbed by others. In some locales in central Wisconsin corn piles or platforms were used all winter when corn patches failed or had been destroyed by deer. At Crex, prairie chickens used the standing corn until the deer depleted it and then shifted to the corn

feeding platforms.

In central Wisconsin, both cocks and hens stopped feeding in agricultural fields in late April or early May. This shift coincided with the peak of egg-laying in hens. A relationship seemed to exist between the occurrence of green-up and onset of breeding since both were usually associated with warm early springs. This relationship may rest with recovery of winter weight loss due to the availability of green vegetation. Hamerstrom and Hamerstrom (1973) found that over a 25 year period the main breeding peak in prairie chickens in central Wisconsin occurred between 18-26 April.

Gates and Woehler (1968) found that a delay in weight recovery in penned pheasant hens, leads to a later onset of egg-laying and lower weights during egg-laying. They also found that onset of egg-laying varied between years and the physical condition of hen was a factor. Gerstell (1942) and Breitenbach et al. (1963) found penned pheasant hens in poor condition began egg-laying later. Early weight recovery and nest initiation could result in more nesting attempts per season if initial nests were destroyed.

The decline in mean weight in both adult and immature cocks in April was associated with the peak of display. Eight cocks regularly displaying twice a day lost an average of 43.6±7.2 g (4.0%) from the last week of March to mid-May. Six other displaying cocks lost an average of

86.6±8.3 g (9.0%) from mid-April to mid-June, a loss similar to that in immature cocks and higher than that recorded in hens (6.4-6.6%) during winter. Display appeared to be as physiologically demanding for the cocks, as winter was to hens and immature cocks. Weight loss in males during the breeding season has been observed in many other gallinaceous birds (Bump et al. 1947, Koskimies 1958, West and Meng 1968, Roseberry and Klimstra 1971, Beck and Braun 1978, Ellison and Weeden 1979, Robinson 1980, Brittas 1984, and Linden 1984).

Mean weights of prairie chicken hens, in contrast to cocks, peaked just before the onset of egg-laying in late April, with immatures peaking later than adults (Fig. 4). Based on back dating and adjustments for the variations in the breeding peak, immatures initiated egg-laying 5±1.0 days later than adults. Hens, unlike cocks, were not burdened with the high energy demands associated with display and the morning and evening attendance on booming grounds.

During egg-laying, hens localized their movements in a relatively small area (24-84 ha). This may be part of a behavioral pattern that serves to reduce energy demands and weight loss during egg production. The peak weight which occurred later in immature hens than adults was related to their smaller size in spring (904.9 g, n=21 versus 943.7 g, n=34, P=0.040). Thus more time was required for immature

hens to reach physical or physiological maturity and delay breeding. Beck and Braun (1978) reported that the weights of immature sage grouse hens also peaked later than adults while Zwickel (1977) found that most immature blue grouse bred after most adults had started to nest.

Pendergast and Boag (1973) found that the weight gained by female spruce grouse in spring was due to the enlargement of the reproductive tract and increases in the mass of body muscle and the digestive tract. Kabat et al. (1950) also found that pheasant hens reached maximum weight at the start of egg-laying and weight declined during egg-laying and Linden (1984) found gross energy intake in capercaillie hens was highest during egg production.

Increases in weight of hens before egg-laying is a common phenomenon in gallinaceous birds (Bump et al. 1947, Koskimies 1958, West and Meng 1968, Roseberry and Klimstra 1971, Ellison and Weeden 1979, Robinson 1980, Brittas 1984, Linden 1984). Breitenbach et al. (1963) indicated that hen pheasants lose very little weight during egg-laying and food the hen obtains during the day contributes to produce the next day's egg. In contrast, 2 prairie chicken hens recaptured during the first and second day of incubation had lost 63.1 and 72 g respectively during egg-laying.

A high protein diet was also important during egg-laying. Beckerton and Middleton (1983) found that ruffed grouse females fed high protein diets lost less weight

during egg-laying than groups fed at lower levels. Kabat et al. (1956) reported that pheasant weights started declining rapidly at the onset of incubation since the hens depleted fat reserves and were using protein.

Prairie chicken hens lose weight rapidly during incubation since feeding periods are reduced to 2 to 3 times a day for 15-55 minutes. One hen weighed on 10 April (933.0 g) and again on 21 June (690.5 g) after egg-laying and 25 days of incubation lost 240.2 g (26%). This hen hatched 9 eggs, and died that evening following a heavy rain storm on 29 June. A second hen recaptured on her first nest lost 63 g (6.6%) in the first 5-6 days of incubation. This rate of weight loss would extrapolate to approximately 17% over the total incubation period. Two other hens captured on nests late in incubation, had sharp breast keels and concave breast muscles.

Besides 2 birds that starved, incubating hens experienced the greatest weight loss. Breitenbach et al. (1963) found that pheasant hens lost 18.8% of their body weight after 20 days of incubation. Despite their vulnerability and declining condition during incubation survival during this period was high (87.5% in this study and 82.5% in North Dakota, (Toepfer and Newell unpubl. data). Therefore condition of the hen at the start of incubation is critical to her survival and that of her chicks. Breitenbach and Meyer (1959) stated that the

hen pheasants have depleted most of their energy stores by the 11th day of brooding. Thus diet is important to the recovery and well being of the hen which influences her ability to survive and care for her chicks.

Although a high protein diet may be important to offset weight loss during incubation, no information is available on food habits of nesting prairie chickens. McCourt et al. (1973) indicated that incubating spruce grouse "need to acquire food quickly and in large quantities" while Herzog (1978) observed them feeding upon the new growth of white spruce and suggested they were selecting a specific food source for a physiological need. Zwickel and Bendell (1972) found that incubating blue grouse were also selective in their feeding.

Survival of radio-tagged hens in this study was much higher for broodless hens than hens with broods (80% versus 65%). The importance of weight loss from egg-laying through incubation is supported by the following data: most chicks and 55% of the prairie chicken broods which were lost had disappeared within 3 weeks (Mean 24.7 ± 19.6 days, n=20, 18.2% due to death of hen); 90% of the broods disappeared within 6 weeks (45% due to death of hen)(Toepfer and Newell unpubl. data.)

The weight cycle in prairie chicken hens is a continuum of increases and decreases that influence survival and reproduction. Moss et al. (1975) showed that

the condition of the hen influenced the number of eggs laid, their hatchability and the survival of the chicks. This "maternal condition hypothesis" is an important aspect of reproduction in grouse and the condition of the hen at the completion of egg-laying or during incubation influences the survival of chicks or the hen's ability to renest. Gallinaceous chicks are precocial, but are highly dependent upon the hen for protection and warmth at night for the first several weeks. A hen in poor condition is less likely to provide close parental care as she attempts to rebuild or maintain her condition. Egg quality, hatchability and genetics of the chicks are moot if the hen is unable to provide the necessary parental care. Cool wet conditions during early brooding will increase both the need for parental care, and the energy drain on the hen.

Finally, the prenesting condition of the hen and the weight loss during reproductive efforts influenced the ability of a hen to renest. Three adult prairie chickens have been known to renest twice in 1 season (Toepfer and Newell unpubl. data). Robel et al. (1970) also reported a prairie chicken hen renesting twice in 1 season in Kansas.

Because immature grouse hens do not reach full size until their second winter they probably do notreproduce as well as adults. This hypothesis is supported by other studies where immatures lay fewer eggs than adults (Mean difference range 0.4-2.1 eggs) (blue grouse, Redfield 1973,

Zwickel 1975; spruce grouse Keppie 1975; sage grouse, Wallestad and Pyrah 1974; white-tailed ptarmigan, Giesen et al. 1980). This age relationship to clutch size also exists in mallards (Krapu and Doty 1979), snow geese (Finney and Cooke 1978), and many other bird species (von Haartman 1971 and Cody 1971). Lack (1954) believed that older birds laid larger clutches because they were more experienced in gathering food, while Zwickel (1975) thought that smaller clutches in yearling blue grouse were related to physical maturity.

Adult prairie chickens are more productive than immatures. They lay more eggs per clutch (0.7 eggs), they are likely to produce a brood (56.7% versus 45.2%, Total 52%), renest (79.5% versus 38.5%, Total 64.9%) and to fledge a chick from a hatched clutch (56.3% versus 36.8%, Total 49.0%). Adults also fledge more chicks per brood (6.4 versus 4.6). Renesting by prairie chickens provides a significant portion of the year's production. Of 143 chicks fledged by radioed hens, 38% were produced by renesting hens. (Toepfer and Newell unpubl. data). Lovett et al. (1971) found that adult turkeys were more likely to renest than juveniles (29.4% versus 14.3%) and Wallestad and Pyrah (1974) found, that adult sage grouse hens were more likely to bring off a brood than immatures (76.9% versus 44.4%).

Although experience may play a role in the higher

reproductive success of adults, larger size and better condition as they influence the ability to renest is probably a greater influence. Winter condition and weight loss, along with weight recovery and the renesting abilities of adult and immature hens, are important aspects of grouse population dynamics that warrant additional study.

Summer. Weights of both prairie chicken cocks and hens decline to an annual low in August (Fig. 4). Mean weight loss from the April peak was 14% for hens and 13.5% for cocks. Weights of Minnesota prairie chickens (Marshall and Erickson 1945) also reached a low point during the summer (729.1±42.8, n=8 hens, and 886.0 for a cock in August). This decline occurred even with warm temperatures and when food and cover were abundant. Most of this weight loss was attributed to the high energy demands of the annual molt as suggested by weight/molt pattern reported in penned pheasants (Breitenbach and Meyer 1959). Food intake is increased during the molt because of protein demands for feather development (Kendeigh et al. 1977, Dolnik and Gavrilov 1979) and maintenance of body temperature due to reduced insulation both of which increase energy demands causing weight loss (Payne 1972). Rintamaki et al. (1983) found that body temperature and metabolic rate in adult black grouse were higher in summer than winter. Linden (1984) reported that energy consumption of penned male

capercaillie was highest during the molt.

The summer weight decline and molt in prairie chickens also was accompanied by a reduction in flying and movements. Daily observations of a group of 12 birds (2 radioed) indicated that they made 2 flights of only 200-400 m per day; 1 when they left the roost to feed and the second when they returned. Some individuals walked short distances between feeding and roosting areas. This reduction in flying may lead to some breast muscle atrophy. Hanson (1963) indicated that the metabolic breakdown of protein in unused flight muscles contributed amino acids for feather growth in molting geese.

High protein diets appeared conducive to weight maintenance during the molt in ruffed grouse (Beckerton and Middleton 1983). In central Wisconsin, 12 prairie chickens (2 radioed) were observed regularly, feeding twice a day in a heavily grazed field (height less than 0.5 cm) from 1 July-5 September. These birds, like those observed feeding in the rye at Crex, appeared to be grazing on new green shoots of grasses that are high in protein. Examination of fresh droppings confirmed these observations. The use of these areas of (0-5 cm) short vegetation for feeding was common for most of the radioed birds at Crex and in central Wisconsin and probably reflected a need for protein for growing feathers.

Fall. After the molt, daily movements increased

as the the adult cocks return to the booming grounds. However, in contrast to the demands of spring display the cocks visited only in the morning. During fall, food and cover are not as limited as in winter and conditions were comparable to those in early spring, when birds also recovered weight loss. Little information is available on fall weights of prairie chickens in Wisconsin, but prairie chicken weights from Kansas in October (Baker 1953 and Horak 1985) lie between the summer low and early winter peak of Wisconsin birds. Mean weight gain from the summer low to the early winter peak for adults in Wisconsin was 142.8 g (13.4%) and 119.1 g (13.1%) for 8 cocks and 4 hens respectively (Fig. 4).

Seasonal weight changes for prairie chickens are dynamic and complex and are influenced by the environment, behavior, age, and sex. Further, these changes influenced survival and all aspects of reproduction. The condition of an individual at any given point in time appeared to be a function of its habitat, particularly quantity and quality of food.

Weights and Measurements

Pen-reared Birds. Seasonal weight trends of 681 pen-reared prairie chickens paralleled, but remained below, those of wild immatures (Fig. 5). Winter weight loss was not as apparent because some groups of pen-reared birds maintained and even gained weight during winter (Fig. 6).

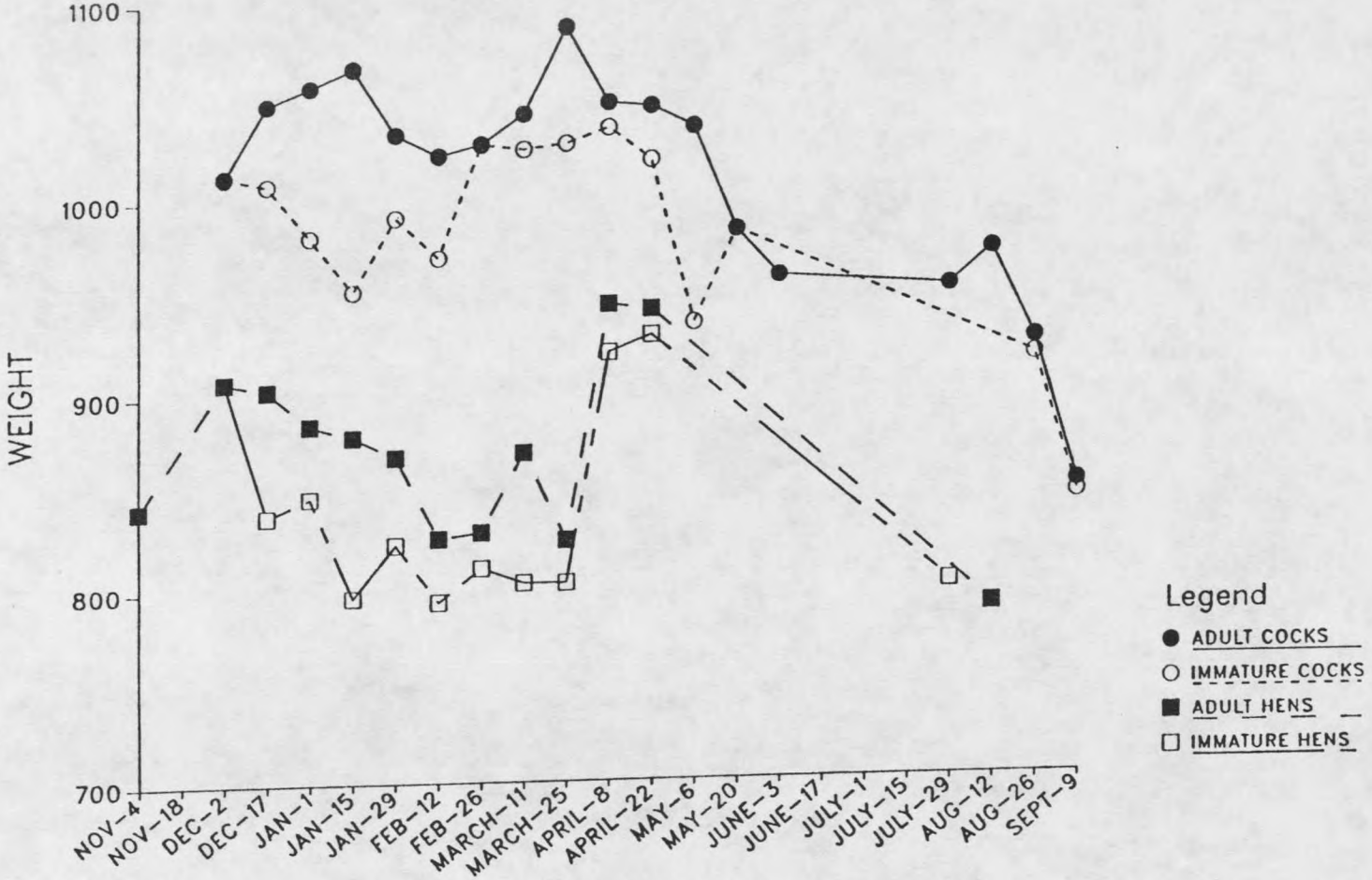


Figure 5. Mean biweekly weights (g) of immature wild prairie chickens central Wisconsin, 1972-76 and western Minnesota 1977 and immature pen-reared prairie chickens, Crex Meadows Wildlife Area, Wisconsin, 1974-76.

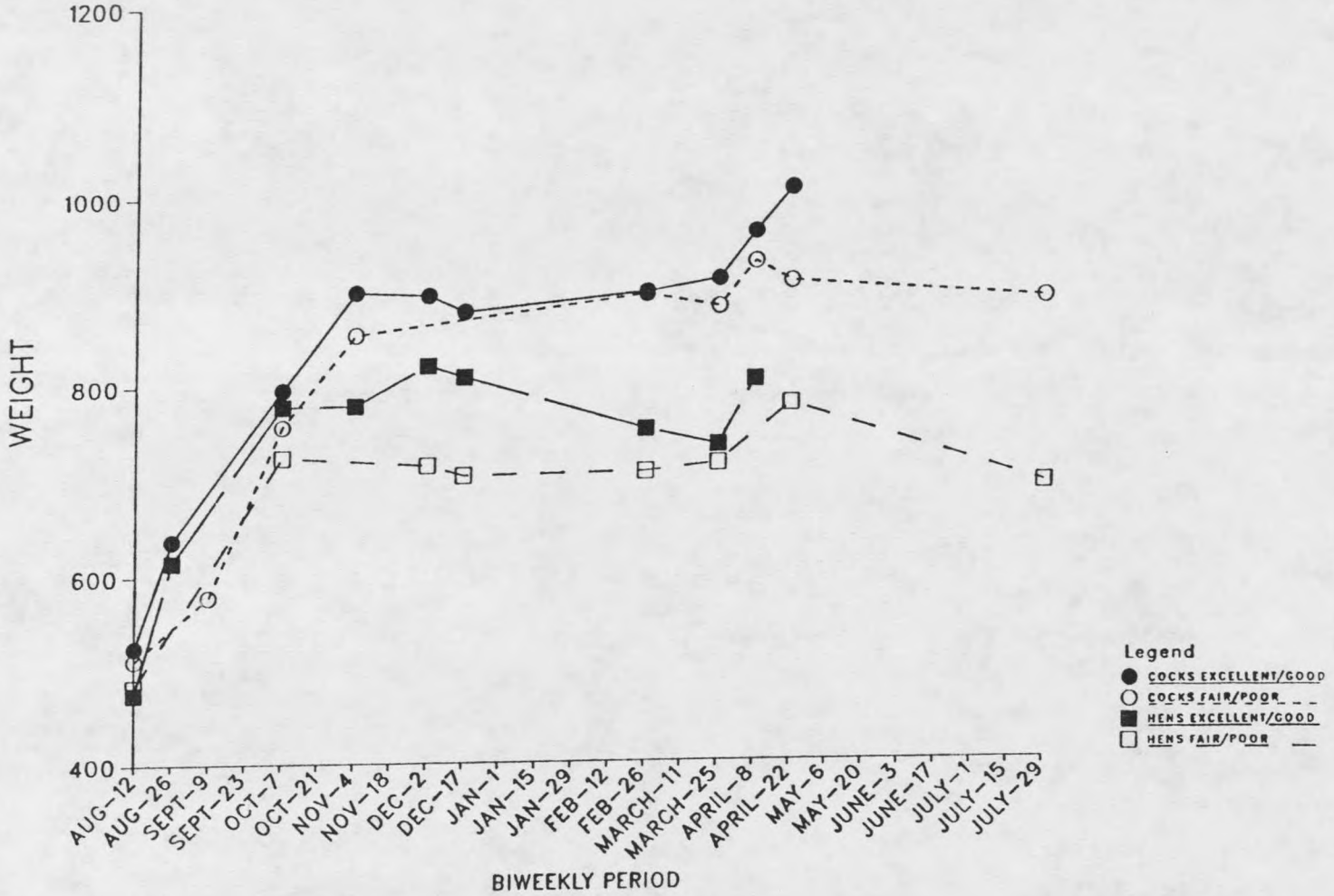


Figure 6. Mean biweekly weights (g) of pen-reared prairie chickens by sex and wing condition, Crex Meadows Wildlife Area, Wisconsin, 1974-76.

lower energy demands as a result of reduced movements and the constant presence of food inside the pen. Linden (1984) found that pen-reared capercaillie actually gained weight during winter. Seasonal ranges in weights of pen-reared birds overlapped and in some cases exceeded those of wild immatures. However, wild birds at the lower end of their weight range weigh 50-144 g more than the lowest weights of the pen-reared birds (Table 9).

Weight gain in pen-reared birds was a function of age, 60-328 days for cocks ($r=0.655$, $P=0.001$, $n=180$) and hens ($r=0.652$, $P=0.001$, $n=190$) and followed a logistic curve (Fig. 6). This growth pattern was similar to those reported for other bird species: redhead ducks, Weller (1957); bobwhite quail, Roseberry and Klimstra (1971); blue grouse, Bendell (1955), Redfield (1973); and capercaillie, Linden (1981, 1984). The mean weight gain from 8-28 weeks (early winter peak) in pen-reared prairie chickens was 369.4 g (41.2%) for cocks and 344.9 (42.1%) for hens (Fig. 5). Mean weight gain for three wild cocks 10 weeks old to the early winter peak was 366.5 (36.2%), while pen-reared cocks gained less weight over this same period, 257.5 g (28.8%). Although sample sizes were small, the trends suggest retarded weight development in young pen-reared prairie chickens (Fig. 5).

Mean weights of immature pen-reared birds were substantially less than mean weights of wild immatures

taken during the same spring period, 6 March-25 April. Pen-reared cocks weighed 127.6 g or 12.3% less, while the hens weighed 132.3 g or 15.3% less, than wild immatures (Table 14).

Mean weights of pen-reared prairie chickens varied directly with wing condition (Table 15). However, even the mean weights of the larger pen-reared cocks and hens in excellent wing condition were still 9.1 and 12.0% less, respectively, than their wild cohorts (Table 14). The reasons for the greater discrepancy in the mean weights between the pen-reared hens and wild hens, than between pen-reared cocks and wild cocks was not clear, but was believed to be related to dominance by larger cocks.

Little information is available on weights of prairie chickens in fall, but weights of immature prairie chickens from Kansas, (Horak 1985), averaged 917 g (n=236) for immature cocks and 788 g (n=160) for hens during the first week of November. Baker (1953) reported mean weights of 926 g (n=45) and 777.9 g (n=44) respectively for Kansas cocks and hens in October. These mean weights are 3.5-4.5% and 3.3-4.6% larger, respectively, than the mean weights of pen-reared cocks and hens in early November (Cocks 885.1 g, n=14, Hens 752.2 g, n=11) in this study.

Of all measurements taken, only breast circumference was different between pen-reared and wild prairie chickens (Table 14). This indicated that differences in weights

Table 14. Mean weights (g) and measurements of immature wild and pen-reared prairie chickens by sex. Number of birds are in parentheses.

	Cocks			Hens		
	Wild	Pen-reared	P	Wild	Pen-reared	P
Measurement						
Weight (g)[a]	1030.7(55)	902.8(128)	0.001	863.4(36)	731.1(147)	0.001
Weight (g)[b]	1030.7(55)	936.1 (19)	0.001	863.4(36)	760.1 (20)	0.001
Total length (cm)	45.0(13)	45.5(14)	0.134	43.9(9)	43.1 (5	0.098
Tail length (cm)	9.6(26)	9.6(42)	0.772	9.0(17)	8.9 (39)	0.881
Pinna length (cm)	7.6(20)	7.5(42)	0.630	3.9(31)	3.9 (28)	0.320
Bent tarsus (cm)	6.2(7)	6.5(6)	0.134	5.9(6)	5.8 (4)	0.827
Middle toe (cm)	4.9(7)	4.7(6)	0.224	4.8(6)	4.8 (4)	0.619
Breast circumference (cm)	28.0(21)	27.2(66)	0.001	25.8(19)	25.2 (86)	0.001
Breast circumference[b] (cm)	28.0(21)	27.5(15)	0.001	25.8(19)	25.5 (14)	0.041

[a] Weights and breast circumferences taken between 5 March and 30 April.

[b] Only birds in excellent wing condition.

Table 15. Mean weights (g) of immature pen-reared prairie chickens by sex and wing condition, Crex Meadows Wildlife Area, Wisconsin, 1974-76.[a]

	Wing Condition				
	Excellent	Good	Fair	Poor	Total
Cocks					
Fall 1974[b]	898.3 (9)[de]	838.3(38)[df]	780.3(14)[f]	795.8(7)[ef]	830.5 (68)
Fall 1975[c]	563.5(74)	543.4(18)	573.1 (8)	504.8 (4)	558.5(104)
Spring 1975	917.9 (4)	933.1(15)[d]	894.8(10)	891.3(29)[d]	904.6 (58)
Spring 1976	941.0(15)[d]	903.6(34)[f]	884.4(15)[de]	831.1 (6)[def]	901.3 (70)
Total Spring	936.1(19)[d]	912.7(49)[f]	888.6(25)[d]	881.0(35)[df]	903.1(128)
Hens					
Fall 1974[b]	791.8 (6)[dg]	781.0(10)[ef]	709.5(10)[df]	702.1 (4)[fg]	748.8 (30)
Fall 1975[c]	500.2(93)	490.9(23)	480.6(14)	490.5 (5)	496.4(135)
Spring 1975	749.5 (5)[df]	748.6 (5)	721.9(20)[d]	722.3(22)[f]	727.3 (52)
Spring 1976	761.9(16)[de]	743.2(45)[de]	711.7(17)[d]	701.1(17)[e]	733.2 (95)
Total Spring	758.8(21)[dg]	743.8(50)[ef]	717.2(37)[eg]	713.1(39)[de]	731.1(147)

[a] Means on same line with the same subscript are significant (P>0.05)
[b] Weights taken October 12-17, 1974.
[c] Weights taken two different groups 1 and 17 September birds approximately same age.

were not due to pen-reared birds being a smaller strain. Furthermore, there were no obvious differences in the fall and spring weights or measurements between F1 pen-reared prairie chickens and the offspring of wild cocks and second or greater generation pen-reared hens (Table 15). Breast circumferences, like weight, varied directly with wing condition classes (Table 16).

The breast circumference measurement would appear to provide the best index to differences in condition, as it was related directly to the size and development of the breast muscles. Owen and Cook (1977) found that the pectoral muscle of mallards averaged 21% of the body weight and was highly correlated with weight (r=0.92). The breast circumference measurement used here was also highly correlated with body weight (r=0.880, P=0.001, n=308). Accuracy of the breast circumference measurement was not known, but precision between first and second measurements was 2.3$\pm$2.1 mm (n=95), average error was -.06$\pm$0.37 mm and maximum error ranged from +7 to -3 mm , or less than 3% of the total length of the measurement. There was a very high correlation between first and second measurements (r=0.952, P=0.001, n=95).

Breast circumference measurements of the same individuals following a change in weight, were correctly detected in 44 of 49 cases (89.8%). Four of 5 birds whose weight changes were not correctly detected, experienced

Table 16. Mean weights and measurements of pen-reared progeny of South Dakota greater prairie chicken cocks and hens and wild cocks and pen-reared hens, Crex Meadows Wildlife Area, Wisconsin, 1975-76. Number of birds are in parentheses.

	Cocks			Hens		
	Off-spring Wild Hens & Cocks	Off-spring Pen-reared Hens & Wild Cocks	P	Off-spring Wild Hens & Cocks	Off-spring Pen-reared Hens & Wild Cocks	P
April Weight (g)	895.2(12)	901.4(31)	0.944	724.5(16)	734.5 (64)	0.599
Fall Weight (g)	556.2(17)	558.2(87)	0.847	515.5(16)	493.7(116)	0.149
Total length (cm)	45.0(13)	45.3 (18)	0.610	43.4 (9)	43.4 (14)	0.629
Tail length (cm)	9.6(30)	9.6 (50)	0.504	8.9(17)	9.0 (30)	0.303
Pinna length (cm)	7.6(29)	7.6 (50)	0.502	3.7(19)	3.9 (31)	0.146
Bent tarsus (cm)	6.2(7)	6.3 (11)	0.571	5.9 (6)	6.0 (8)	0.535
Middle toe (cm)	5.0 (7)	4.9 (11)	0.710	4.6 (6)	4.7 (6)	0.351
Total length (cm)	22.6(11)	22.6 (17)	0.860	21.8 (5)	21.9 (10)	0.906
April Breast circumference (cm)	27.1(12)	27.2 (31)	0.814	25.2(16)	25.3 (64)	0.356

weight losses less than 50 g. (Mean=44.4±14.5), the fifth bird lost 77 g. The mean change for the group was 70.5±42.5 g (n=44). Thus it appeared that the breast circumference measurement used in this study was not reliable in detecting weight losses of less than 50 g. Baldwin and Kendeigh (1938) pointed out that weights in larger birds may vary by 5% during the day due to the passage of undigested food. There is a daily weight cycle, with the minimum weight occurring just before feeding in the morning and the maximum after feeding in the evening. With the exception of birds received in the fall, pen-reared birds were usually weighed after they had fed in the morning. Wild birds were usually captured in the morning or afternoon before they had time to feed.

Gross (1932) found that the weight of the crop contents in prairie chickens averaged 25.7 g and could be as high as 83 g. In this study, crop contents ranged from 9-56 g (n=17). In central Wisconsin, 48 cocks and 47 hens were captured at the same time of day during winter, all with food in their crops, primarily kernels of corn. The mean weights of individuals estimated to have half to full crops were larger than those individuals with less than half full crops (Anova, df=3, P=0.001). Because of this added weight, all wild birds with half full or full crops, were excluded from the weight analysis (n=44). Birds captured on booming grounds or in the summer either had empty or at

most quarter-full crops.

The restriction of movement and the constant presence of food inside the pen, suggested that factors other than energy demands and limited food were responsible for differences in the mean weights of pen-reared and wild prairie chickens. Smaller breast circumferences in pen-reared prairie chickens suggested that the differences in weight were the result of reduced breast muscle development caused by a dramatic reduction in flying while inside the pen. This hypothesis is supported by the fact that both mean weights and breast circumferences of pen-reared prairie chickens increased with improving wing condition (Table 16 and Table 17). This may be the result of individuals in fair and poor condition getting less flight exercise. Observations of penned birds indicated that birds in fair and poor condition rarely used the taller perches inside the pen.

This idea was reinforced by weight gain from fall to spring when the birds in lower classes gained less weight (Table 18). Furthermore, weights of the 9-12 week pen-reared birds taken in the late summer, already showed a direct relationship between weight and wing condition (Table 16). Subsequent experiments with green pheasants (Toepfer unpubl. data), showed that weight development of young pheasants was retarded by clipping the flight feathers at various ages.

Table 17. Mean breast circumference (cm) of pen-reared prairie chickens by sex and wing condition, Crex Meadows Wildlife Area, Wisconsin, 1974-76. Number of birds in parentheses.

	Wing Condition		
	Excellent/Good	Fair/Poor	P
Cocks	27.3(45)	26.9(21)	0.001
Hens	25.4(53)	24.9(33)	0.002

Table 18. Overwinter weight gain (g) of pen-reared prairie chickens relative to wing condition 1975-76. Number of birds are in parentheses.

	Weight Gain			Percent Weight Gain		
Sex	Excellent Good	Fair Poor	P	Excellent Good	Fair Poor	P
Cocks	356.3(30)	314.1(16)	0.040	.67(30)	.59(16)	0.141
Hens	232.0(32)	189.2(29)	0.044	.49(32)	.41(29)	0.203

The smaller breast circumferences of pen-reared prairie chickens also implied that the breast muscles may be limited physiologically. Breast muscles of several dead pen-reared birds showed that they were lighter in color, than breast muscles of wild birds. No histological or chemical analyses were run, but a lighter color suggest a reduction in myoglobin and cytochrome in the muscle cells. The color of red muscle fibers is due primarily to these two oxygen carrying compounds (Welty 1975). A reduction in oxygen transport in the red fibers would increase muscle fatigue and reduce the strength and duration of flight. Once outside the pen, any physiological limitations in muscles would influence survival through the ability or desire to fly. This also suggests it would take time for the released pen-reared prairie chickens to overcome these physical deficiencies.

The higher survival rates and lack of scraped heads for penned birds in fair and poor wing condition further suggests that they were less likely to fly while inside the pen. Lastly, observations made at the pen suggests that individual birds in poor condition were aware that they could not fly and ran from danger. Experiments with Japanese green pheasants corroborate this idea of modification of flight behavior as only 9% (n=44) of the individuals that had their flight feathers clipped a month earlier, attempted to fly when released singly into a new

pen. This was in contrast to birds whose flight feathers were clipped just prior to release where 83% (n=66) attempted to fly unsuccessfully before running to the opposite end of the pen (Toepfer unpubl. data). This type of flight response would result in a further reduction in the use of their wings and breast muscles. In short, birds are aware of their flying abilities and modify their behavior accordingly.

A decline in weight and muscle size due to reduced flying occurred when wild birds were placed in pens. In this study weight loss was observed in the wild and pen-reared birds sent to Jamestown to supplement their breeding flock. The wild birds were wing clipped to prevent flying in the pens. Both pen-reared and wild hens produced eggs. However, for reasons unknown, the eggs from wild hens were infertile. These birds were returned to Crex on 1 August, 1975 and all were regrowing flight feathers. All of the wild birds lost weight as did 11 of the 14 pen-reared birds but pen-reared hens lost less than the wild hens (2.1 g, n=13 versus 78.6 g, n=8). Most of the weight loss was attributed to a reduction in the breast muscles as breast circumferences declined more in the wild birds than the pen-reared birds. Hens and cocks in the wild typically lose weight from February to August (Fig. 4). However, they lose only 5-7%, rather than the 11-18% observed when held in pens. Because both types of birds were treated in a similar manner

greater weight loss in wild birds was attributed to the adjustment to the pen and lack of flying exercise.

The amount of time it takes for the muscles of wild prairie chickens to atrophy once placed in pens is not precisely known, but Hamerstrom et al. (1941) reported a 10-12% loss in 7-44 days. Kabat et al. (1956) found that in starvation studies, wild pheasant hens lost more weight (30-31%) than pen-reared hens (18-20%). Thus a minimum amount of flying exercise is necessary for prairie chickens and other species to develop and maintain normal weight and breast muscle condition and size. This minimum is not met in a penned environment.

The influence of density on the physical development of penned prairie chickens is not known. Morrow et al. (1980) and Robel et al. (1981) found that increased density in penned bobwhite quail increased activity and reduced weight gain in males, but in females only when separated from males. This did not appear to be the case in this study as density was highest in 1976 when both sexes were mixed together and mean weights of both sexes in 1976 were similar to those in 1975 (Table 11).

It is evident that the weight and development of the breast muscles and probably the flying ability of prairie chickens was dramatically reduced by being in a penned environment. The effects of the lower weights on reproduction in pen-reared hens was not known, but lower

weights would probably put these hens at a considerable disadvantage when normal weight loss occurred during egg-laying and incubation. Clutch sizes of pen-reared birds appeared normal (Mean 11.3±2.3, n=9), but only 1 of 9 hens known to nest, hatched eggs. She lost her brood within a week. Three other pen-reared hens abandoned nests during incubation. Abandonment during incubation was was less than 5% for wild prairie chickens.

The difference in weight and breast muscle size between wild and pen-reared prairie chickens raise questions about the physical condition of other pen-reared animals, particularly those species that fly often or move over large areas. This lack of muscle development accompanied by an abundance of food also raises questions about the validity of physiological information collected from birds. If pen-reared animals are to be used successfully in reestablishing populations, more and better information is needed on the behavioral, genetic and physiological differences between penned and wild animals.

Population Trends

Booming Ground and Winter Counts 1974-75

No prairie chickens were observed at Crex during the fall or winter following the initial release of pen-reared birds in October 1974 and April 1975 and subsequently no booming cocks were heard or observed in late March or April

before the 1975 or 1976 April releases.

A maximum of 13 displaying cocks were observed on 2 booming grounds following the gentle release of 36 cocks on 18 April, 1975. Eight cocks displayed at the open release pen (5 inside and 4 outside) and 5 in a rye strip 0.4 km southeast of the release pen. The 4 cocks inside the pen occupied the same territories they used before their release. Individual displaying cocks began to disappear after 22 April. In 5 instances they were replaced by individuals that had not been observed displaying or defending territories, which suggested the existence of a non-territorial cohort in pen-reared birds similar to that reported for wild grouse (Grange 1948, Dorney and Kabat 1960; Jenkins et al. 1963, Watson and Jenkins 1967; Robel 1969; Rusch and Keith 1971; Ballard and Robel 1974, Zwickel 1980, Gullion 1981).

By 13 May, 25 days after their release no cocks displayed at or in the release pen. A second booming ground located to the southeast of the pen, started with 2 cocks (1 radio-tagged) on 25 April, increased to a maximum of 5 (1 radio-tagged) by 29 April, declined to 3 by 4 May, 2 on 16 May and finally 1 on 17 May. This remaining bird displayed through 27 May and was found dead 0.3 km west of the booming ground the next day. No cocks were observed or heard after 30 May in 1975. Wild prairie chicken cocks in central Wisconsin usually displayed until late June.

Booming Ground and Winter Counts, 1976

All transplanted wild birds were released 7-10 days before the pen-reared birds in 1976. The presence of 77 hens and the displaying pen-reared cocks inside the pen attracted and apparently held the transplanted wild cocks in the pen area. One wild cock displayed intensely at the holding pen on 12 April, the morning following his release. The next morning, 2 days after their release, 3 wild transplanted cocks (1 radio-tagged) displayed and fought with the pen-reared cocks through the wire sides of the pen. A total of 9 of 19 transplanted wild cocks, at most 7 on 19 April, displayed at the pen between 12 and 21 April. In all, 79% (15 of 19) of the transplanted wild cocks (6 of 7 radio-tagged) were eventually observed displaying at 5 separate locations within 0.8 km of the pen between 12 April and 31 May, in 1976.

After the release of the pen-reared birds (50 cocks and 77 hens) on 23 April, the number of cocks displaying in and around the open pen increased from the 4 regular wild cocks (2 radio-tagged) to a maximum of 18 cocks (4 wild, 3 radio-tagged) and then declined to 2 wild and 1 pen-reared cock (1 of each type radio-tagged) by 19 May. Twelve of the 16 released pen-reared cocks occupied the same territories inside the pen as they did before their release. The discrepancy in total numbers is due to 12

cocks, (4 territorial) being released 0.6 km northwest of the pen site. As happened in 1975, different pen-reared cocks replaced some of the displaying cocks that disappeared or died.

At least 7 of these new replacement displayers had not been observed defending territories and 3 of the 7 were never observed displaying before being released from the pen. These cocks established on the periphery of the pen and in 2 instances moved into unoccupied territories inside the open pen. The wild cocks displayed and defended territories along the edges of the pen both before and after the sides of the pen were raised.

A booming ground of 6 cocks (1 wild and 2 pen-reared radio-tagged) developed 0.3 km southeast of the pen by 28 April in the vicinity of the 1975 booming ground. This ground reached a maximum of 10 cocks (3 wild and 1 pen-reared radio-tagged) on 4 May. Several of these cocks (2 wild and 1 pen-reared) had originally displayed at or in the pen and shifted to this location. On 5 May, this booming ground broke up and from this date on the displaying pen-reared and wild cocks changed locations and appeared to follow single or small groups of pen-reared hens feeding in the agricultural area adjacent to the pen. In addition to the cocks displaying at the pen area, 2 other stable booming grounds developed in the refuge in 1976. One booming ground with 3 wild cocks and a pen-

reared cock developed in agricultural fields, 1.2 km northwest of the release pen, while a single wild cock established on a dirt road 0.6 km northwest of the pen.

Fall and winter observations of feeding prairie grouse in 1976-77 indicated that in addition to 100-120 sharptails there were 45-50 prairie chickens using the Crex refuge.

Booming Ground Counts 1977

At least 16 regular prairie chicken cocks were observed displaying on 4 booming grounds at Crex in April 1977. Six of these cocks were banded wild transplants and only 1 was a banded pen-reared bird released in April 1976. The largest booming ground was located in a sedge marsh 0.5 km north of the release pen and totaled 8 cocks (2 wild transplants and 6 unbanded). These birds displayed on top of the vegetation (Carex spp.) matted by ice and snow over 0.6-1 m of water. A second booming ground with 4 regular cocks (3 wild and 1 pen-reared) was located 50 m southeast of the old pen site and 2 other cocks, both banded transplants displayed alone 0.6 km southeast and 0.3 km northwest of the pen. The last 2 cocks, also banded 1976 transplants, displayed with 7 sharptail cocks in a sedge marsh 2 km northeast of the old pen site.

Post Release Populations 1978-87

The post release populations of booming cock prairie chickens on the Crex Meadows Wildlife Area varied from a

high of 25 on 3 booming grounds in 1978 to a low of 3 on 1 ground in 1987 (Table 19). The number of individual hens observed on grounds varied from 5 in 1978 to 1 in 1983 and at least 1 was observed every year during the spring censuses.

The populations from 1979 on were probably native birds, as the last known banded prairie chicken, a cock disappeared over the winter of 1978-79. Figure 7 shows the locations of prairie grouse display grounds on the Crex Meadows Wildlife Area, 1975-87. Figure 8 shows changes in the spring prairie chicken and sharptail cock counts for the 16 year period, 1972-87.

The reason for the decline from 19 cocks in 1981 to 11 in 1982 is not known. However the sharp-tailed grouse season was reopened in the eastern portion of Crex in the fall of 1980 and the winter of 1981-82 was severe with deep snows and and cold temperatures. Either or both of these factors could have contributed to the drop in prairie chicken numbers in 1982. In addition to prairie chickens, sharptail, ruffed grouse and pheasants also declined from 1981 to 1982.

The drop in prairie chicken numbers from 19 in 1981 to 2 in 1987 was believed to be due to changes in habitat as the amount of upland grass in the refuge area decreased 23.4%. In addition, brush encroachment from 1981-86 altered cover in many areas from grass-shrub to shrub-grass.

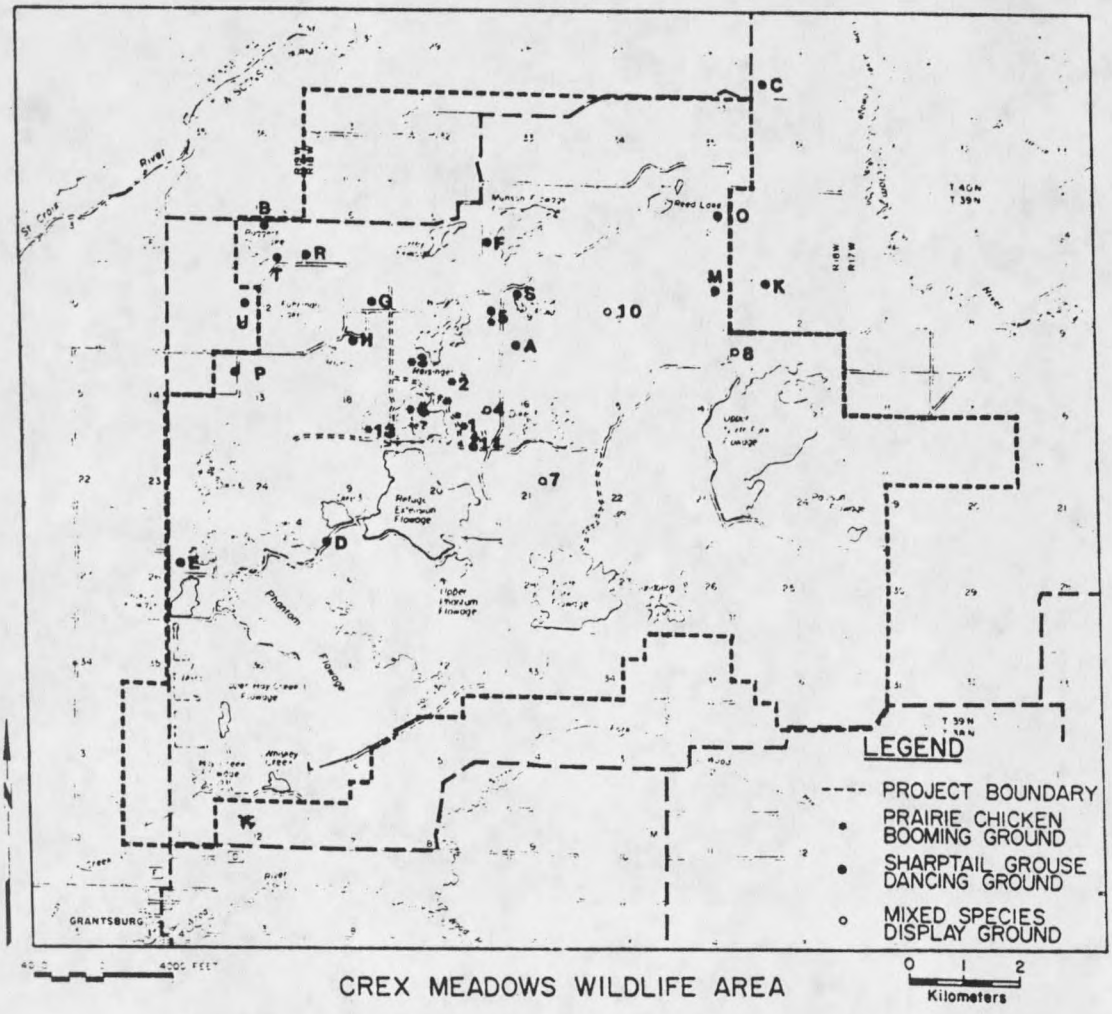


Figure 7. Distribution of sharptail dancing grounds and prairie chicken booming grounds, Crex Meadows Wildlife Area, Wisconsin, 1975-87.

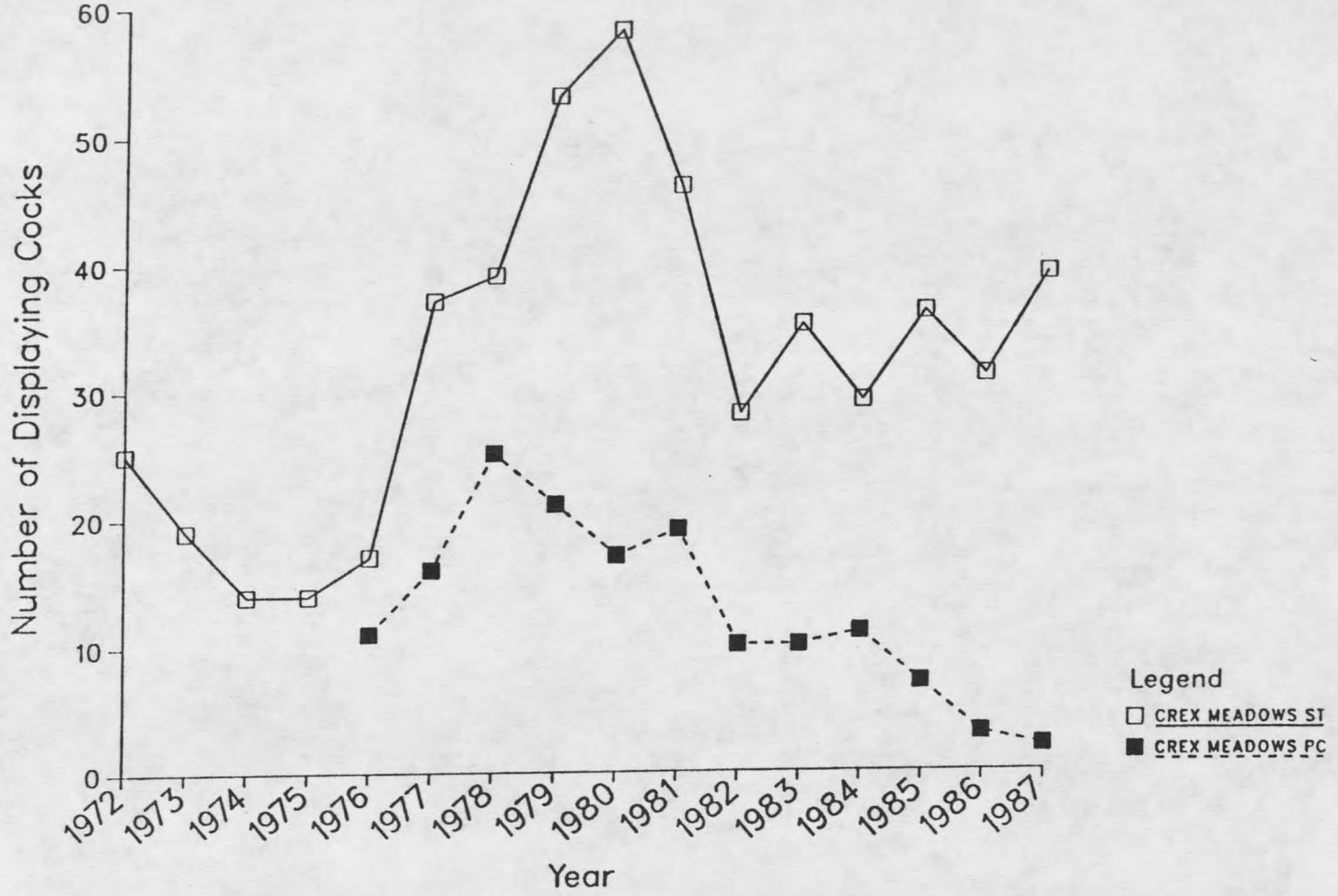


Figure 8. Spring counts of prairie chicken cocks on booming grounds and sharptail cocks on dancing grounds, Crex Meadows Wildlife Area, Wisconsin, 1972-87.

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Table 19. Summary of spring booming, dancing ground and crowing pheasant counts, Crex Meadows Wildlife Area, Wisconsin, 1972-87.

Year	Prairie Chicken Cocks	No. of Booming Grounds	Sharptail Cocks	No. of Dancing Grounds	N mixed Display Grounds	PC X ST Hybrids	Ratio ST/PC	Pheasant Cocks
1972	0	0	25	4	0	0	0	0
1973	0	0	19	5	0	0	0	0
1974	0	0	14	2	0	0	0	0
1975	13-0	2	14	3	0	0	0	0
1976	0-29-11	0-4	17	7	0	0	1.6	0
1977	16-18	6	37-45	10	1	0	2.3	1
1978	25-26	3	39-44	11	1	1	1.6	1
1979	21	4	53-59	10	1	1	2.5	1
1980	17	3	58-63	13	1	1	3.6	2
1981	19-20	4	46-49	9	1	1	2.4	4
1982	10-11	4	28-34	10	0	0	2.8	2
1983	10	4	35-41	9	0	0	3.5	3
1984	10-11	2	29-34	7	1	0	2.9	0
1985	7-8	2	36-38	9	1	2	5.1	0
1986	3-4	2	31-34	7	1	2-3	10.3	0
1987	3	2	39-42	9	1	1	13.0	0

Large blocks of woodland have been cleared since 1981 creating more open space and potential grassland, but this clearing and burning has initially created more brushland allowing the sharptails to increase their range 35% approximately 35%. Burning once every 3-5 years depending upon weather and work load almost precludes maintaining enough upland grass for prairie chickens. Under the present management practices the Crex Meadows Wildlife Area is better suited for sharp-tailed grouse.

A single prairie chicken X sharptail hybrid was observed each spring from 1978-1981. It was believed that this was 1 individual that survived for 4 years. No hybrids were observed from 1982-1984. Two hybrids were observed in 1985 and 3 in 1987. This increase in the number of hybrids coincided with habitat changes and a decline in the number of prairie chickens coupled with an increase in the ratio of sharptails to prairie chickens (Table 19).

Sharp-tailed Grouse Populations 1972-87

The sharp-tailed grouse population at Crex varied from a low of 14 cocks on 3 grounds in 1974 and 1975 to a high of 63 cocks on 13 grounds in 1980 (Table 20 and Fig. 9). In 1976, the sharptail grouse hunting season was closed on Crex to protect the released prairie chickens. However, at least 4 sharptails were known to have been harvested in 1978 on county land adjacent to the closed area. In

Table 20. Comparison of annual spring dancing ground counts (cocks) between the area open to sharptail grouse hunting with the area closed to hunting, Crex Meadows Wildlife Area, Wisconsin, 1972-87.

Year	Area Open to Sharptail Hunting 1980-87	Area Closed Sharptail Hunting 1980-87	Total
1972[a]	-	-	25
1973[a]	-	-	19
1974[a]	-	-	14
1975[b]	8	6	14
1976[b]	10	8	18
1977[b]	30-33	7-12	37-45
1978[b]	21-22	18-22	39-44
1979[b]	34	19-25	53-59
1980[c]	34-37	24-26	58-63
1981[c]	23	24-26	46-49
1982[c]	10	18-23	28-34
1983[c]	7	27-36	35-41
1984[cd]	1	28-33	29-34
1985[cd]	3-4	33-34	36-38
1986[cd]	3-4	28-30	31-35
1987	3	36-39	39-42

[a] All of Crex Wildlife Area open to sharptail hunting except refuge.

[b] All of Crex Wildlife Area closed to sharptail hunting.

[c] Eastern portion of Crex Wildlife Area open to sharptail hunting.

[d] At least 7-11 cocks displayed along NW border of closed area. These birds included in closed area for 1984 and 1985 as hunters were not aware of the birds in this area during the 1983 and 1984 seasons. This area closed to hunting stating fall of 1985. Note two birds harvested on private land fall 1985.

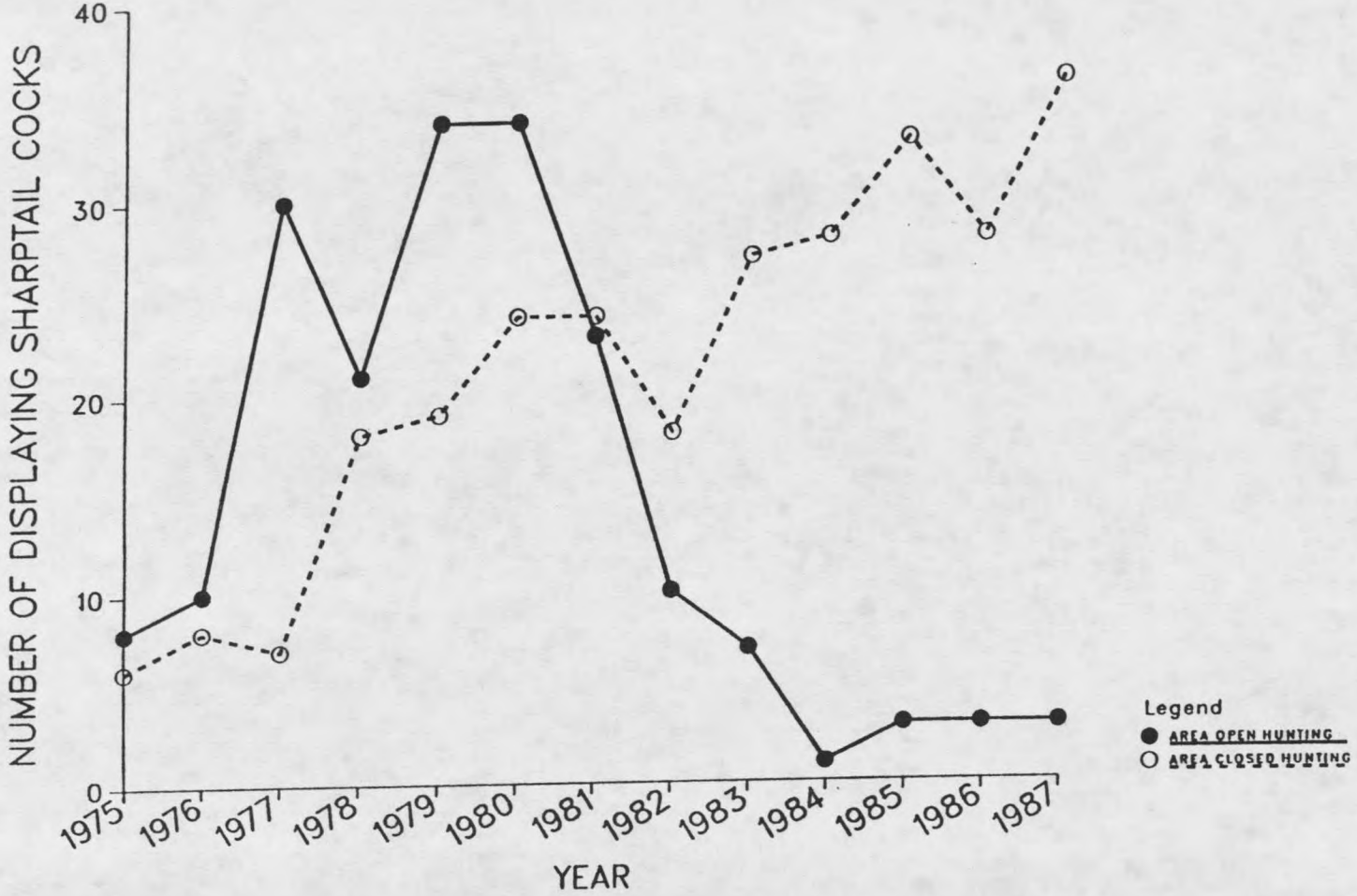


Figure 9. Spring counts of sharptail cocks on dancing ground in the areas open and closed to hunting, Crex Meadows Wildlife Area, Wisconsin, 1974-87.

addition to the legal harvest, 5 prairie chickens in 1976 and 1 sharptail and a prairie chicken in 1977 were known to have been shot in the closed area. In 1980 the sharp-tailed grouse season was reopened in the area east of Reeds Lake in the northeastern corner of the Crex Meadows.

During the 5 years (1975-79) preceding the reopening of a portion of the Crex Meadows Wildlife Area to sharptail hunting, the dancing ground counts increased from 8-34 cocks in that area. The closed area increased from 6-24 cocks (Table 20, and Fig. 9). The higher number of cocks in the closed area suggested it may contain better habitat.

After 2 hunting seasons the total dancing ground counts at Crex reached a low of 28 cocks, a decline of 51.7% and after 7 seasons (1980-86) the population declined 36.2%. The lower decline over the 7 year period was believed to be due to the influences of the 10-year cycle and expansion of the population due to prescribed clearing and wildfire.

The area open to hunting experienced the greatest decline as the number of cocks declined 70.5% (34-10) during the first 2 years of hunting, and the closed area declined only 25% (24-18). Over 7 hunting seasons the number of cocks in the area open to hunting declined 91.2% (34-3 cocks), and the closed area increased 14.3% (24-28 cocks). If the dancing ground counts from recently acquired range are excluded and only counts from the

originally occupied range are used, then the closed area increased 33%. It is unlikely that these changes in numbers of cocks were due to movements of birds to the closed area. Movements of radio-tagged and banded birds showed that there was very little exchange between the 2 areas. (Toepfer unpubl. data, Gratson 1983, and Larry Greg pers. comm.).

Yearly harvest data from Crex are limited, but figures provided by the local manager (Paul Kooiker pers. comm.) indicated that in 1982, 25-30 sharptails were shot on Crex and adjacent county land. These figures do not include adjustments for crippling losses. Assuming an equal sex ratio, 50% nesting success and 5 chicks fledged per successful hen the 1982 harvest figure could represent as much as 56-67% of the fall population in the area open to hunting.

Whether hunting is solely responsible for the decline in sharptail numbers is not known, but is implied by the data presented here. Other studies on prairie grouse have reported similar effects of hunting on isolated prairie grouse populations. Ammann (1963) studying an isolated sharptail population on Drummond Island found that the number of cocks increased in the springs following closed seasons and decreased following open seasons. Baker (1953) working on prairie chickens in Kansas, felt that declines were less in areas where hunting was prohibited and/or

hunting pressure was reduced, and he felt that it was possible to place excessive pressure on isolated prairie chicken populations.

The best data on the influences of hunting on an isolated prairie grouse population come from earlier work in central Wisconsin by Hamerstrom and Hamerstrom (1973). Because of the limited number of areas available to hunt prairie chickens, the Buena Vista attracted a large number of hunters in 1951 (F. N. Hamerstrom pers. comm.). Results from their banding studies indicated that hunting increased normal mortality by 25% during the last open season in 1951.

There have been many early studies on the effects of hunting on bird populations which have made comparisons between populations in areas open and closed to hunting (Errington and Hamerstrom 1935, Baumgartner 1944a, Glading and Sarni 1944, Leopold 1945, Allen 1947, Bennitt 1951, Palmer 1956, Marsden and Basket 1958, Palmer and Bennett 1963, Wagner et al. 1965 and Campbell et al. 1973). All of these studies found that hunting did not depress the populations and/or that hunting pressure was self-regulating. However, these studies were all conducted 25-40 years ago and were conducted on species with wide distributions in contiguous habitat and in areas with relatively moderate hunting pressure. However, the effects of hunting on bird populations under present day habitat

conditions and hunting pressure could be different.

More recently Bergerud (1985) reviewed the effects of hunting mortality on grouse and concluded that hunting was additive and depressed grouse populations where restricted space made the whole population accessible to hunters. Under these conditions the number of colonizers available to rebuild numbers becomes reduced and losses due to hunting cannot be compensated for by the surviving birds. Likewise, Kubsiack (1984) found that ruffed grouse numbers were depressed within a quarter mile of roads where hunting pressure was heaviest.

All populations do not have the same threshold of security where sport hunting is concerned. A similar phenomenon often called a "burnout" has been well documented in waterfowl. This occurred where heavy hunting pressure on local populations dramatically reduce the subsequent breeding population (Hochbaum 1947 and Sowls 1955). However, because of the migratory nature and wide distribution of waterfowl, areas suffering overharvest can be replenished from adjacent areas. This is not the case with resident species of low mobility where the nearest population may be beyond the annual cruising radius of the species involved. However, even in waterfowl, distributions have become limited as they are confined to wetland areas where hunting pressure is concentrated. In Minnesota, Jessen (1970) found that highly restrictive

regulations resulted in a reduction in the harvest, increased survival of local mallards and that within large refuge areas, survival and subsequent production of mallards was higher than on non-refuge areas. It appears that hunting can also become additive in waterfowl.

The data presented here and by other grouse researchers suggest that concentrated hunting pressure on isolated populations in limited and/or marginal habitat can increase mortality and depress the population. In view of the tremendous decline in available wildlife habitat since the 1950's and 60's and/or the increase in hunting pressure, it appears that hunting may become additive in certain resident and migratory species where habitat and distribution are limited. Under such conditions any threshold of security usually provided by habitat will be overcome by a large number of hunters in a small area. With regard to sharptails, Ammann (1963) went so far as to recommend that closed seasons could be used as a management tool where populations were low and hunting pressure heavy. Baker (1953) recommended establishing refuges or regulating the number of hunters by special permit to achieve a better distribution of hunting pressure.

Finally, there is one important aspect of hunting that is usually ignored in the management of game birds--harvests usually increase the percentage of immatures in the population. In grouse, adults typically lay more eggs

than immatures and in prairie chickens, adults were more likely to renest and fledge chicks (See Condition Section). This means that whenever an adult is harvested in the fall it will likely be replaced in the spring breeding population by a less productive immature. Thus the overall reproductive potential of the population is reduced not because of fewer hens or poor habitat, but subtly through a change in age ratios. The effects of hunting on isolated populations and the influence of hunting on age ratios and reproduction in game birds needs to be explored in more detail under present day conditions.

Predator Suppression

Predator suppression was minimal except for the removal of owls which visited and harassed the birds in the pen. A total of 19 great horned owls (13 in 1974-75 and 6 in 1975-76), 7 snowy owls (Nyctea scandiaca), 2 short-eared owls (Asio flammeus), 1 long-eared owl (Asio otus), 1 goshawk (Accipiter gentilis), 1 red-tailed hawk (Buteo jamaicensis), and 1 Cooper's hawk (Accipiter cooperi) were captured alive and removed from the pen area from November 1974-June 1976. One Cooper's hawk and a red-tail were captured with bal- chatris approximately 0.8 km from the pen in April 1976.

A total of 210 manhours of upland trapping within 1.6 km of the pen in the spring of 1976, resulted in the capture of 4 mink, 3 raccoons, 1 skunk (Mephitis mephitis) 11

thirteen-lined ground squirrels (Spermophilus tridecemlineatus), 5 Franklin's ground squirrels (Spermophilus franklini), 1 mallard and 1 wild cock prairie chicken. The 2 birds were released alive. In addition to the trapping, 21 mink dens were smoked and 1 mink was shot at the pen.

Both the mammalian and raptor trapping were done by inexperienced personnel. It was believed that the predator suppression effort had little influence on the local predator populations, as mink, red fox, badgers (Taxidea taxus), coyotes (Canis latrans), short-tailed weasels, ground squirrels and raptors were still observed in the vicinity of the release pen.

Releases

Two hundred twenty-three pen-reared prairie chickens (131 cocks, 92 hens), 10 semi-wild birds (1 cock, 9 hens), and 60 wild-trapped prairie chickens (29 cocks, 31 hens) were released on the Crex Meadows refuge during this study. Nine separate releases were made during the 3 years September 1974 to September 1977 (Table 21). Appendix Table 72 summarizes release chronology, numbers, type, sex, and age of the released birds. In addition, to the scheduled releases, 5 radio-tagged hens that moved away from Crex after their initial release, were recaptured by nightlighting and released at Crex a second time on 16 August 1976, 12 and 13 May and 2 on 18 August 1977.

Table 21. Total number of prairie chickens released by type, sex, and age at Crex Meadows Wildlife Area, Wisconsin, 1974-77.

Type	Number	Sex		Age				Number Radio-tagged		
				Cocks		Hens				
		Cocks	Hens	Ad	Imm	Ad	Imm	Cocks	Hens	Total
Pen-reared	236	130	106	1	130	14	92	34	21	55
Semi-wild	10	1	9	1	0	9	0	0	3	3
Wild Wisconsin	31	19	12	17	2	11	1	7	7	14
Wild Minnesota	29[a]	10	19	10	0	5	14	6	10	16
Total wild	60	29	31	27	2	16	15	13	17	30

[a] 30 released, but 1 hen collected with broken wing.

Radio Locations

A total of 14,417 radio locations were obtained from 83 wild and 55 pen-reared radio-tagged prairie chickens. In central Wisconsin, 8,374 radio locations (5,694 day and 2,680 night) and 8,122 bird days were obtained from 54 resident radio-tagged wild birds during the period March 1972-April 1976; 1,791 of these locations were collected and provided by Lowell Tesky (unpublished data). The 29 radio-tagged prairie chickens transplanted to Crex Meadows yielded 4,713 radio locations in 4,614 bird days from April 1976- June 1978; 4,067 (3,252 day and 1461 night) were collected from transplants after they established and became residents of the Crex area. The 55 radioed, pen-reared prairie chickens yielded 1,330 radio locations (931 day and 399 night) in 775 bird days.

Only residents and transplants surviving for 10 or more days were included in the analysis. None of the radio-tagged semi-wild and pen-reared birds released in August 1975 survived longer than 3 days, and data from these birds were not used in this study. Tables 22 and 23 present radio locations and bird days data by year, study area and sex for the radio-tagged pen-reared and wild prairie chickens.

Table 22. Number of radio locations and bird/days by season and year for radio-tagged pen-reared prairie chickens, Crex Meadows Wildlife Area, Wisconsin, 1974-76. Number of radio-tagged birds in parentheses.

Season	Year	Number of radio locations		Total Locations	Bird Days
		Cocks	Hens		
Fall	1974	187 (8)	0	187	116
Spring	1975	210 (8)	97 (6)	307	133
Summer	1975	0	34 (9)	34	34
Fall	1975	85 (4)	0	85	49
Spring	1976	272 (9)	445(10)	717	443
Total Pen-reared		754(30)	576(22)	1330	775

Table 23. Number of radio locations and bird/days by year and study area for radio-tagged prairie chickens, 1972-78. Number of radio-tagged birds are in parentheses.

Study Area	Dates	Year	Cocks	Hens	Total	Bird Days
Central Wisconsin	02/15-12/31	1972	1866	1766	3632	3054
Central Wisconsin	01/01-03/21	1973				
	03/28-12/31	1973	735	0	735	1148
Central Wisconsin	03/21-12/31	1974	1932	1858	3790	3715
Central Wisconsin	01/01-03/29	1975				
	01/18-04/01	1976	114	103	217	205
Total Central Wisconsin			4647(29)	3727(25)	8374	8122
Crex Meadows	04/11-12/31	1976	1523	898	2421	2116
Crex Meadows	01/01-03/15	1977				
	04/18-12/31	1977				
	01/01-06/30	1978	451	1841	2292	2498
Total Crex Meadows			1974(12)	2739(17)	4713	4614
Grand Total			6621	6466	13,087	12,736

Survival

Seasonal Survival

Wild Birds. Seasonal survival of radio-tagged prairie chickens is presented in Table 24. Survival was calculated only for radioed birds alive within 10 days of the start of a season. Data from central Wisconsin (1972-76) and Crex (1976-78) were combined to examine seasonal and period survival of resident radio-tagged prairie chickens. At Crex, only those transplanted birds that became established residents were used to calculate survival.

Seasonal survival of radio-tagged adult wild prairie chickens was highest in the summer and fall (73%) and lowest in the winter (41.9%). Survival during spring, summer and fall was relatively similar (69-73%) and points out the influence that cold, snow and reduced cover have on prairie chicken survival. Radio-tagged hen pheasants in southern Wisconsin also exhibited the lowest seasonal survival during the winter (61.3%) (Dumke and Pils 1973).

The seasonal survival of prairie chickens varied with sex in both areas (Table 24). Winter survival was higher for hens than cocks (53.8% versus 33.8%), probably a result of greater mobility and a greater ability to survive the stress of food shortages. Cocks appeared to remain close to their booming ground in fall while hens were not associated with any specific booming ground in fall and

Table 24. Seasonal survival (%) of resident radio-tagged greater prairie chickens central Wisconsin, 1972-75 and Crex Meadows Wildlife Area, Wisconsin 1976-1978.

	Cocks			Hens			Total		
	Alive Start Period	Alive End Period	Survival	Alive Start Period	Alive End Period	Survival	Alive Start Period	Alive End Period	Survival
Winter									
Central Wisc.	13	4	30.8	7	3	42.8	20	7	35.0
Crex Meadows	5	2	40.0	6	4	66.6	11	6	54.5
Total	18	6	33.3	13	7	53.8	31	13	41.9
Spring									
Central Wisc.	12	9	75.0	5	3	60.0	17	12	70.6
Crex Meadows	2	2	100.0	4	2	50.0	6	4	66.6
Total	14	11	78.5	9	5	55.6	23	16	69.6
Summer									
Central Wisc.	23	17	73.9	15	9	60.0	38	26	68.4
Crex Meadows	7	5	71.4	7	7	100.0	14	12	85.7
Total	30	22	73.3	22	16	72.7	52	38	73.1
Fall									
Central Wisc.	18	14	77.7	9	6	66.7	27	20	74.1
Crex Meadows	7	5	71.4	7	5	71.4	14	10	71.4
Total	25	19	76.0	16	11	68.8	41	30	73.2
Mean Central Wisconsin			64.4			57.4			62.0
Mean Crex Meadows			70.7			72.0			69.6
Total Mean			65.3			62.7			64.5

moved when conditions deteriorated. The lower survival of cocks during winter may have been influenced by occasional visits to the booming grounds in early February.

The lower survival of hens during the spring (55.6% versus Cocks 78.5%) and summer was related to the rigors of nesting and raising young. Some hens did not raise young, but all attempted to nest. Because annual survival of cocks and hens was similar (Hamerstrom and Hamerstrom 1973, This study), the lower survival of hens during breeding season appeared to be compensated for by higher survival during winter.

Information on winter survival of prairie chickens which were trapped during the winters of 1972-76 in central Wisconsin supported winter survival data from radioed birds. Winter survival of banded cocks captured during the period 25 December-7 January (1974-76) was 36.0% (Adults 38.1%, n=63, Immatures 34.2%, n=76) and varied from 29.7% to 68.4%. The total figures were within the range of winter survival of radioed cocks (30-40%). Survival of banded hens was 37.2% (Adults 36.8%, n=19, Immatures 38.5, n=13). Survival data for hens must be considered low because our booming ground observations concentrated on identifying banded cocks.

Using the mean winter survival of banded cocks (52.8%), spring, summer and fall survival of cocks would have to have been 95% to yield the mean annual survival of

47.1%. It thus becomes apparent that the declines recorded in central Wisconsin in 1972-76 were related to reduced survival, especially in winter.

Pen-reared Birds. Seasonal survival of the released radioed pen-reared prairie chickens was very low. Spring survival was 11.1% with no summer survival and none of the birds released in the late summer or fall survived past November 15.

Transplanted Birds. All of the radioed transplants survived their adjustment periods. Total survival during orientation was 64.4%, (77.8% [n=9]) for cocks and 58.8% [n=17] for hens). Survival was higher for cocks because their orientation periods were shorter and their movements were less than hens. Survival of hens that left Crex during orientation was 33% (n=12) and 100% (n=4) for those that returned to Crex or did not move away. Extensive wandering movements through unfamiliar areas were believed to be responsible for the high mortality. Once the birds established new ranges, survival increased to 83.3% (n=6). The birds transplanted in the summer exhibited short orientation periods and survival was 85.7% (n=7).

None of the radio-tagged transplants were killed during the spring while on the Crex area. The large number of pen-reared birds released in 1976 may have served as a buffer and improved the survival of the transplants. However, survival of the transplanted hens

that remained at Crex in 1977, when no pen-reared birds were released, was 100%. The critical factor in achieving high survival of transplanted prairie chickens is function of restricting movements away from the release site.

Period Survival

Wild Birds. Comparisons of survival during the breeding season showed that survival of cocks was higher than hens (71.4% versus 59.4%). Comparisons of hen and cock survival during the breeding season in central Wisconsin showed that survival of hens was lower during all periods except prenesting (66.7 versus 58.8%) (Table 25). The pattern did not hold for Crex, where sample sizes for hens were small. However, data from North Dakota (Toepfer and Newell unpubl. data) also showed higher survival of radio-tagged hens than cocks during prenesting (85.0% versus 73.7). The lower survival of cocks during this period may be related to the attraction of migrating raptors to the displaying cocks during this period.

Comparisons between survival of cocks and hens were made by selecting comparable time periods to represent the reproductive periods of the hens during the breeding season (Prenesting,--1 April-30 April, Egg-laying--22 April-15 June, Incubation,--22 April-30 June and Brood Rearing--10 June-15 Sept). Survival of hens during egg-laying and incubation was 12-20% lower than cocks during comparable periods (Table 25). During egg-laying hens became solitary

Table 25. Survival (%) for selected periods for resident radio-tagged prairie chickens central Wisconsin, 1972-75, Crex Meadows Wildlife Area, 1976-78.

	Hens			Cocks		
	Alive Start Period	Alive End Period	Survival	Alive Start Period	Alive End Period	Survival
Prenesting[a]						
Central Wisc.	15	10	66.7	17	10	58.8
Crex Meadows	4	2	50.0	6	5	83.3
Total	19	12	63.2	23	15	65.2
Egg-laying[b]						
Central Wisc.	20	14	70.0	23	21	91.3
Crex Meadows	10	7	70.0	6	5	83.3
Total	30	21	70.0	29	26	89.7
Incubation[c]						
Central Wisc.	16	14	87.5	30	30	100.0
Crex Meadows	8	7	87.5	4	4	100.0
Total	24	21	87.5	34	34	100.0
Hatched Brood[d]						
Central Wisc.	11	4	36.4	22	17	77.3
Crex Meadows	3	3	100.0	10	7	70.0
Total	14	7	50.0	32	24	75.0
Hatched Brood[e]						
Central Wisc.	6	2	64.2	-	-	-
Crex Meadows	3	3	100.0	-	-	-
Total	9	5	55.5	-	-	-
Without Brood[f]						
Central Wisc.	5	5	100.0	-	-	-
Crex Meadows	4	4	100.0	-	-	-
Total	9	9	100.0	-	-	-
Breeding Season[g]						
Central Wisc.	21	10	47.6	16	12	75.0
Crex Meadows	11	9	81.8	5	3	60.0
Total	32	19	59.4	21	15	71.4

[a]Prenesting: Hens, 1 April to egg-laying, Cocks 1 May-30 June.
[b]Egg-laying: Cocks 22 April-15 June.
[c]Incubation: Hens all or part of incubation, Cocks 1 May-30 June.
[d]Hatched brood: Hens hatched brood, Cocks 10 June-15 September.
[e]Hatched brood: Hens with brood for 4 weeks or longer.
[f]Without brood: unsuccessful nester.
[g]Breeding Season: Hens egg-laying to 15 Sept., Cocks 22 April-Sept. 15.

and limited their movements to a small area around the nest. During incubation, hens left the nest only for short periods to feed. Hens were more active and more vulnerable during egg-laying than during incubation.

Survival of cocks during the egg-laying and incubation periods was higher than hens (Table 25). During these periods, cocks were still visiting the booming grounds and remained in small groups when feeding.

Survival was lower for hens that hatched a brood (50.0% versus 55.5%) than for hens that lost their nests (100%) or for cocks during the same period (73.3%). The lower survival of hens that completed incubation versus those that did not suggested that completing incubation may place the hen in poor physical condition and contribute to losses during the early weeks of brood rearing. The physical stresses of nesting and brood rearing are probably responsible for the lower annual survival (Hamerstrom and Hamerstrom 1973; This study) and lower spring survival of the radio-tagged prairie chickens hens.

Survival of pen-reared hens while incubating was also high (83%, 5/6). The high survival of pen-reared hens observed during incubation was probably due to their restricted movements since they, like their wild counterparts, spent all but a few minutes on their nest. All the nests of pen-reared hens were destroyed (4) or abandoned before these hens were killed.

The factors that reduced survival of prairie chicken hens also influenced the survival of radio-tagged pheasant hens. Breeding season survival of hen pheasants (Dumke and Pils 1973) was comparable to radioed prairie chicken hens (59.4% versus 58.1% respectively). Survival of nesting pheasants was lower than that observed in prairie chickens (66.2% versus 77.8%), while survival during the brood rearing period (15 June-15 Sept, Dumke and Pils 1973) was slightly higher for pheasants (83.2% versus 77%).

The lower survival for pheasants on nests was probably related to their association with agricultural habitats and activities, which increased the chances for nest mortality. Dumke and Pils (1973) reported that 5% of hen losses could be attributed to haymowing. Most prairie chicken hens in central Wisconsin nested in the non-agricultural communities. Limited data are available on survival of radioed cock pheasants, but these data also suggested that survival of cock pheasants was higher than hens during the breeding season (Dumke and Pils 1973).

The survival figures presented here are relative and at best represent general survival patterns in prairie chickens. Sample sizes were small and were composites for several years from 2 separate areas. For example in 1977-78, all 4 hens alive in the fall survived to spring and in 1972-73 none of 5 hens alive in the fall survived to spring. However, the similarity in seasonal patterns in 2

separate areas suggested that these comparisons of survival patterns using radioed birds are valid.

Data collected from radioed animals always raises the question of what effect do radios have on behavior and survival. This aspect of radio telemetry has been treated by many authors (Dumke and Pils 1973, Boag et al. 1973, Erikstad 1979, Herzog 1979, Johnson and Berner 1980, Warner and Etter 1983, Hines and Zwickel 1985 and Small and Rusch 1985). Some of these studies indicated little effect on behavior or survival while others have reported reduced survival. One problem common to studies that examine the survival of radioed birds is small sample sizes. To effectively evaluate the effects of the radio on survival one needs to generate a life table for banded birds and radioed birds using sample sizes of at least 100 birds.

Most of the above studies were conducted on species that are ground oriented. Radio packages should have the greatest adverse effect on species like prairie chickens that frequently move by flying. Prairie chickens are regular fliers and radio packages did appear to affect annual survival. The annual survival of radioed birds alive in April was overall 33% (10/31), 4 of 16 (25%) in central Wisconsin (1972-73) and 6 of 15 (46.7) at Crex (1976-78).

The survival data from central Wisconsin was collected during a population decline. The higher survival at Crex

could be related to more experience in placement of the radio packages since the placement of backpacks was subjective and must take into account annual and age related weight changes. A radio placed too tight will cause rubbing under the wings and result in mortality months later.

Radio-tagged prairie chickens appeared to behave in a normal manner, and held territories, nested, raised young, snow burrowed and moved with other birds. However, the real test of a radio package is, if individuals wearing it can survive for a year and reproduce in the second year. In this study at least 5 hens and 4 cock prairie chickens survived and attempt to breed in a second year while wearing back pack radios.

Pen-reared. Survival of the released pen-reared prairie chickens was very low as 90% of the radioed birds were dead within 31 days and none survived longer than 120 days. Other researches have also documented high mortality of released pen-reared birds. Hessler et al. (1970) reported that 81% of 74 released pen-reared pheasants were dead in 28 days and Schladweiler and Tester (1972) indicated that 71% of radioed hand-reared mallards were dead wihtin 21 days. Burger (1964) estimated that 65% of the pheasants released in his study were dead within a week and Backs (1982) found that 70% of his released radioed quail were dead 35 days after release.

Mean survival for all radio-tagged pen-reared birds was 14.3 days and was higher for radioed hens than cocks (17.8 days, n=16 versus 12.3 days, n=27, P=0.321) (Table 26). Although survival of the non-radioed cohort was not known, observations and a daily tally of banded individuals known to be alive parallels the slope of known mortality of radio-tagged cocks and hens released in the fall and spring (Figs. 10 and 11). Similar survival graphs for released radioed pen-reared birds have been reported for pheasants (Hessler et al. 1970, Krauss et al. 1987), mallards (Schladweiler and Tester 1972) and bobwhite quail (Backs 1982).

Observations of radioed birds during each release showed that the longest any radioed individual went without being identified during the spring was 3 days in 1975, 6 in 1976 and 2 in the fall of 1974. Thus if a non-radioed individual was not observed within 2-6 days, it was assumed to be dead. Therefore one can estimate survival for each individual by assuming they were dead at most 2, 3, and 6 days after they were last seen. These estimates of individual survival increased the sample size and permitted comparisons to be made regarding the influences of behavior and physical condition on mean survival. The small number of radioed birds and the fact that all but 1 were in excellent or good condition prevented their use in this type of comparison.

Table 26. Comparison between mean survival (days) between radio-tagged and non-radioed pen-reared prairie chickens by release, Crex Meadows Wildlife Area, Wisconsin, 1974-76.

	Survival			
	Known	Estimated	P	Total
	Radio-tagged	Non-radioed		
Cocks				
Fall 1974	9.5 (8)	13.0 (8)	0.300	11.3 (16)
Spring 1975	11.6 (9)	12.0 (26)	0.927	11.9 (35)
Spring 1976	15.2(10)	15.6 (16)	0.939	15.5 (52)
Spring Total	13.5(19)	14.2 (68)	0.824	14.0 (87)
Total cocks	12.3(27)	14.1 (76)	0.459	13.6(103)
Hens				
Spring 1975	9.3 (6)	14.3 (8)	0.082	12.5 (17)
Spring 1976	22.8(10)	13.6 (67)	0.262	14.8 (77)
Total hens	17.8(16)	13.7 (78)	0.438	14.4 (94)
Total Spring	15.4(35)	13.9 (78)	0.602	14.2(181)
Grand Total	14.3(43)	13.9(154)	0.869	14.0(197)

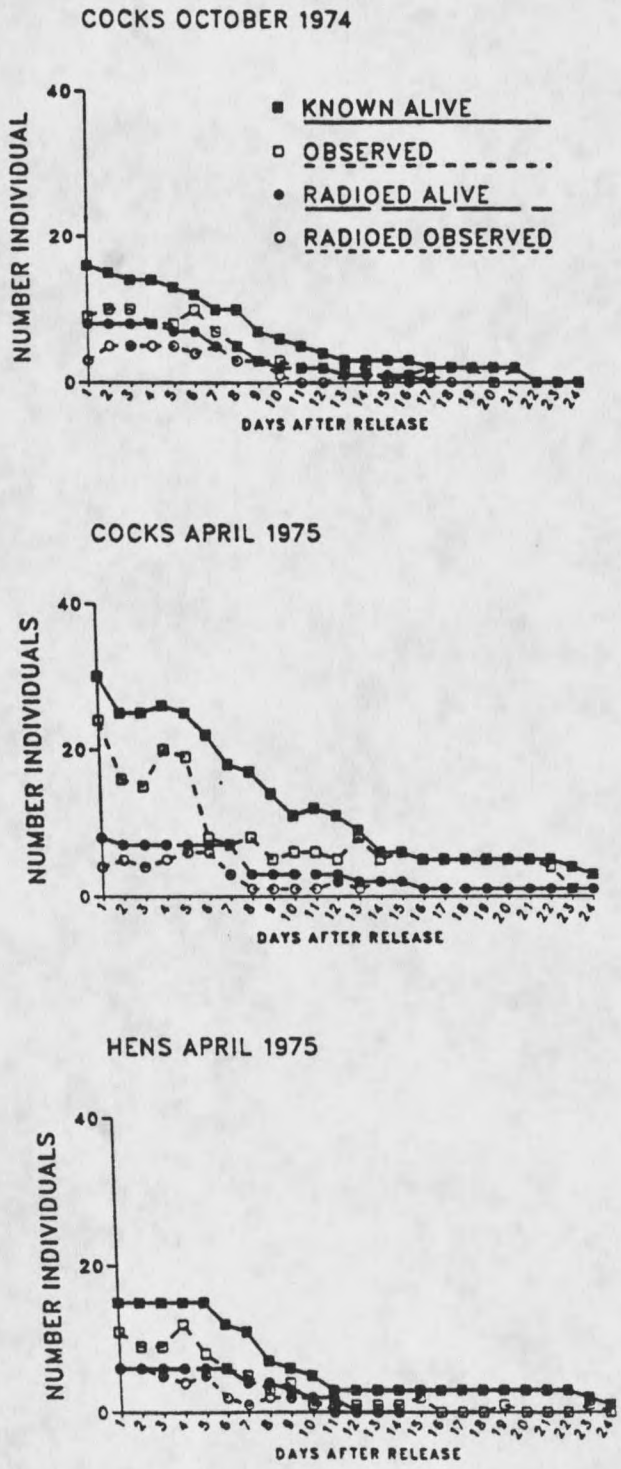


Figure 10. Number of radio-tagged and banded pen-reared prairie chickens known alive and observed by release, cocks October 1974, hens and cocks April 1975, Crex Meadows Wildlife Area, Wisconsin.

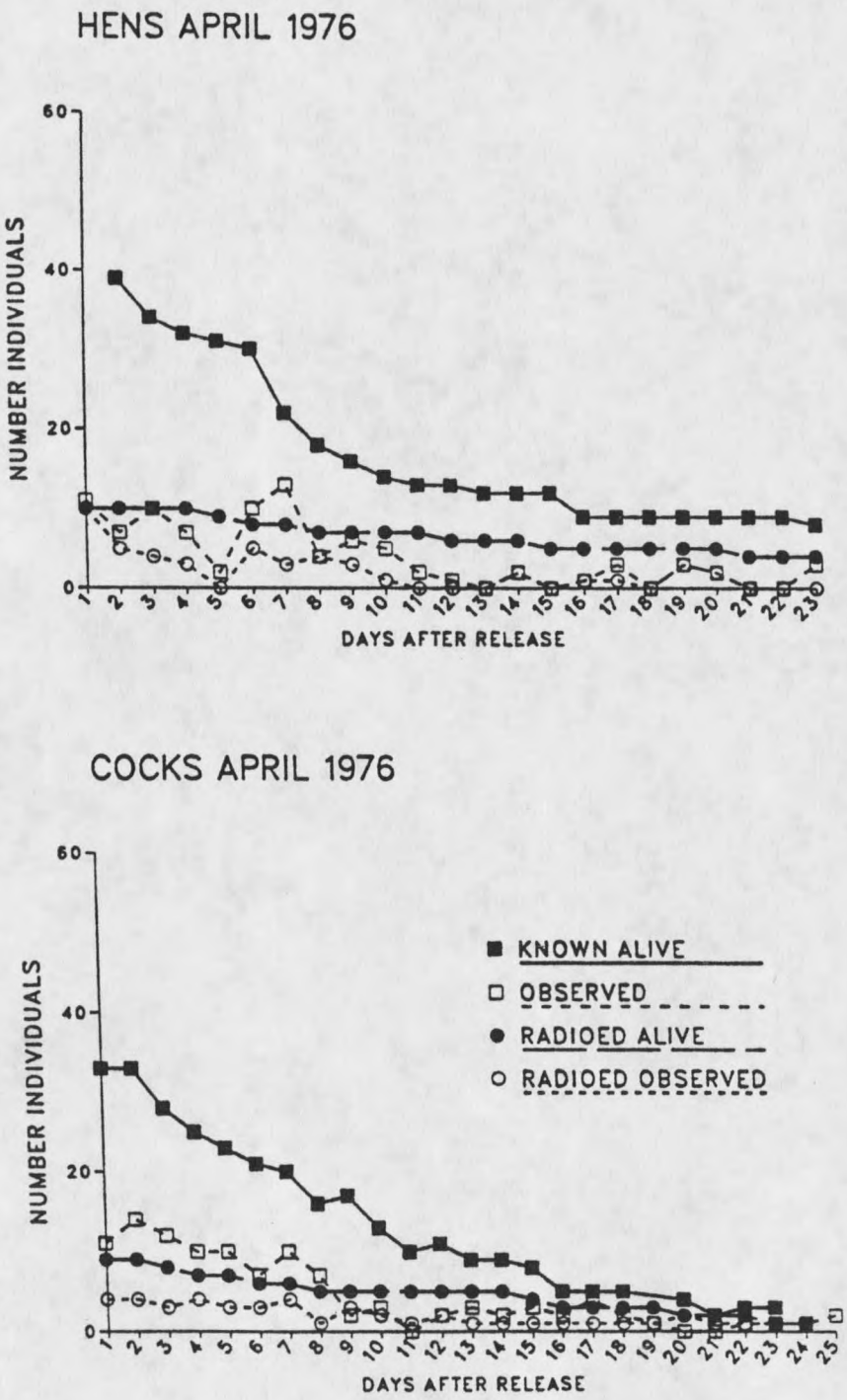


Figure 11. Number of radio-tagged and banded pen-reared prairie chickens known alive and observed by sex,, April 1976, Crex Meadows Wildlife Area, Wisconsin.

Estimated survival based on the assumption that individuals not observed within 2-6 days were dead may be questioned, but it appeared to provide a realistic estimate of survival. Intensive field observations of fall and winter feeding areas revealed no surviving pen-reared prairie chickens in 1974-75 or 1975-76 and only a single cock in 1976-77.

Also, in June and July 1976 25%, of the area within 0.8 km of the pen was searched and the remains of 26 banded pen-reared birds were found. These remains, along with those of other birds found in the spring accounted for 60% of the birds released in April 1976. It is unlikely that birds left the area, as all observations and radio locations of the pen-reared birds were within 1.8 km of the release sites. Finally, there was no mathematically significant difference (P=0.869) between the mean estimated survival in days between radioed and non-radioed birds (Table 26).

Using estimated survival there were no significant differences in survival between the 4 (P=0.251, df=3) and 2 (P=0.373) wing condition classes. However, individuals in poor condition generally experienced the lowest survival (Table 27).

There was no strong relationship between estimated survival and weight (Cocks, r=-0.044, n=87, Hens, r=0.147, n=94), or with age in days (Cocks, r=0.125, n=87, Hens,

Table 27. Mean survival (days) by wing condition, sex and release for pen-reared prairie chickens, Crex Meadows Wildlife Area, 1974-76. Number of birds are in parentheses.

Release	Wing Condition				P	Total
	Excellent	Good	Fair	Poor		
Cocks						
October 1974	9.0 (6)	13.3 (3)	-	12.3 (7)	0.664	11.3 (16)
Cocks						
April 1975	6.7 (3)	12.2(13)	14.3 (8)	11.1(11)	0.5746	11.9 (35)
April 1976	12.4(10)	16.0(26)	17.7(13)	11.3 (3)	0.5619	15.5 (52)
April Total	11.1(13)	14.8(39)	16.4(21)	11.1(14)	0.561	14.0 (87)
Hens						
April 1975	9.0 (3)	18.2 (5)	11.0 (8)	-	0.1157	12.5 (16)
April 1976	23.3(12)	12.1(35)	18.1(17)	10.2(13)	0.0370	14.8 (77)
Total Hens	20.4(15)	12.8(40)	15.8(25)	10.2(13)	0.1534	14.4 (93)
Total April	16.1(28)	13.8(79)	16.1(46)	10.7(27)	0.275	14.3(180)

r=0.127, n=94). Hessler et al. (1970) reported that radioed pen-reared hen pheasants below the median weight survived longer in the wild than those above the median. This was not the case with pen-reared prairie chickens as no significant difference in survival was found based on median weight in either cocks (Above 12.3±10.4 days, n=46, Below 13.0±13.6 days, n=41, P=0.792) or hens (Above 13.3±14.4 days, n=49, Below 11.2±11.2 days, n=45, P=0.436).

There also was no significant difference in survival between radioed and non-radioed birds for all the releases combined nor for the individual releases. However, survival of the radioed hens in 1976 was much higher than survival of cocks (Table 26), which may have been influenced by the cocks being more conspicuous because of display. Thus pen-reared cocks, like wild cocks may have served as a buffer, thereby increasing hen survival. However, examination of survival of cocks showed that display location and status appeared to have the greatest influence on their survival. Estimated survival of cocks that regularly displayed at or in the release pen lived longer than cocks that displayed away from the pen (Table 28). This was also true for the radio-tagged cocks displaying at the pen (At pen, 18.0±13.5, n=8, Away, 11.0±11.3, n=13, P=0.197). The pen with its intact top apparently provided a protective screen for the cocks that used it. Whether the pen provided protection for the

Table 28. Mean survival (days) of released pen-reared prairie chickens relative to display location and status, Crex Meadows Wildlife Area, Wisconsin, 1975-76.

	Displayers								
	Location Relative Release Pen							Non-displayer[a]	
	Inside	Edge	P	Total	Away[b]	P	Total		P
Spring 1975	16.1(10)	18.4 (5)	0.582	16.9(15)	10.9 (7)	0.264	15.0(22)	6.6(13)	0.001
Spring 1976	23.6 (9)	22.4 (5)	0.886	23.1(14)	14.6(26)	0.078	17.6(40)	8.5(12)	0.001
Total	19.6(19)	20.4(10)	0.701	19.9(29)	13.8(33)	0.004	16.7(62)	7.5(25)	0.002

[a] Non-displayer while inside pen.

[b] At least 200 meters from release pen.

radioed hens was not known. However, the estimated survival of cocks that displayed away from the pen compared with all hens (Cocks, 13.8±12.0, n=33, Hens, 14.4±12.8, n=78, P=0.950) implies that the pen did not protect the hens as it did the cocks.

Non-displayers (observed as such only during the day they were released) had the lowest estimated survival of all birds (7.5±3.9, n=25) (Table 28). This suggested that display was not the only reason for lower survival in cocks and that, behaviorally these non-displayers were more susceptible to predators. Jenkins et al. (1967) showed that non-territorial male red grouse became part of a surplus and either dispersed or died. However, Gullion (1981) indicated that survival of non-drumming ruffed grouse was equal to or greater than survival of drumming males.

Based on estimated and known survival of radioed birds, there appeared to be a survival hierarchy in released pen-reared prairie chickens. Cocks that displayed at the pen survived the longest (19.6 days) followed by all displaying cocks (16.7), hens (14.4), cocks displaying away from the pen (11.1), and the non-displaying cocks (7.5).

Survival varied between the different releases and was directly related to the number of birds released (r=0.983, n=5, P=0.001). It would appear that larger numbers of individuals released have the greatest positive influence

on survival simply because it takes predators longer to reduce numbers when more are present.

The influence of numbers released and the protection provided by the release pen was reflected in survival of the 25 birds that were released 1.6 km north of the pen in 1976. Survival of the 6 radioed birds (3 cocks and 3 hens) was approximately 7 days less than overall survival of radioed birds released at the pen (8.0 ± 5.4, n=6, 15.3 ± 15.9, n=37, P=0.044). Estimated survival for all 25 birds was approximately 3 days less than the overall estimated survival of all birds (11.3 ± 5.7, n=25 versus 14.2 ± 12.0, n=172, P=0.052).

Wild radioed prairie chickens experienced superior survival to that seen in pen-reared birds. The best comparison being that shown by survival of 4 wild cocks (3 radioed) and 1 wild hen that established in the release pen area. The hen nested 100 meters from the pen and the cocks displayed at the pen with the pen-reared birds. These wild birds were exposed to the same conditions as the released pen-reared birds. All but 1 of the wild birds survived to the fall (80%) and the hen fledged 13 chicks. Of 127 pen-reared birds released from the pen in 1976 only 3 survived to summer and only 1 to fall. This contrast between wild and pen-reared birds suggests factors other than habitat were responsible for poor survival and lack of production in pen-reared birds. Krauss et al. (1987) and Roseberry et

al. (1987) recently reported that survival was higher for transplanted pheasants and bobwhite quail than for released semi-wild and game farm birds.

Survival of the released pen-reared birds also appeared to be influenced by parentage relative to the number of generations removed from the wild. Pen-reared, first generation (F1) prairie chickens produced from the matings of wild birds in pens survived in the wild an average of 6 days longer (20.3, n=17 versus 14.3, n=112, P=0.221) than individuals produced from the matings of wild cocks and second or greater generation pen-reared hens. This survival pattern was apparent in both cocks and hens (Table 29). Although sample sizes were small, the data suggest that factors favoring survival inside a pen can become fixed in 1 or 2 generations.

Backs (1982) found that radioed F1 bobwhites produced from wild stock in pens survived an average of 33 days longer when released than second or greater generation stock obtained from game breeders. Ellsworth et al. (1988) recently found that genetic variability was reduced in the F2 generation of pen-reared bobwhite quail. However a companion study found no significant difference in the survival of these birds when released (Roseberry et al. 1987). Ellsworth et al. (1988) suggested that early environment may be more important than genetics in influencing behavior in the wild.

Table 29. Mean survival (days) of pen-reared prairie chickens of different parentage, Crex Meadows Wildlife Area, Wisconsin, April, 1976.

	Parentage		
	Wild hens with wild cocks	Pen-reared hens with wild cocks	P
Cocks	22.8+15.1 (9)	14.0+12.9 (43)	0.135
Hens	17.5+21.2 (8)	14.5+12.9 (69)	0.707
Total	20.3+17.8(17)	14.3+12.8(112)	0.197

The information collected in this study and by Backs (1982) indicates that genetic wildness may be lost quickly and that survival of pen-reared birds released for re-establishment may be improved by simply using the progeny of wild birds. However, this would increase the cost per bird as many wild birds fail to adjust and do not produce in pens as well as birds raised in captivity. It is also possible that wild birds that survive the transition to a penned environment are initially "less wild" to begin with and thus could further reduce wildness in future penned generations. This is essentially the path to domestication.

Many people fail to recognize that under penned conditions more than 95% of the eggs produced hatch and 90% of the chicks could easily survive to the following breeding season. Although this hatchability of eggs is similar to that seen in the wild, only approximately 50% of the wild nests hatch, and 50% of the chicks hatched will fledge and only 25% of these will survive to the following breeding season. Thus of 100 eggs laid in the wild only 6 birds would survive to the following spring. From a genetic perspective this means that in the pen there are approximately 90 birds or 84% whose genes would have been eliminated from a wild population. It is possible that because of selection for a penned environment the 6 birds that would survive in the wild would not be part of the 90

birds produced in the pen.

In an effort to raise large numbers of birds for release into the wild, breeders may have unknowingly selected behavioral traits that enhance survival and productivity in the pen and against those favoring survival in the wild. Even though the F1 progeny from wild parents raised in pens survived longer their, survival was still far below that seen in wild birds. Genetics undoubtedly plays a role in survival of penned birds but the conditioning and selection that occurred inside the pen appear to have the greatest influence on the survival of released pen-reared birds.

Annual Survival

Pen-reared. Annual survival of all the pen-reared prairie chickens released in April based on observations of banded birds on booming grounds and in feeding areas was 0.5% (Hens zero [0/92] and cocks 1.1% [1/86]). Low annual survival of pen-reared birds has been reported from other bird studies: pheasants- MacNamara and Kozicky 1949 (1-2%), Harper et al. 1951 (2%), Roby 1951 (1.4%), Burger 1964 (8%), Mallette and Harper 1964 (1-1.1%), and Jarvis and Engbring 1976 (0%); bobwhite quail, Baumgartner 1944 (3%), Sexson 1971 (1%) and Backs 1982 (0%).

Pen-reared waterfowl have been successfully used to establish wild populations (Doty and Kruse 1972, Evrard 1983 and Lee et al. 1984). However, pen-reared waterfowl

experience higher annual survival than pen-reared gallinaceous birds :Sowls 1955 (5-13%), Doty and Kruse 1972 (11%), Sellers 1973 (25%), Lee and Kruse 1973, (33%) and Gatti 1981 (17%). This greater success and higher survival of pen-reared waterfowl is attributed to protection from mammalian predators provided by a wetland habitat.

The pen-reared cock released in April 1976 that survived to April 1977 was not observed in 1978. It was unlikely that any banded birds were missed at Crex, as all birds on the booming grounds were checked for bands. Some hens could have been missed as they do not regularly attend the booming grounds, but none were observed in feeding areas during the winter. Furthermore, the lone pen-reared cock, along with all the banded wild cocks and hens identified on the booming grounds in April 1977 were observed on the corn feeding platforms during winter 1976-77. Lastly, it was unlikely that any of pen-reared birds left the area since all radio locations and observations of pen-reared prairie chickens were made within 1.8 km of the release pen.

Transplants. Minimum annual survival of the April 1976, Wisconsin transplants was 32% (6/19) for cocks and 13% (1/8) for hens. Annual survival of the Minnesota hens transplanted in April 1977 was 26% (5/19) compared to 40% (4/10) for cocks transplanted in the summer. The lower survival of hens during the first year at Crex resulted

from more hens than cocks leaving the release area. Second year survival of the established cocks in 1977-78 was 50% (5/10). The last banded cock observed at Crex was a Wisconsin transplant at least 4 years old when last seen in 1979. Hamerstrom and Hamerstrom (1951) and Ammann (1957) reported maximum annual survival rates of 21 and 28% respectively, for transplanted banded sharptails.

Wild Residents. Hamerstrom and Hamerstrom (1973) reported an annual survival rate of 46% for greater prairie chickens in central Wisconsin from 1956-1970, with no difference between sexes or age classes (yearlings versus adults). Toepfer and Tesky (unpubl. data, Table 30) found that the combined annual survival of 270 banded prairie chickens in the same study area from 1972-1980 was 48.9%; 48.2%(n=222) for cocks and 52.0%(n=48) for hens.

Four cocks and 1 hen lived for at least 7 years and 1 cock at least 8. Of interest was the high survival of the immatures (yearlings) in 1975-76 and 1976-77. It was during this period that the population in central Wisconsin increased from 138 to 213 cocks (R. K. Anderson pers. comm.). Four cocks and 1 hen lived for at least 7 years and 1 cock at least 8.

Information on survival of hens was not as complete as that for cocks, as limited manpower forced concentrating our efforts on checking booming grounds for banded cocks. The annual survival figure of 48% was slightly higher than

Table 30. Annual survival (%) of banded prairie chickens in central Wisconsin 1972-80 (Toepfer and Tesky unpubl. data). Number of birds are in parentheses.

	Cocks[a]			Hens[b]		
	Adults	Immatures[c]	Total	Adults	Immatures[c]	Total
1972-73	28.6 (2/7)	80.0 (4/5)	43.8 (6/12)	-	-	-
1973-74	63.6 (7/11)	16.7 (1/6)	47.1 (8/17)	-	-	-
1974-75	38.9 (7/18)	40.0 (6/15)	39.4 (13/33)	66.7 (4/6)	100.0 (8/8)	85.7(12/14)
1975-76	56.6 (17/30)	60.0(15/25)	58.2 (32/55)	26.7 (5/16)	44.4 (8/18)	38.2(13/34)
1976-77	38.8 (17/45)	69.2 (9/13)	44.8 (26/58)	-	-	-
1977-78	46.2 (12/26)	-	46.2 (12/26)	-	-	-
1978-79	75.0 (9/12)	-	75.0 (9/12)	-	-	-
1979-80	11.1 (1/9)	-	11.1 (1/9)	-	-	-
Total	45.6(72/158)	54.7(35/64)	48.2(107/222)	40.9 (9/22)	61.5(16/26)	52.0(25/48)

a Based on spring booming ground observations.
b Based on spring booming ground, winter blind observations and winter trapping.
c Terminology after Hamerstrom et al. 1973; immatures were approximately 9 months old at capture.

the 46% reported by Hamerstrom and Hamerstrom (1973). However, the Hamerstrom's data was collected during a population decline, whereas ours was collected during a decline followed by an increase.

No information is available on first year survival of prairie chickens. Because all of the transplanted and pen-reared birds in this study were banded, it was possible to estimate a minimum first year survival. There were 4 broods with 26 chicks known to be alive in late August of 1976; assuming an equal sex ratio, 13 young cocks were alive at this time. Six unbanded cocks were observed on the booming grounds at Crex in May 1977. Hence, survival from September to May was at least 46% (6/13) and estimated survival from hatching to the following May was 25% (6/24) i. e. assuming clutch size=12, 4 broods, 48 chicks hatched, 24 cocks)

Based on annual survival and rate of establishment for the different types of birds released at Crex, it was estimated that to have 25 prairie chickens alive the following spring it would be necessary to release 3,571-5,000 pen-reared birds or 95 wild prairie chickens (39 cocks and 56 hens) in the spring with birds in a pen to hold the cocks. The same results could be obtained without building a pen by releasing 62 wild birds (32 cocks and 32 hens) in the summer during the molt.

Mortality Factors.

Radio-tagged birds were walked in on when a daytime signal indicated inactivity suggesting the bird was dead. All radio-tagged pen-reared birds were recovered within 24 hours, most within 12 hours of mortality. No effort was made to classify the cause of death for wild radio-tagged birds if remains were not examined within 24 hours. Major criteria used to differentiate mammalian and raptor feeding were a combination of broken and chewed bones versus hot or cold plucked feathers, and stripped bones, in addition to tracks, feathers, hair, droppings and castings found at the feeding sites (Darrow 1938, Einarson 1942, Hamerstrom 1972, and Dumke and Pils 1973).

Early in the study in central Wisconsin the presence of stripped or frayed tendons at the joints of bones was found to be a key factor in determining raptor feeding. Canids are not capable of stripping flesh in this manner (A. Sargent, pers. comm). When possible, tracks were followed to locate the kill site. In cases where only the radio was found and the harness was chewed or broken it was classified as unknown mammalian predation. If no evidence was present mortality was classified as unknown.

Of 68 radioed wild resident prairie chickens in central Wisconsin the fates of 54 were known and the radio signals were lost from 14 (12 batteries ran out with bird still alive and 2 unknowns).

The fates of all 32 of the radio-tagged pen-reared birds released in the spring and fall were known. Predation appeared to be responsible for most of the losses of both pen-reared and wild resident prairie chickens. Evidence collected from the remains of radio-tagged individuals indicated that 85.9% and 84.4% of the wild and pen-reared prairie chickens respectively, were fed upon by predators with predation the likely cause of death.

An analysis of the probable causes of predation indicated that the pen-reared birds were more susceptible to mammalian than avian predation (55.6% versus 44.4%). This was opposite of the pattern in wild birds (33.3% versus 66.7%) ($CSq=19.2$, $df=1$, $P=0.001$). Table 31 presents probable causes of death for pen-reared and wild radio-tagged prairie chickens. The higher incidence of mammalian predation in the pen-reared birds was believed to be due to their inferior physical condition and ground oriented habits.

Dumke and Pils (1973), working with radio-tagged wild hen pheasants in Wisconsin, reported mammalian and raptor predation (70.7% versus 29.0%) pattern comparable to that seen in the pen-reared prairie chickens. Burger (1964) and Krauss (1987) also reported high predation losses and a high incidence of mammalian predation in released pen-reared pheasants. Hessler et al. (1970) reported over 90% of radioed pen-reared pheasants released in Minnesota were

Table 31. Probable mortality factors for 54 radio-tagged prairie chickens (27 cocks, 27 hens) in central Wisconsin, February 1972-June 1975, and 32 radio-tagged pen-reared prairie chickens, (26 cocks and 16 hens), Crex Meadows Wildlife Area, Wisconsin, April and October releases combined, 1974-76. Percentages are in parentheses.

Probable Cause of Death[a]	Wild		Pen-reared	
Predation	45(85.9)		27(84.4)	
Raptor		26(57.8)		12(44.4)
Mammalian		13(29.5)		15(55.6)
Unknown		6(13.6)		0
Wire collision	1 (1.9)		0	
Other	3 (5.7)		2 (6.3)	
Unknown	5 (9.4)		3 (9.4)	
Total	54		32	

[a] Based on sign found at feeding site.

dead in 28 days due to predation. Like pen-reared prairie chickens, pheasants are more ground oriented than wild prairie chickens. Conversely, Rusch and Keith (1971) felt that two-thirds of the ruffed grouse found dead were killed by raptors, primarily great horned owls and goshawks.

Examination of mortality due to predation (including unknown causes) showed that wild prairie chicken cocks appeared to be slightly more susceptible to raptors than hens (69.6% versus 56.3%, CSq=0.73, df=1, P=0.393). The greatest discrepancy occurred in the spring when all the wild radioed and non-radioed cocks found dead were fed upon by raptors (Table 32). The pen-reared cocks were also more susceptible to raptor predation than hens (53.8% versus 35.7%, CSq=1.98, df=1, P=0.001). The high incidence of raptor predation for cocks during the spring may be related to the attraction of raptors to the displaying birds.

Mortality of pen-reared prairie chickens also included 1 bird that was shot and 2 radioed birds that drowned. It was thought that the latter 2 birds tried to land on the water at night since their night locations were different from where they were found dead the next morning. Other mortality factors in wild prairie chickens included a hen with a brood killed by a rotary haymower, illegal shooting and collisions with telephone and power lines along roads.

In addition to the radioed birds found dead, the fates of 32 wild resident and 36 non-radioed pen-reared prairie

Table 32. Seasonal distribution of probable mortality factors for 45 radio-tagged prairie chickens (24 cocks and 21 hens) in central Wisconsin, February 1972-June 1975. Percentages are in parentheses.

	Winter		Spring		Summer		Fall		Total		
	Raptor	Mammal	Raptor	Mammal	Raptor	Mammal	Raptor	Mammal	Raptor	Mammal	Unknown
Cocks	5(55.6)	4(44.4)	6 (100)	0	3 (100)	0	2(50.0)	2(50.0)	16(69.6)	7(30.4)	1
Hens	3(50.0)	3(50.0)	4(75.0)	2(25.0)	3(66.7)	1(33.3)	0	1 (100)	9(56.3)	7(43.8)	5
Total	8(53.3)	7(46.7)	10(83.3)	2(16.7)	6(85.7)	1(14.3)	2(40.0)	3(60.0)	26(66.7)	13(33.3)	6

chickens supported the idea that predation was the main mortality factor with avian predation dominating both types (Table 33). However information based on the remains of nonradioed birds surely overestimates the role played by raptors since the large amounts of feathers at a raptor feeding site are more easily detected. Mammals often carry the carcass away to consume it, cache what is left, and often leave little, if any, obvious sign of predation.

Based on the sample of non-radioed wild residents, it would appear prairie chickens suffer significant mortality due to collisions with wires (Table 33). This high incidence (31.0%) may be biased, as birds that hit the wires fell onto the road where they would be readily observed and usually reported by local residents. All but one were found in the winter or fall along flight paths between agricultural feeding and roosting areas. These birds probably hit the wires while leaving feeding areas. If birds were killed with equal incidence while flying into these fields, one could speculate, that only half of the birds killed by hitting wires would land in the road. It is thought that the real figure for wire mortality may be closer to 1.9% as indicated by the radio-tagged cohort (Table 33).

If wire collisions are a problem, then the solution at least in central Wisconsin is to avoid putting food patches adjacent to telephone and powerlines. Wire mortality is

Table 33. Probable mortality factors for 32 non-radioed wild prairie chickens (21 cocks 6 hens and 5 unknown) in central Wisconsin, February 1972-June 1976, and 36 non-radioed pen-reared prairie chickens, (20 cocks, 16 hens) Crex Meadows Wildlife Area, Wisconsin, 1974-76. Percentages are in parentheses.

Probable Cause of Death[a]	Wild		Pen-reared	
Predation	20(63.0)		36(100)	
Raptor		17(85.0)		30(83.3)
Mammalian		3(15.0)		4(11.1)
Unknown		3 (7.0)		2 (2.8)
Wire collision	10(31.0)		0	
Unknown	1 (3.0)		0	
Gunshot	1 (3.0)		0	
Total	32		36	

[a] Based on evidence and sign found at feeding site.

probably nonselective as all the birds found killed in this manner were in good physical condition.

Of the 21 transplanted birds found dead, all but 2 were fed upon by raptors. Two hens, 1 in each spring, were apparently killed by mammals while incubating infertile eggs. In addition to natural predation, 1 radioed summer transplant cock was shot by hunters the opening day of waterfowl season and 1 radioed cock was killed in a tornado. A transplanted hen drowned in a lake after she was flushed at night during a recapture attempt. In 1978, a year after their release, 2 of 4 surviving hens were killed by raptors during egg-laying. The radio signals were lost on the remaining two hens in May, 13 months after their release. Two non-radioed birds, 1 cock and one hen were found fed upon by raptors near the release pen and 3 prairie chickens were reported shot by waterfowl hunters in October 1977.

Of the 11 radioed birds released in August 1975, the 3 semi-wild birds were fed upon by raptors and the 7 pen-reared birds were fed upon by mammalian predators (fox, coyote, and mink). These birds were excluded from the mortality analysis since they were poor flyers. The inclusion of these birds increases the incidence of mammalian predation for pen-reared prairie chickens from 55.6 to 64.7%.

It must be emphasized that the classification of

mortality based only on remains is a difficult task and all that can really be determined is what type of predator last fed upon the carcass. Only if mortality is observed can a positive determination be made as to the cause of death and even then factors such as disease, injury and abnormalities may unknowingly contribute to the death of the individual.

Actual field observations of mortality in central Wisconsin have shown how interactions between different mortality factors make it very easy to misinterpret the examination of remains and sign. Two observed goshawk kills were fed upon in a relatively short time by other raptors in 1 case and a fox the other. A wire kill was observed and in sequence, fed upon by a raptor and a dog. Either of these could have drawn different conclusions depending upon the time frame of observations.

Scavenging of kills and the removal of the carcass from the kill site are not uncommon and can occur in a short time span. In 3 instances, the backtracking of fox tracks in the snow from the remains led to locations 0.8, 1.6 and 3.2 km away, where the sign in snow indicated all 3 birds had been killed by a raptor (probably a horned owl) as they left their night roosts. A fox picked up the remains and radio sometime between sunrise and noon and carried them off. If the author had not noticed stripped tendons on the legs and wings, these 3 kills would have been incorrectly classified as fox predation.

Using stripped tendons as an index to previous feeding by raptors, 7 of 39 probable predator kills (17.9%) showed evidence of scavenging and 7 of 24 presumed raptor kills (29.2%) were scavenged by mammals. Kenward (1977) reported that 18% of the pheasants killed by goshawks were scavenged by another hawk and that 16% of these kills were scavenged by mammals. Based on planted whole pheasant carcasses, Dumke and Pils (1973) implied that scavenging did not influence their results and they reported no scavenging of raptor kills. This seems unusual based on the results obtained in this study and that of Kenward (1977). Sargent et al. (1984), based on wild and captive foxes, believed that foxes were wary of placed carrion and usually avoided them. Rusch and Keith (1971) found that most of the 157 ruffed grouse carcasses set out in the fall and left over winter were scavenged, but there was no sign that raptors or mammalian predators had visited them.

Scavenging of carcasses was not observed at Crex in either the pen-reared or wild transplants. Many of the pen-reared birds were found only partially consumed, 2 were cached with their heads removed, and 1 bird, apparently killed by a mink was not eaten at all. This suggests that predators were having an easy time obtaining food in the form of pen-reared prairie chickens.

No evidence was found that indicated raptors scavenged mammalian kills. It is more likely that mammals would

scavenge from raptors and it is possible that mammals may even learn to associate raptor activity with food.

In spite of all the problems in interpreting sign, it is believed that with experience and care in examining the remains, it is possible to determine what fed upon a carcass. This type of information should provide a reasonable index of the major mortality factors in radio-tagged birds.

Observability

Pen-reared prairie chickens released during April were much more observable than wild prairie chickens over comparable periods. Observability of pen-reared birds in the springs of 1975 and 1976 were 1.5-9 times higher than for wild prairie chickens during spring in central Wisconsin in 1972-73 and at Crex 1976-78. Table 34 compares weekly observability indices, means and totals for wild prairie chickens during the spring. Pen-reared birds released in October 1974 were 3-17 times more observable than wild birds during the fall (Table 35) and 3-12 times more observable than pen-reared birds in the spring.

Observability indices were based on the number and type of birds observed and adjusted to birds/100 hours. The spring index does not include displaying cocks or hens associated with displaying cocks. The observability indices for wild birds are thought to be high because they include non-radioed birds associated with radio-tagged

Table 34. Weekly observability (birds/100 hours) during the spring for wild prairie chickens in central Wisconsin 1972 and 1973 and released pen-reared birds Crex Meadows Wildlife Area, Wisconsin, 1975, 1976-78.

	Central Wisconsin		Crex Meadows				
	Wild Birds					Pen-reared	
Period	1972	1973	1976	1977	1978	1975	1976
04/15-04/21	3.3	22.5	7.7	5.5	12.0	18.3	-
04/22-04/28	0.5	4.8	19.9	0.7	1.3	10.4	10.1
04/29-05/05	0.9	10.8	6.9	17.7	1.0	37.3	9.0
05/06-05/12	1.8	2.5	13.8	0.8	0.0	10.9	14.9
05/13-05/19	0.6	1.2	3.8	0.9	4.4	32.6	13.3
05/20-05/29	2.5	9.1	3.1	1.9	7.2	49.6	16.6
Mean	1.6	14.5	9.2	4.6	4.3	36.5	12.8
Total[a]	2.5	7.5	7.4	4.1	3.5	24.2	11.4
Hours	274.5	110.7	111.4	155.9	145.7	139.0	123.5

[a] Equals total number of birds observed during 4 week period per 100 hours and adjusted for density.

Table 35. Weekly observability (birds/100 hours) during fall for wild prairie chickens in central Wisconsin 1972 and 1973 and released pen-reared birds 1974, and wild birds 1976 and 1977, Crex Meadows Wildlife Area, Wisconsin.

Period	Central Wisconsin		Crex Meadows		
	Wild Birds				Pen-reared
Year	1972	1973	1976	1977	1974
10/21-10-27	14.0	4.0	26.3	24.7	84.7
10/28-11/03	14.2	29.8	40.1	10.6	80.0
11/04-11/10	2.7	33.9	28.4	39.7	79.5
11/11-11/17	1.5	22.7	10.4	34.5	82.0

Table 35. Continued.

Period	Central Wisconsin		Crex Meadows		
	Wild Birds				Pen-reared
Year	1972	1973	1976	1977	1974
Mean	8.1	22.6	25.4	27.3	81.5
Total[a]	7.0	28.8	25.4	25.2	85.5
Hours	114.8	41.7	60.2	137.0	93.8

[a] Equals total number of prairie chickens observed away from the booming ground during the four week period per 100 hours and adjusted for density.

individuals flushed to determine habitat and flock sizes. Pen-reared birds were rarely flushed intentionally and were usually alone or in small groups. Comparisons between wild and pen-reared birds at Crex are more realistic because they were calculated for a common area. However, the index for wild birds for the week of April 22 in 1976 were inflated due to the presence of 3 wild cocks that were regularly observed with the pen-reared birds at the release pen. Fall observability indices for wild birds at Crex were also inflated as they included mixed flocks of prairie chickens and sharptails.

Although numbers of pen-reared birds alive declined due to mortality, the weekly indices did not (Tables 34 and 35). This indicated that pen-reared birds did not become less observable as their numbers declined or as they gained experience outside of the pen. Weekly indices for wild birds are inconsistent, but showed a general tendency to decline over the spring observation period (Table 34). This decline was due to the wild birds shifting away from agricultural areas as green-up occurred and as hens became solitary during nest selection and egg-laying.

Observability indices for wild birds in the fall were higher than in the spring. This was the result of the summer productivity and small flocks joining together to form larger flocks as the birds shifted back to agriculture when daily seasonal temperatures begin to decline. The fall

observability index for pen-reared birds in 1974 was 2.3-6 times higher than in the spring. This increase in observability was not due to the released pen-reared birds forming flocks like wild birds, but was the result of the pen remaining closed after the release (violent release) and the released cocks returning to the pen where they walked the fence trying to rejoin the birds inside.

The presence of pen-reared birds habituated to a vehicle appeared to influence the behavior of transplanted wild birds at the pen. The 2-3 wild cocks which displayed at the pen in April 1976 initially appeared confused at the approach of a vehicle. These wild cocks did not flush as did wild birds on booming grounds, but would run, stop, run or make a short flight to cover. This type of behavior in the open was unusual for wild prairie chickens either on or off the booming grounds and has only been observed in injured birds, or hens on nests or with broods. This "confused behavior" by the transplanted cocks was thought to be due to a conflict between their natural impulse to flee and their impulse to remain with the pen-reared birds that did not take flight. After approximately a week these wild birds no longer flushed, but ran to cover and would resume displaying as soon as the vehicle stopped or moved on.

Wild birds at the pen never became totally habituated to a vehicle or people as did pen-reared birds. It was

originally thought that the presence of wild birds would make the pen-reared prairie chickens more wary. However the observations made here indicated the reverse. Pen-reared birds made the wild birds less wary.

There are several explanations for the pen-reared prairie chickens being more observable than wild birds. First, pen-reared birds were attracted back to the pen to feed, display and associate with other birds. Wild birds, particularly cocks, exhibited a similar pattern in the spring, when they concentrated their daily display activities (morning and evening) on the booming grounds. However, unlike pen-reared birds that fed at the pen, wild cocks typically left the booming grounds during the latter part of the morning to feed and loaf until the evening display period. Wild hens remained away from the booming grounds visited only to select a mate and breed.

In contrast to wild birds, the pen-reared cocks and hens remained in the vicinity of the pen throughout the day and night. The equal observability of both hens and cocks in 1976, 7.5 and 8.3 respectively, indicated that the attraction or tie to the pen was probably the main reason for the higher observability of pen-reared birds. No index was computed for cocks and hens in 1975 because the cocks were released a week earlier than the hens. However, after the hens were released, they were twice as observable (34.2 versus 15.3) as the cocks even when adjustments were made

for differences in numbers. This was probably due to these hens being less wary, suggesting that experience and time outside of the pen did influence behavior. This difference was compounded by the possibility that only the more wary cocks were still alive when the hens were released from the pen. Information on observability for wild cocks and hens was difficult to calculate as most observations were of flocks or individuals flushing at a distance making it difficult to differentiate the sexes.

Analysis of weekly observability indices for wild birds (Fig. 12) showed that wild prairie chickens are least observable in summer during the molt. Only in winter, when snow reduced cover and birds formed large flocks, were wild birds as observable as pen-reared birds were in the spring or fall. Winter was the period when wild prairie chickens were most vulnerable and suffered highest mortality.

Little information was available on the observability of pen-reared birds released away from the pen area, but data from the first week following the April 1976 release showed that these birds were only slightly less observable (7.5 versus 10.1) than the birds released at the pen. This indicated that the attraction back to the pen was not the only reason for the greater observability and that the high observability of pen-reared birds was not just a direct function of the increased number in the area, but was also related to the behavior of individuals.

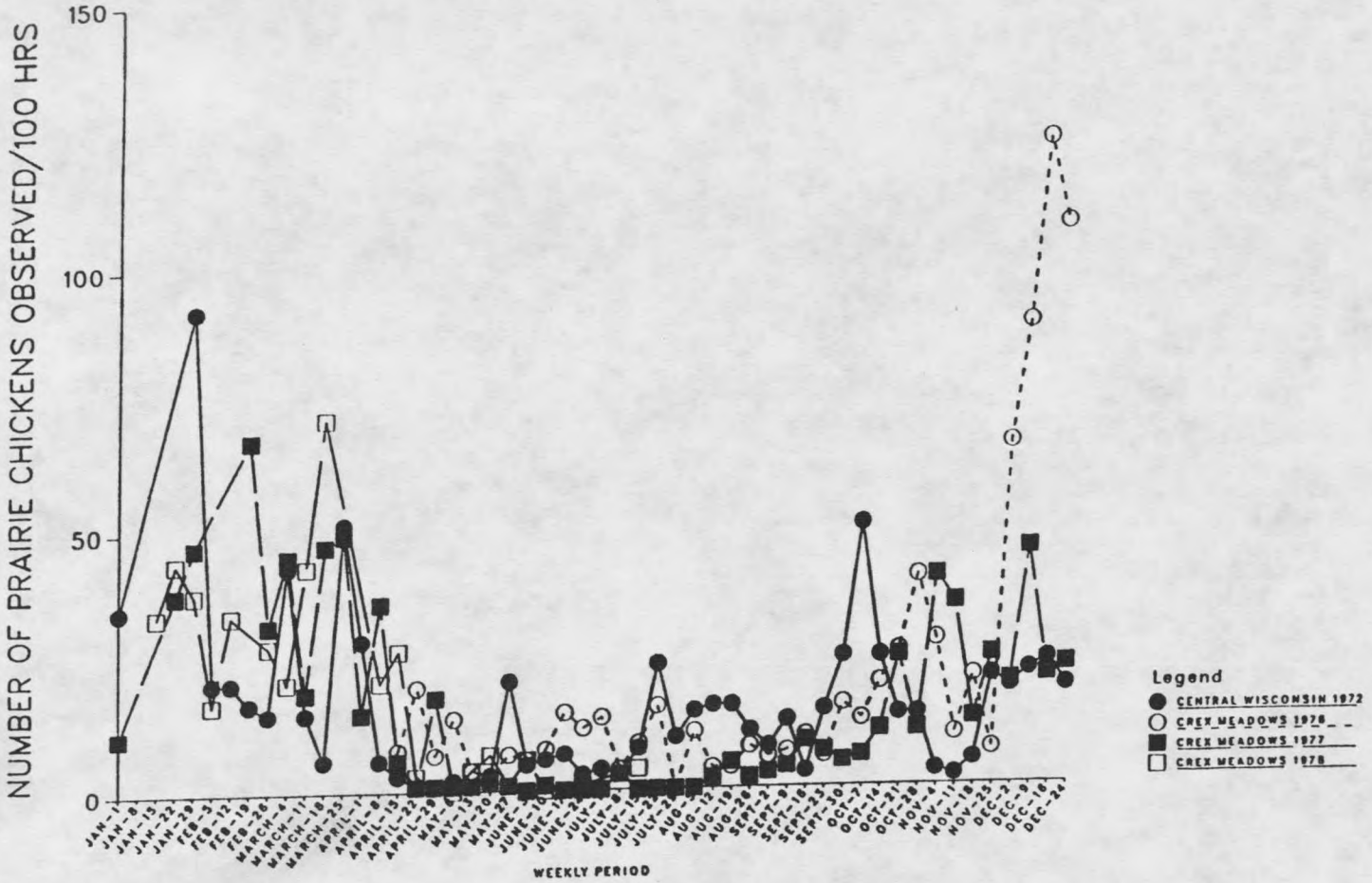


Figure 12. Weekly observability of wild prairie chickens (birds/100 hours) central Wisconsin, 1972, Crex Meadows Wildlife Area, Wisconsin, 1976-78.

Another explanation for the higher observability of pen-reared prairie chickens was that they became habituated to people and vehicles. This behavior would cause pen-reared individuals to remain in the open making them more conspicuous than wild birds. The failure of the observability indices to dramatically decline in the spring suggested that habituation was fixed and not easily overcome. Regardless of the cause or reason, it is apparent that the observability indices indicate that the pen-reared birds released at Crex were much more observable and less wary than wild prairie chickens during the spring and fall.

Response of Predators to Prairie Chickens

Wild Birds

Responses of diurnal raptors to the pen-reared and wild prairie chickens were documented by recording all raptors observed within 200 m of radio-tagged birds, at booming grounds and the pen at Crex. This information was tallied for weekly periods in central Wisconsin during 1972 and at Crex from 1974-78 and converted to a raptor exposure index of raptors per 100 hours. Raptor exposure on booming grounds was calculated for the morning booming period when at least 1 radio-tagged bird was present. Data from all radioed birds were combined to calculate collective exposure to raptors for birds away from the booming ground.

Total exposure was calculated by adding exposure on and off the booming ground. Exposure rates provided an index to potential predation of prairie chickens by diurnal raptors.

Wild radioed prairie chickens on booming grounds in central Wisconsin were exposed to 3.5 times (Range 2.4 - 9.4) more raptors than radio-tagged birds away from the booming ground from 25 March-20 May 1972 (Table 36). The higher exposure on booming grounds suggested that the increased observability of displaying prairie chickens attracted raptors. Berger et al. (1963) suggested that some raptors may be attracted to booming grounds to test for injured or handicapped prairie chickens.

The conspicuous nature of displaying prairie chickens while on booming grounds would appear to make them easy prey for predators. However, many authors have shown that losses to predators are uncommon on the booming grounds. Berger et al. (1963) documented 3 raptor kills during 4,745 mornings (21 years) of observations from blinds on booming grounds in central Wisconsin. Anderson (1969a), working in the same area, observed 4 kills during 2,115 mornings. Sparling and Svedarsky (1978) observed a single kill in two springs while observing booming grounds in Minnesota. During this study, 4 cocks were killed by goshawks and 1 by a Cooper's hawk while on the booming grounds in central Wisconsin during 222 mornings from 1972-76.

A summation of available information showed that of 17

Table 36. Weekly changes in exposure to diurnal raptors (raptors/100 hours) for radio-tagged wild and pen-reared prairie chickens during the spring for central Wisconsin, 1972 and Crex Meadows Wildlife Area, Wisconsin, 1975-76.

	Wild Birds			Pen-reared Birds					
	Central Wisconsin			Crex Meadows					
	1972			1975			1976		
Period	While[a] on Booming Ground	While[b] off Booming Ground	Total	While[a] on Booming Ground	While[b] off Booming Ground	Total	While[a] on Booming Ground	While[b] off Booming Ground	Total
0325-0331	9.8	23..5	33.3	-	-	-	-	-	69.8[d]
0401-0407	30.4	6.8	37.2	-	-	-	-	-	37.7[d]
0408-0414	30.0	3.2	33.2	-	-	37.0[d]	-	-	29.4[d]
0415-0421	27.0	10.0	37.0	30.6	48.0	78.6[e]	-	-	22.6[d]
0422-0428	16.3	5.5	21.8	29.9	12.8	42.7[f]	29.2	32.8	62.0[g]
0429-0505	12.0	6.1	18.1	100.8	25.6	126.4	23.7	23.3	47.0
0506-0512	27.9	3.9	31.8	12.1	17.8	29.9	27.8	12.1	39.9
0513-0519	5.0	2.1	7.1	28.5	3.5	32.0	21.1	3.1	24.2
Mean[c]	17.6	5.5	23.2	40.4	21.5	61.9	25.5	17.0	39.1

[a]During morning display only.
[b]Includes both cocks and hens.
[c]Means calculated for common period 0415-0519.
[d]While birds inside pen.
[e]25 pen-reared cocks released on 0418.
[f]16 pen-reared hens released on 0428.
[g]127 pen-reared cocks and hens released on 0422.

prairie chickens killed while on booming grounds, 10 (62.5%) were killed by goshawks and all but 2 were killed by raptors that typically hunt from perches (goshawk 10, Cooper's 2, redtail 1, horned owl 1, snowy owl 1). The goshawk was also implicated in 2 of 6 probable kills. Others have reported kills or probable kills by goshawks on prairie grouse (Ammann 1957, 1959, Moran 1966, Buls 1967, Jacobs 1968, Gratson 1982). Eng and Gullion (1962) suggested that the goshawk was the most important mortality factor on ruffed grouse.

Visits to booming grounds by mammalian predators are not as common as visits by raptors. Hamerstrom et al. (1965) observed 93 incidents involving mammalian predators but only 1 kill by a farm dog in 4,745 mornings. They indicated that prairie chickens "evaded approaching mammals simply by walking aside; when flushed, they generally flew only a short distance and never in the panic flight often elicited by raptors". In the course of this study we observed only 7 mammalian predators on booming grounds (2 skunks, 2 foxes and 3 coyotes). Maxson et al. (1979) presented evidence that a fox killed a sharptail on a dancing ground and Hartzler (1974) observed a bobcat kill a sage grouse on the strutting ground. However, sage grouse often night roost on strutting grounds in the spring.

There is little quantitative information on responses of mammalian predators to wild prairie chickens encountered

away from booming ground. Scavenging by mammals on birds killed by other factors make it difficult to determine the exact role mammals play in predation. Capture of prairie chickens by mammals most likely occurs by stalking or surprising individuals while they are on nests, tending broods or night roosting, particularly in snow burrows. These are situations where individuals hold and are hesitant to take flight, making them more susceptible to predation by mammalian predators.

Although hens have been killed by mammalian predators while on nests and with broods, over 2,200 prairie grouse night roosts were examined in central Wisconsin and at Crex, with no indication of mammalian predation. Fox and coyote tracks were often observed in roost areas, at times within 10 m of roosting sites.

The most common raptors observed at booming grounds in central Wisconsin in 1972 were the northern harrier (77.4%, N=41) followed by the goshawk (9.4%, N=5) and rough-legged hawk (3.7%, N=2). Berger et al. (1963), and Anderson (1969a) both working in central Wisconsin and Svedarsky and Sparling (1978) in Minnesota also reported that harriers were the most frequently observed raptor at booming grounds.

Away from the booming grounds, the most common raptors associated with radio-tagged prairie chickens in 1972 in central Wisconsin during the spring were the northern

harrier (32.0% N=8), rough-legged (32.0% N=8), redtail (20.0% N=5) and goshawk (12.0% N=3). The decline in the number of harriers and increase in incidence of perching raptors reflected differences in both the hunting behavior of raptors and the daily activity of prairie chickens. The harrier hunts while flying over open treeless areas, while the redtail, goshawk, roughed-legged and horned owl hunt from elevated perches. Contact with the displaying prairie chickens was limited because booming grounds were usually located more than 200 m from trees. However, some access to potential prey in these open treeless areas was provided by telephone poles and fence posts.

Hens spend most of their time away from the booming grounds and are exposed to fewer raptors. Exposure for hens was not known because the indices for radioed birds away from the booming grounds could not be broken down by sex; however, raptor exposure has to be at least equal to the combined total index while off the booming grounds.

In April, hens were usually found within 1.6 km of the booming grounds in small flocks or alone during nest site selection and egg-laying. Hens during egg-laying localized in a relatively small area. The regular use of a small area and solitary behavior could make them susceptible to a predator, particularly a raptor. Both Allee (1938) and Moriarity (1976) indicated that predators are more likely to be observed by groups than solitary animals.

Oring (1982) concluded that grouse practicing communal display in open areas were less vulnerable to predation than if they displayed alone. One explanation for the evolution of the communal display is that males gain an advantage through better predator detection. However, if advantages are obtained by being in a flock and since prairie grouse spend far more time away from the display grounds than on them, it is possible that the communal display simply evolved as a result of flock feeding behavior.

The differences in flocking behavior between cocks and hens and the tendency for hens to spend more time closer to trees would appear to make hens more susceptible to raptors. These differences in raptor exposure between cocks and hens put the hens at a disadvantage especially when they are alone during egg-laying and incubation. This hypothesis was supported by data on survival of radio-tagged prairie chicken cocks and hens during the spring.

Mean mortality during prenesting to incubation (1 April-20 June) was higher for hens (25.7%) than cocks (16.6%). However, during the prenesting period (1-30 April) mortality in central Wisconsin was higher for cocks (41.2%) than hens (33.3%; see section on Survival). The prenesting period coincides with the peak of spring raptor migration while egg-laying occurs near the end (Heintzelman 1979). The high mortality of cocks during the prenesting period

suggests that they may serve as a buffer by attracting raptors to the booming grounds and away from the hens.

An alternative explanation is that individual raptors may avoid the cocks because they are difficult to catch. This could ultimately discourage raptors from pursuing hens. This type of avoidance has been observed in North Dakota on the Sheyenne Grasslands in 1985 (Toepfer unpubl. data). In early April a redtail (with a broken 7th primary) attempted unsuccessfully to catch a displaying cock on the same booming ground 3 mornings in a row (April 4-6). Although not observed visiting this ground again from 7 April-10 May, this redtail was observed on a daily basis for 3 weeks, 1.6 km from the booming ground. It was observed using 4 tree perches within 0.4-0.8 km of 5 radioed hens during prenesting and egg-laying. One of these hens was killed during egg-laying and fed upon by a raptor, as was a radioed cock near the booming ground.

Conversely, "raptor education" by cocks on booming grounds placed the hens in greater jeopardy by causing raptors to look for prey away from the display grounds where the hens are located. This could be particularly true if perches were available near the feeding and loafing areas of individual hens. "Raptor education" may best function during spring raptor migration, but not during egg-laying and incubation when hen behavior increases their vulnerability to resident predators.

Although there probably is no simple explanation regarding display ground influence on predation, the presence of trees in prairie chicken habitat provides perching raptors with the opportunity to hunt prairie chickens. Trees were not common on the native prairie. Fire suppression, the planting of windrows, homesteads, and fence and telephone poles have all increased the number of perches. At one time the prairie chicken existed in openings created by agricultural activities in every county in Wisconsin (Leopold 1931, Grange 1948). Today they are limited to isolated artificial grassland areas where natural succession is controlled by intensive management. These northern prairie chicken areas are apparently not within the original range of the prairie chicken (Leopold 1931, Aldrich and Duvall 1955 and Aldrich 1963).

The low observed mortality of prairie chickens while on the booming grounds means that most mortality must occur away from the display grounds. As indicated by observations on booming grounds, only the perching raptors can be considered serious predators of wild adults. However the harrier has been known to capture young prairie chickens (Svedarsky 1976) and I observed a female harrier kill and feed upon an 11 week chick.

While trapping and radio tracking wild prairie chickens, raptors were observed flushing or chasing prairie

chickens in areas away from the booming grounds on 36 occasions from 1972-1978. The most active hunter of the prairie chicken away from the booming ground in central Wisconsin was the goshawk. Of 36 chases, the goshawk was observed 20 times (55.6%), the harrier 9 (25.0%), snowy owl 2 (5.6%), redtail 2 (5.6%), peregrine and gyrfalcon 1 each (2.8%). Only 4 (11.1%) of 36 chases resulted in kills, 3 by goshawks and 1 by a redtail. Most of the observed chases occurred in the winter (58.3%), while the birds were feeding (85.1%). Most of the raptors were perched in trees before the attack (60.9%). Table 74 in the appendix contains information on the species, date, time, behavior of prairie chickens, habitat and fate of raptor pursuits.

Two types of attack behavior were used by goshawks when chasing prairie chickens: a low flight 3-5 meters off the ground where the hawk blended in with the treeline and an ambush where the hawk sat in a tree and waited for the birds to visit a nearby feeding area. Both methods were successful in capturing prairie chickens. Gullion and Marshall (1968) felt that coniferous trees were used by raptors as screens in ambushing ruffed grouse. Gullion and Alm (1983) reported declines in longevity of ruffed grouse that were associated with presence of coniferous trees and goshawks. Sparling (1976) reported a goshawk killing a cock prairie chicken while on the booming ground by coming out of the sun. The carcasses of 4 prairie chickens (2

cocks and 2 hens) killed by goshawks in this study were examined and none appeared to be underweight or previously injured.

In part as a result of a goshawk "invasion" in the fall of 1972 (Hofslund 1973), the goshawk was particularly active in hunting prairie chickens in central Wisconsin at food patches and bait piles during the winter of 1972-73. On 12 January 1973, based on time and location, as many as 6 individual goshawks were observed perched in areas where 6 separate flocks of prairie chickens fed daily. These agricultural patches also attracted other species of prey for raptors.

Grange (1948) stated, "The goshawk which sometimes winters in the state in numbers, is by far the most skillful and is quite capable of reducing a grouse covey by more than half its birds before the balance of the covey acquires equal skill in escaping or finds perfect cover. Goshawk winters are rather unusual, but when they occur they assume real importance." Mueller and Berger (1967) reported large fall peaks in goshawk flights in Wisconsin in 1962 and 1963 and hypothesized that these increases were related to the 10-year cycle.

Raptors can also indirectly influence prairie chicken survival by harassing birds at feeding sites. On 2 February 1976, 2 goshawks prevented a flock of 20-44 prairie chickens from feeding in a corn field by

periodically flushing them (Table 74, Appendix). This type of behavior could prove to be self-serving in that some individuals may be weakened and more easily caught by predators. Any build-up in numbers and concentration of raptors in an area would make winter survival more difficult for prairie chickens.

Goshawks were also observed hunting prairie chickens in central Wisconsin during the 3 winters from 1973-76, but not as regularly nor in the numbers observed in 1972-73. The prairie chicken populations declined 33.9% following the winter of 1972-73 and continued to decline through 1976. This decline appears to be associated with the increase in the number of goshawks during fall migratory flights (Toepfer unpubl. data).

No goshawks were observed at Crex during the winters of 1976-77 and 1977-78. This lack of goshawks was believed to have been a function of habitat (no trees or perches within 0.8 km of feeding areas).

Great horned owls were observed on booming grounds in central Wisconsin but not commonly. They were also observed near wild birds away from the booming grounds on only 4 occasions, though they were often heard calling near roosting radioed prairie chickens. Several radioed and non-radioed birds were found dead and fed upon by raptors near or in their roosting areas and horned owls were the suspected cause of death. Horned owls, like goshawks, are

influenced by the 10-year cycle and are known to emigrate during hare declines (Adamicik and Keith 1978). Regarding the great horned owl, Grange (1948) felt that "it is semi-migratory" and "Under high nesting densities and also in areas subject to heavy winter influx, the great horned owl can be and is a formidable consumer of birds and under certain circumstances of grouse".

The evidence to date suggests that northern prairie chicken populations are cyclic (Leopold 1931, 1933, Schmidt 1936, Grange, 1948, Hamerstrom 1973). This author believed that the cyclic nature of certain predators, particularly goshawks and horned owls, may play a key role in a prairie chicken population cycle. Keith (1963), using kill estimates, felt that the prairie grouse showed a relatively synchronous 8-11 year cycle in the Lake states and a 9-10 year cycle in Manitoba, similar to the cycle in ruffed grouse. Keith and Windberg (1978) suggested that the "grouse are cyclic due to varying rates of predator induced mortality - a spin-off from the hare predator interaction" and that synchrony is reinforced by a highly mobile predator population. The northern prairie chicken management areas are situated in the ecotone between the northern deciduous and coniferous forests. Based on observations made in this study it is hypothesized that migrating and dispersing goshawks and horned owls become associated with forested habitat surrounding open

grasslands in central Wisconsin management areas where they hunt prairie chickens that congregate in feeding areas. This increase in the number of raptors hunting prairie chickens increases mortality causing the population to decline and then increase when raptor numbers decrease.

Pen-reared Birds

The released pen-reared prairie chickens displaying at Crex in the spring of 1975 and 1976 also attracted raptors but at a rate 1.5-2 times higher than wild prairie chickens on booming grounds (Table 36). Evidence from western Minnesota and Crex, collected for only a 2 week period during 1-20 April, 1977 indicated that raptors were also attracted to booming grounds in these areas, but at levels lower than the displaying pen-reared birds at Crex in 1975 and 1976 (24.3 and 21.7 versus 30.3 and 29.2 raptors/100 hours respectively).

The pen-reared radioed birds attracted raptors at a rate 3-4 times greater than wild birds in central Wisconsin and 2.5 times higher than those at Crex in 1977 and 1978 (Tables 36 and 37). The raptor indices for wild radioed birds at Crex were approximately twice those of wild birds in central Wisconsin. This higher concentration of raptors migrating through Crex was probably due to its proximity to Lake Superior which tends to funnel them through the Crex area (Heintzelman 1979).

The most frequently observed raptor at the release pen

Table 37. Weekly changes in exposure to diurnal raptors (raptors/100 hours) for radi-tagged wild and pen-reared prairie chickens during the spring, Crex Meadows Wildlife Area, Wisconsin, 1975-78.

	Wild Birds						Pen-reared Birds					
	1977			1978			1975			1976		
Period	While[a] on Booming Ground	While[b] off Booming Ground	Total	While[a] on Booming Ground	While[b] off Booming Ground	Total	While[a] on Booming Ground	While[b] off Booming Ground	Total	While[a] on Booming Ground	While[b] off Booming Ground	Total
03/25-03/31	-	-	-				-	-	-	-	-	69.8[d]
04/01-04/07	-	0	-	16.7	0	-	-	-	-	-	-	37.7[d]
04/08-04/14	20.0	15.4	35.4	-	0	-	-	-	37.0[d]	-	-	29.4[d]
04/15-04/21	-	0	0	24.1	15.4	39.5	30.6	48.0	78.6[e]	-	-	22.6[d]
04/22-04/28	16.1	0	16.1	34.1	0	34.1	29.9	12.8	42.7[f]	29.2	32.8	62.0[g]
04/29-05/05	25.8	20.7	46.5	14.3	2.0	16.3	100.8	25.6	126.4	23.7	23.3	47.0
05/06-05/12	20.0	16.3	36.3	-	20.1	-	12.1	17.8	29.9	27.8	12.1	39.9
05/13-05/19	-	0	-	-	2.6		28.5	3.5	32.0	21.1	3.1	24.2
Mean[c]	20.6	9.3	26.9	24.2	9.4	30.0	43.4	26.1	69.4	26.9	22.7	42.9

[a] During morning display only.

[b] Includes both cocks and hens

[c] Total calculated for common period 04/15-05/12

[d] While birds inside pen

[e] 25 pen-reared cocks released on 04/18/75

[f] 16 pen-reared hens released on 04/28/75

[g] 127 pen-reared cocks and hens released on 04/22/76

during the spring in 1975 and 1976 was the northern harrier (79.6%, n=43), followed by the redtail (7.4% n=4) rough-legged (5.6% n=3) and the bald eagle (3.7% n=2). There was no obvious increase in the incidence of perching raptors while the birds were off the display grounds at Crex. The most common raptors associated with the radioed pen-reared and wild prairie chickens throughout the area during spring 1975-78 were the harrier (71.4, N=15 and 62.7, N=37 respectively) the redtail (22.0%, n=13 and 14.3%, n=3) and the rough-legged hawk (14.3%, n=3 and 13.6%, n=8). Only a modest difference in the incidence of perching raptors was observed on and off the booming ground at Crex (18.5%, n=10 to 28.6%, n=6). However, in central Wisconsin the incidence of perching raptors away from the booming grounds was 3.5 times greater than when on them (18%, n=11 to 64%, n=16). The lower incidence of perching raptors at Crex was because the nearest perch was 0.8 km from the pen and the agricultural areas used by wild radioed birds for feeding.

Raptor exposure indices also indicated that wild birds displaying in the fall attracted raptors, as the index was greater than for radioed birds away from the booming grounds (Table 38). Raptor indices for the fall period when pen-reared birds were released were 2-5 times greater than those for wild birds (Table 38). As in the spring, raptor indices for wild radioed birds in the fall at Crex were 2-4 times greater than in central Wisconsin reflecting the

Table 38. Weekly changes in exposure to diurnal raptors (raptors/100 hours) for radio-tagged wild and pen-reared prairie chickens during late summer and fall, central Wisconsin 1972, and Crex Meadows Wildlife Area, Wisconsin, 1974-77.

	Wild					Pen-reared	
	Central Wisconsin			Crex Meadows			
	1972			1976	1977	1974	1975
Period	While[a] on Booming Ground	While[b] off Booming Ground	Total	While[a] off Booming Total	While[b] off Booming Total	While[a] in Pen Total	While[b] in Pen Total
0916-0922	0	2.4	2.4	11.6	3.8	-	11.2
0923-0929	0	0	0	31.9	18.4	-	27.4
0930-1006	25.0	4.5	29.5	62.5	30.5	8.8	38.5
1007-1013	0	0	0	44.8	4.5	23.5	49.0
1014-1020	15.2	6.5	21.7	11.6	2.5	0	62.5
1021-1027	0	3.0	3.0	0	4.5	12.6[d]	31.2
1028-1103	0	0	0	9.3	7.2	88.8	24.4
1104-1110	0	2.9	2.9	0	6.5	94.4	71.9
1111-1117	0	3.1	3.1	6.5	0	66.7	28.6
Mean[c]	20.1	2.9	8.6	19.2	8.0	42.1	43.7

[a]During morning display.
[b]Includes both radio-tagged cocks and hens.
[c]Means calculated for common period 0930-1117.
[d]16 cocks released at pen on 102174, 190 birds still inside.

larger number of raptors migrating through the Crex area. The similarity in the raptor indices between fall 1974 before birds were released and fall 1975, when no birds were released indicates that a concentration of birds in a pen, as birds on booming grounds, attracts raptors even though they cannot catch the birds. This strengthens the hypothesis that raptors are attracted to these regular concentrations of prairie chickens in order to test for potential prey. The lower levels of raptor exposure for wild birds away from booming grounds suggested that they were not as observable and hence did not appear as vulnerable to raptors.

Based on the total raptor indices, pen-reared birds in fall 1974 and spring 1975 and 1976, were exposed to raptors at a rate 2-3 times greater than wild birds (Tables 37 and 38). The weekly raptor indices for pen-reared birds in both fall and spring showed that the highest numbers of raptors occurred during and just following the release of pen-reared prairie chickens. These peaks are 2-3 times higher than the highest levels for wild birds and clearly show that raptors were attracted to the pen-reared birds, particularly just after they were released. This trend was especially evident during the spring of 1975 when 36 cocks were released on 18 April, 10 days before the hens. The release of the cocks resulted in an initial increase in the number of raptors followed by a decline. The subsequent

release of 16 hens on 28 April, resulted in a second increase in the number of raptors (Table 37). This is in contrast to 1976 when birds were released once and a single increase and decline was observed in the raptor exposure index. The decline in the raptor index paralleled the decline in the number of birds known to be alive following both fall and spring releases. Diurnal raptors appeared to be attracted to concentrations of active pen-reared prairie chickens an attraction which was intensified when the birds become available prey. Although Newton (1976) and Phelan and Robertson (1978) have reported that raptors take advantage of local concentrations of prey, vulnerability was also a key component. Craighead and Craighead 1956, Southern and Lowe (1968), Wakeley (1978) and Bechard (1982) have indicated that vulnerability of prey and not density per se is important in determining where and what raptors hunt.

Brown harriers were observed actively hunting and pursuing the released pen-reared birds in the spring of 1976. Of 2 observed pursuits, both resulted in kills. Harriers were also flushed from the carcasses of 4 other pen-reared birds, 3 of which were still warm. Although harriers have been known to kill adult-sized wild prairie chickens it was not common (Berger et al. 1963). Pen-reared birds were much more susceptible than wild birds and harriers quickly took advantage of the situation.

This susceptibility was compounded when the released

pen-reared birds returned to the pen to feed and display, which localized activity in a relatively small area attracting raptors. Wild birds also concentrate much of their activity in a small area to display. However, they typically disperse 0.8-1.6 m to feed and loaf during the midday hours.

Weekly raptor indices for radioed birds during 1972 in central Wisconsin and at Crex 1976-78 showed that only during migration and winter are wild prairie chickens exposed to the intensity of raptor activity approaching that for pen-reared birds (Figs. 13 and 14). The increase in raptor numbers in the spring and fall seemed to coincide with migration. Seasonally, the raptor exposure indices were generally lower in the late spring and summer when prairie chickens were least observable and cover and alternate prey were abundant.

It is apparent that vulnerability plays a key role in effect that predators have on prairie chicken mortality. Vulnerability appears to be influenced by both prairie chicken behavior and by the availability of raptor perches. Two obvious ways to reduce the influence of the perching raptors on wild prairie chickens are: (1) cut down solitary trees to reduce raptor access and (2) place food patches away from the windrows, solitary trees fencelines and other perches. This will not eliminate, but should reduce predation by the larger perching raptors. Peterson

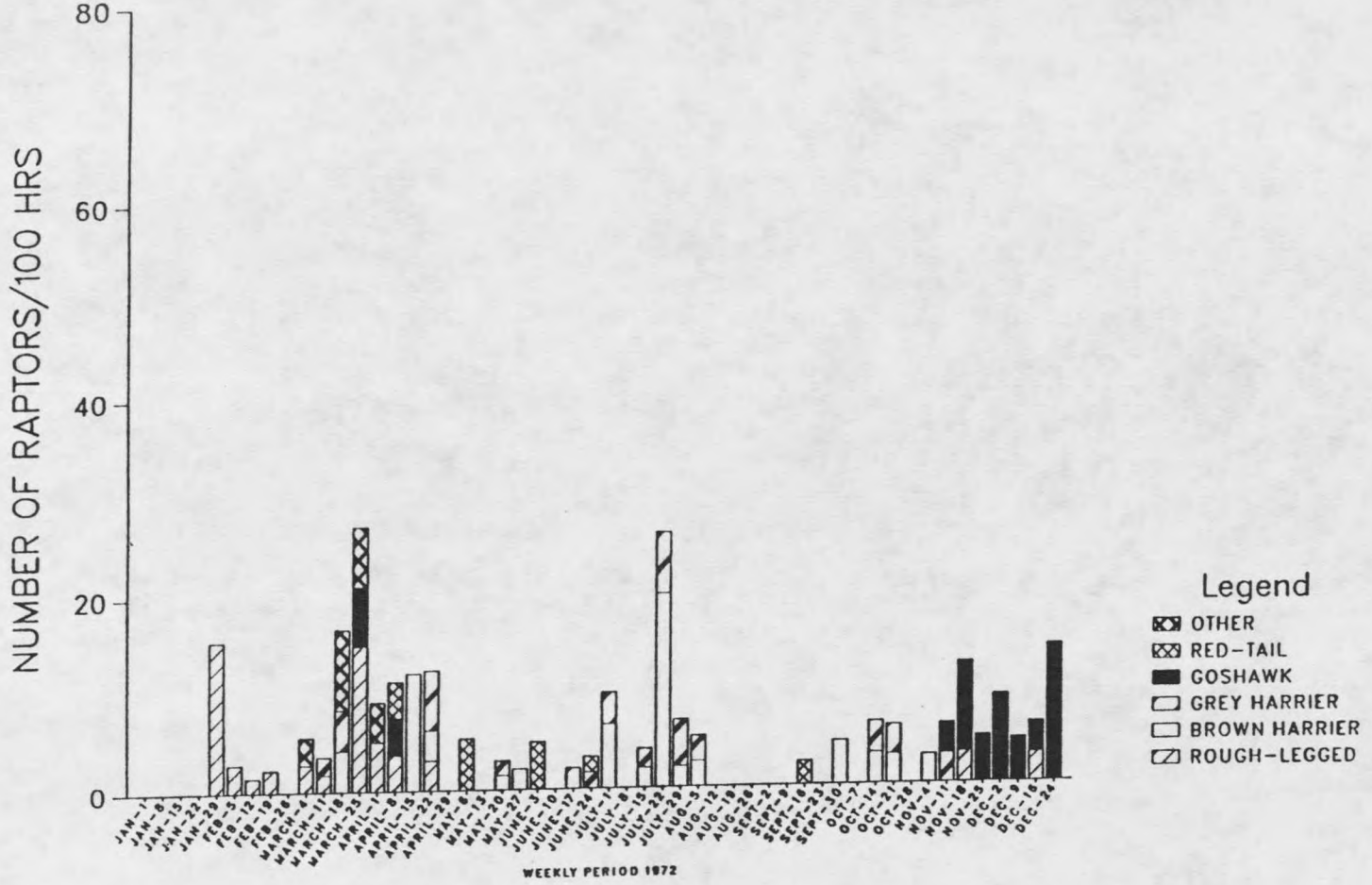


Figure 13. Weekly raptor exposure (raptors per 100 hours, within 200 m) by species for radio-tagged prairie chickens away from the booming grounds, central Wisconsin, 23 January, 1972-February, 1973.

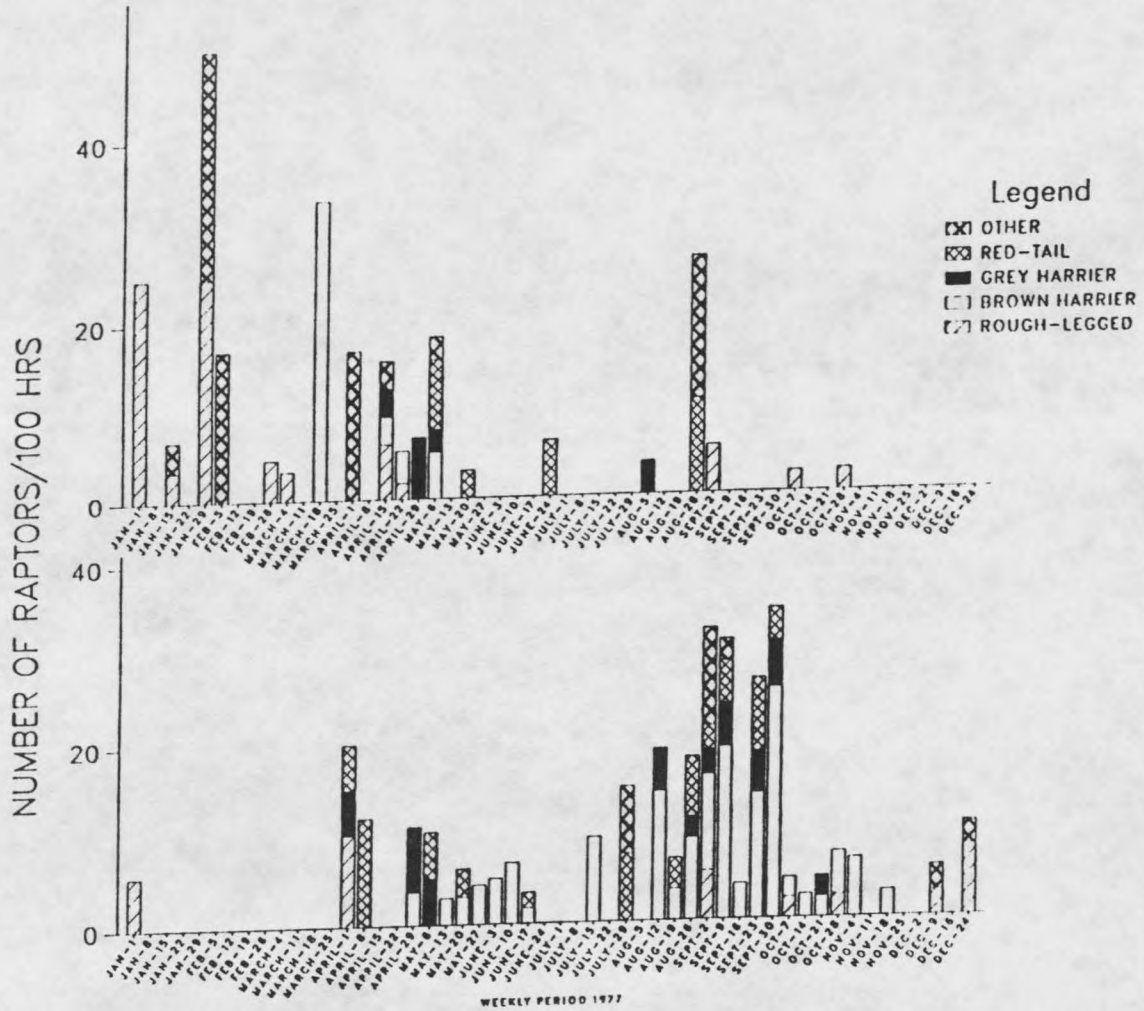


Figure 14. Weekly raptor exposure (raptors per 100 hours, within 200 m) by species for radio-tagged prairie chickens away from the booming grounds, Crex Meadows Wildlife Area, Wisconsin, 1977 (bottom) and 1978 (top).

(1979) found that areas without perches were not used by redtails and horned owls and believed that selective removal of perch sites (primarily trees) would discourage raptors from hunting certain areas. Hamerstrom et al. (1957) stated that "predator control is no substitute for habitat management" and Newton (1970) felt "habitat management more important than predator control".

Flushing Behavior Wild Birds

The distances at which birds take flight (flush) from a potential threat should provide insight into their ability to recognize and react to predators. Published information on flushing distances in prairie chickens is sketchy and limited to a few observations made by Mohler (1952).

Analysis of flushing behavior in prairie chickens was complicated because of interactions between birds, time of day, season, height of vegetation, breeding state and molt. The greatest influence on flushing distances was the number of birds and time of year (Fig. 15). There were significant, but not high correlations between the number of birds in a flock and flushing distances (Total $r=0.51$, $P=0.001$, $n=1024$, Winter $r=0.40$, $n=228$, Spring $r=0.45$, $n=270$, Summer $r=0.47$, $n=216$, Fall $r=0.34$, $n=310$). Larger flocks seemed to reduce the overall security of individuals and caused birds to flush at greater distances than if they were alone or in smaller groups.

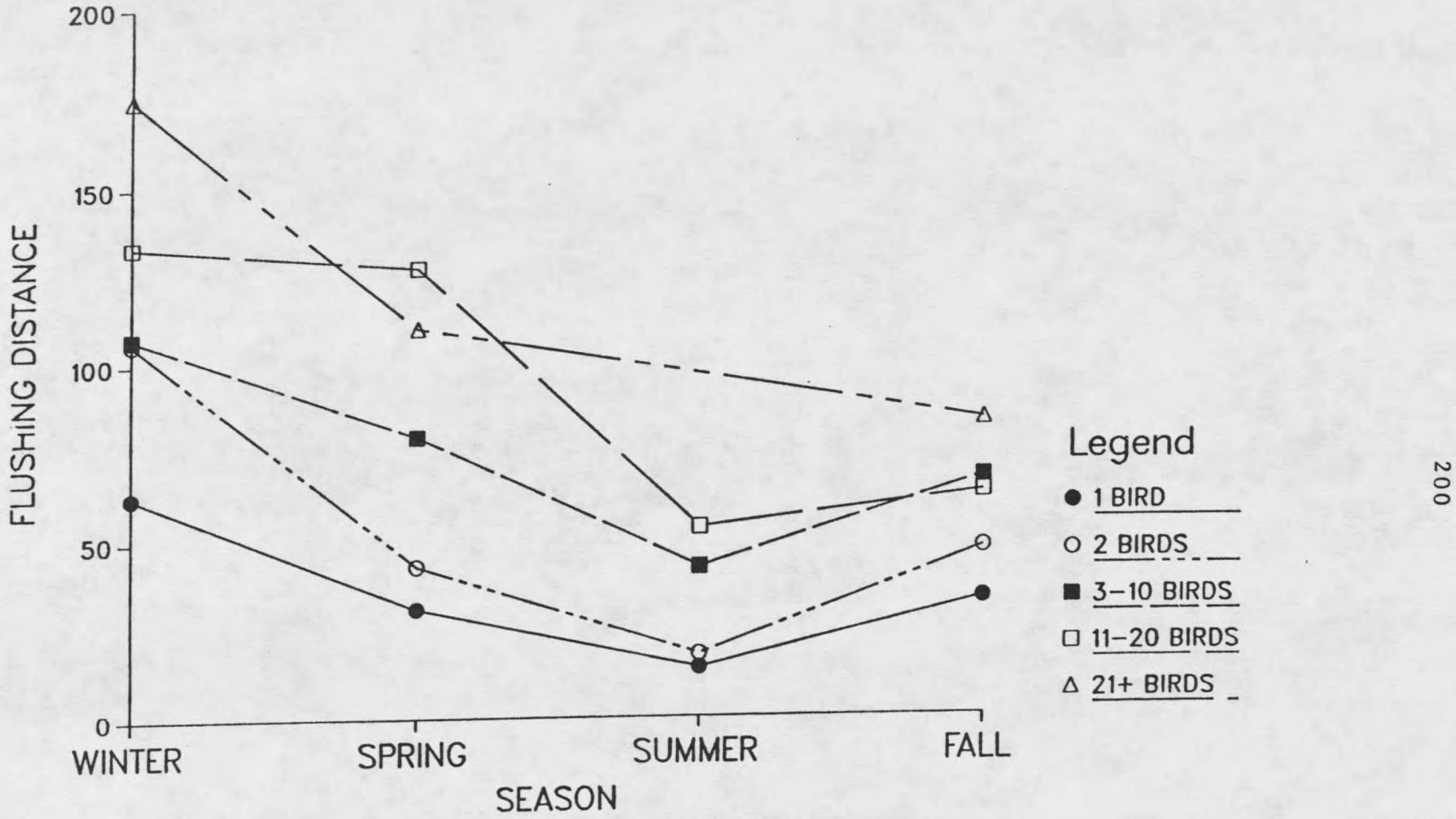


Figure 15. Mean seasonal flushing distances (m) by number of wild prairie chickens, central Wisconsin 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78.

However, flushing distances were influenced by other factors as responses of single birds and larger flocks varied with the seasons (Fig. 15). Seasonal changes in mean flushing distances were somewhat similar for both singles and larger flocks, suggesting that these changes were influenced by behavior and environmental conditions. Because of the strong relationship between the number of birds and flushing distances, single birds were used to examine the effects of other variables on flushing distances.

Seasonal variation in flushing distances was believed to be related to security provided by vegetative cover. Mean flushing distances were greatest in winter when cover was limited by snow and shortest during the summer when vegetation provided the greatest security. Summer flushing distances were also influenced by the occurrence of the body and wing molt which encouraged some birds to run, rather than flush, from the observer. Vegetation conditions and flushing distances were similar during the fall and spring (Fig 15).

The height class of vegetation also influenced flushing distances. Tall cover provided security in the form of screening cover and there was an inverse relationship between cover height and flushing distances in all seasons for single birds (Table 39). The flushing distances of larger flocks were also influenced by the

Table 39. Mean seasonal flushing distances (m) by vegetation height classes for single wild prairie chickens in central Wisconsin, 1972-76 and Crex Meadows, 1976-78 and pen-reared birds inside and outside the pen, Crex Meadows Wildlife Area, Wisconsin 1974-76. Sample sizes area in parentheses.

	Vegetation Height Class					
Season	I (0-8 cm)	II (9-25 cm)	III (26-50 cm)	IV (50-100 cm)	V (100-200 cm)	Total
Winter	97.2+64.9 (15)	61.6+52.4 (11)	47.3+39.7 (20)	55.7+73.8 (6)	41.1+47.2 (15)	60.6+55.0 (67)
Spring	35.5+28.1 (21)	27.6+20.7 (53)	26.4+21.3 (45)	22.4+25.7(12)		27.3+24.0(131)
Summer	26.8+22.3 (16)	14.3+14.5 (30)	10.8+ 9.0 (64)	7.4+ 7.1(38)	20.3+27.7 (3)	19.9+16.1(151)
Fall	72.5+75.0 (6)	25.0+13.3 (23)	31.8+31.5 (56)	21.8+15.5(17)	24.0+15.1 (4)	35.4+29.8(106)
Total	52.9+52.8 (58)	26.9+25.9(117)	24.9+27.1(185)	17.2+27.2(73)	35.2+41.0 (22)	31.4+34.6(455)
Pen-reared						
Inside pen	10.1+ 4.6 (11)	8.8+ 4.9 (17)	7.6+ 3.8 (4)	4.4+ 5.0(25)		7.7+ 4.7(57)
Outside pen	12.5+ 8.7(121)	9.3+6.3 (12)	7.4+ 6.7 (4)	7.7+21.8 (4)		13.6+10.0(141)

height of cover, but to a lesser degree than smaller flocks (Fig 16). The flushing distances within common height classes varied between the seasons and suggested that behavioral changes were involved.

The behavioral and physiological state of the bird also influenced flushing distances. Hens on nests exhibited the shortest mean flushing distances (0.85±1.2 m, n=22) followed by hens with broods (June 1.3±1.3 m, n=8, July 1.7±1.6 m, n=7 and August 2.2±1.7 m, n=14). The flushing distances of hens with broods varied directly with the age of the chicks ($r=0.891$, $n=29$, $P=0.001$).

Darkness provided the greatest security for prairie chickens as exhibited by the short flushing distances of adults at night (Total 1.6±1.3 m, n=68). Even at night, mean flushing distances of single birds varied with the seasons supporting the idea that flushing distances were influenced by seasonal changes in behavior (Summer 1.2±0.9 m, n=37, Fall 1.7±1.0 m, n=13, and Winter 3.3±1.4 m, n=18).

The contagious flushing behavior of flocks observed during the day rarely occurred at night, as it was typical to flush only 1 bird, but find additional roosts within 5-10 m of the flush site the following day. From the survival viewpoint, it was probably safer to hold at night than flush into the dark. Silvy (pers. comm.) noted that when nightlighting prairie chickens in Kansas a number of their birds were killed by great horned owls after they had

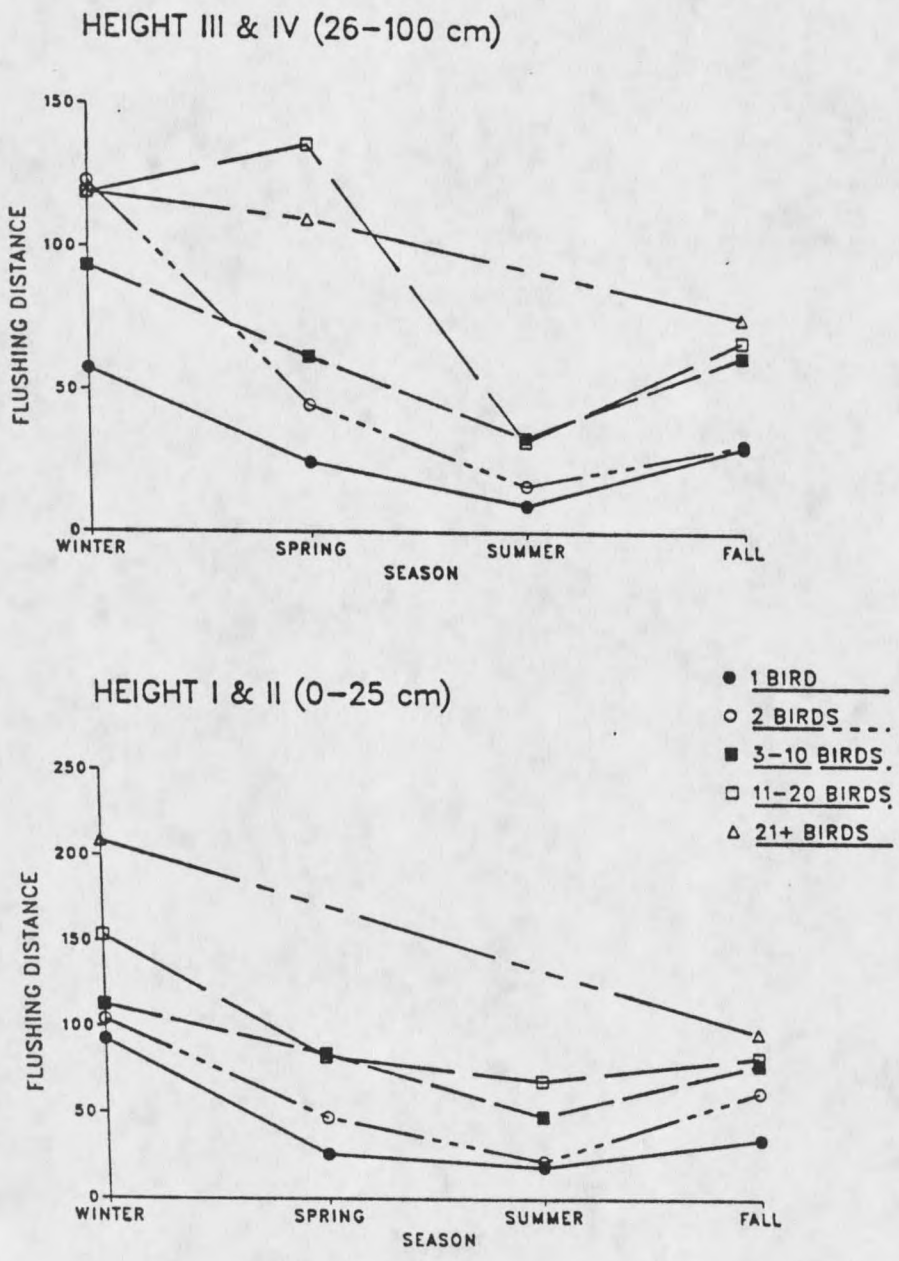


Figure 16. Mean seasonal flushing distances (m) by height class of vegetation (0-25 cm or 26-100 cm) by number of prairie chickens, central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, 1976-78.

been flushed. There was no mortality associated with flushing radio-tagged wild birds at night or during the day during this study. Movements did not appear to be affected by forced flushing as none of the radio-tagged birds abandoned the areas from which they were flushed.

A reluctance to flush was evident in late summer when radioed birds often ran when approached by an observer. This behavior was observed in a radio-tagged bird in a group. Running before flushing and holding tight even in the presence of a dog was primarily due to the birds being in the molt. Running was also observed in non-radioed birds. This behavior raises serious questions about the validity of flush site habitat analysis in the summer and early fall and the use of strip censuses (Burnham et al. 1980) in determining prairie grouse numbers.

Pen-reared Birds

The mean distances at which the released pen-reared prairie chickens flushed were approximately 50-65% less than the maximum mean flushing distances of single birds in the spring (13.6±10.0 m, n=141 versus 27.3±24.0 m, n=131, P=0.001) and fall (11.6±12.9 m, n=84, versus 35.0±29.8 m, n=106, P=0.001)(Table 40). The mean flushing distances of pen-reared birds were most like those of single wild birds during the summer (19.9±16.1 m, n=151), but were still 6-7 m less (P=0.001). Other than the reduced flushing distances, pen-reared prairie chickens exhibited the same flushing

Table 40. Mean flushing distances (m) for pen-reared prairie chickens by flock size by release and while inside the pen, Crex Meadows Wildlife Area, 1974-76. Sample sizes are in parentheses.

Release	Number of birds flushing					
	1	2	3-10[a]	11-20[b]	21+	Total
October 1974	10.0+11.4 (65)	20.0+19.7(12)	13.8+ 3.9 (3)	13.7+ 3.2 (2)	-	11.6+12.9 (84)
April 1975	11.9+ 7.2 (41)	11.4+ 3.2 (2)	-	18.2+ (1)	-	12.1+ 7.1 (44)
April 1976	12.7+ 9.4 (80)	20.8+17.6 (2)	17.4+ 6.7 (4)	31.1+24.8 (3)	-	14.3+11.1 (97)
Total Spring	12.5+ 8.7(121)	19.3+16.3(12)	17.4+ 6.7 (4)	27.7+21.8 (4)	-	13.6+10.0(141)
Inside pen	7.3+ 4.7(104)	11.9+ 4.6 (5)	6.5+ 1.9 (4)	41.5+48.8 (2)	48.9+45.3(10)	11.2+17.9(126)

[a] 3 birds for outside pen.
[b] 4-7 birds for outside pen.

patterns as wild birds. Flushing distances decreased with greater cover height and increased with flock size (Tables 39 and 40).

Flushing distances were apparently suppressed by conditions inside the pen as they increased once the birds were released (Table 40). Mean flushing distances varied directly with wing condition in spring, but even the flushing distances of the best pen-reared birds were still half those of wild birds (13.0±7.3 m, n=27 versus 27.3±24.0m, n=131, P=0.001) (Table 41). The increase in mean flushing distance in spring 1976 over 1975 was a function of improved wing condition in the birds released in 1976, efforts to reduce habituation by increasing cover in the pen and reducing human visits to the pen.

Habituation in birds in the form of reduced flushing distances has been documented by other researchers. Cooke (1980) found that various bird species were more approachable in suburban than rural areas and felt this difference was due to greater contact with humans in the suburban area. General observations indicated that pen-reared birds often ran before flushing, even when not in the molt or with brood, a habit acquired while inside the pen.

Krauss et al. (1987) found that the game-farm pheasants became more wary during the post-release period, but were still more approachable than wild pheasants. It

Table 41. Mean flushing distances (m) for single pen-reared prairie chickens by wing condition, released in April, Crex Meadows Wildlife Area, Wisconsin, 1975 and 1976. Sample sizes are in parentheses.

Wing Condition[a]	Spring 1975	Spring 1976	Total
Excellent	16.5+15.5 (2)	13.0+11.2 (7)	13.8+11.2 (9)
Good	14.2+ 8.0 (5)	12.0+ 2.9(13)	12.3+ 6.7 (20)
Fair	9.3+ 7.6 (9)	8.8+ 4.1 (5)	9.1+ 6.4 (14)
Poor	8.9+ 2.8 (5)	4.6+ 4.5 (6)	6.6+ 3.8 (11)
Total	11.1+ 7.6 (21)	10.6+ 6.9(31)	10.6+ 6.9 (52)
Excellent/Good	14.8+ 9.2 (7)[b]	12.3+ 6.7(20)[b]	13.0+ 7.3 (27)
Fair/Poor	9.2+ 6.2 (14)[c]	6.6+ 3.8(11)[c]	8.0+ 5.0 (25)
Total	13.0+ 7.3 (27)[d]	8.0+ 5.0(11)[d]	-

[a]See text for explaination.

[b]P=0.107

[c]P=0.015

[d]P=0.007

takes a considerable amount of time outside of the pen for pen-reared prairie chickens to overcome the conditioning and habituation acquired while in the pen. There was no strong relationship between flushing distances and number of days (1-45) out of pen in spring 1975 and 1976 ($r=-0.054$, $n=126$, $P=0.276$) or fall 1974 ($r=0.190$, $n=72$, $P=0.055$). The flushing distances of the pen-reared birds that survived 3 months after release, were still less than those of wild birds (6.8 ± 5.0 m, $n=12$ versus 19.9 ± 16.1 m, $n=151$, $P=0.001$). Only 2 pen-reared birds were observed in fall 1976, and both were with wild birds and appeared to have adapted to conditions in the wild.

Hessler et al. (1970) suggested that game farm pheasants became more wary after associating with wild birds. At Crex, just the opposite occurred as flushing distances of single wild prairie chickens were approximately 9 m less when they were with pen-reared birds (27.3 ± 22.6 m, $n=49$ versus 18.4 ± 22.6 m, $n=139$, $p=0.007$).

There was no contagious flushing observed in the pen-reared birds comparable to that observed in wild birds. Such behavior suggests a lack of flock integrity in pen-reared prairie chickens. When flushed from the pen area, both the pen-reared and wild birds flushed and flew alone. Initially birds exhibited contagious flushing when put in the pen at Crex, but this behavior declined with more time in the pen. Penned birds which took part in contagious

flushes were more susceptible to flight feather deterioration and encounters with the sides of the pen conditioning the pen-reared birds to respond as individuals rather than as a flock. This type of behavior would be counter productive once the birds were released because individuals which hesitate or fail to respond to the reactions of other birds would be susceptible to predators.

Flocking

Resident Wild Birds

Wild resident prairie chickens are social birds. Of 20,713 prairie chickens observed away from the booming grounds in central Wisconsin 1972-76 and 5,622 at Crex 1976-78, 97.8% and 88.5% respectively were in groups of 2 or more. Mean flock size was 11.1±10.8 (n=1836) for central Wisconsin and 6.6±4.3 (n=809) for Crex (P=0.001). The data from Crex included mixed flocks of prairie chickens and sharptails. Although the mean seasonal flock sizes varied between years in both areas, seasonal trends between years were similar (Fig. 17), so data from separate years were combined to show seasonal and biweekly changes in mean flock size.

Mean flock size varied between seasons in both areas with the largest flocks being observed in the winter and the smallest in the spring and summer (Table 42). The incidence of single birds also varied between the seasons

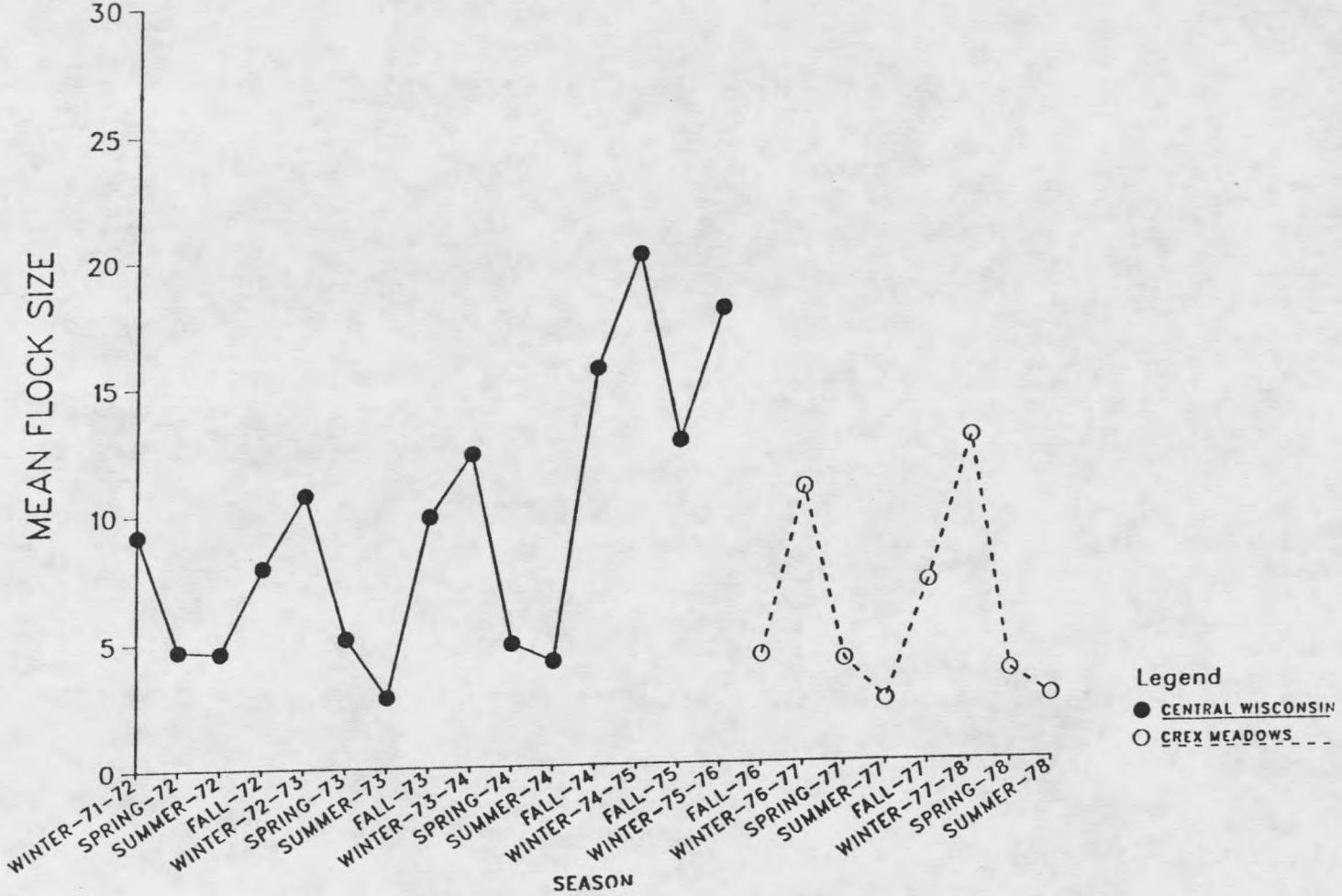


Figure 17. Mean seasonal prairie chicken flock sizes by year in central Wisconsin, winter 1971-winter 1976 and Crex Meadows Wildlife Area, Wisconsin, fall 1976-summer 1978. Flocks at Crex Meadows include mixed flocks of prairie chickens and sharptails.

Table 42. Mean seasonal flock sizes of wild prairie chickens during daylight and at night (based on roost counts) in central Wisconsin, 1972-76and Crex Meadows Wildlife Area, Wisconsin, 1976-78. Number of flocks are in parentheses.

	Central Wisconsin		Crex Meadows[a]	
Season	Day	Night	Day	Night
Winter	14.3±14.8 (1046)	6.6± 6.7 (53)[bc]	13.0±13.1(281)[ce]	4.8±3.9 (44)[de]
Range	1-100	1-17	1-56	1-13
Spring	4.3± 4.8 (240)[b]	5.6± 5.3 (17)	3.8± 4.4(151)[c]	6.4±4.2 (21)[bc]
Range	1-25	1-21	1-36	1-14
Summer	4.2± 3.7 (228)[b]	5.5± 4.7 (82)[bc]	2.7± 2.5 (40)[b]	3.5±2.6 (69)[c]
Range	1-19	1-14	1-10	1-9
Fall	11.4±12.1 (322)[b]	8.4±11.6 (57)	6.5± 8.1(337)[b]	5.5±6.8 (38)[b]
Range	1-51	1-21	1-46	1-17
Total	11.1±10.8(1836)[b]	6.6± 4.3(209)[b]	8.1±10.3(809)[b]	4.7±6.8(152)[b]

[bcde] Means on same line with the same superscript P>0.05.

and was highest in the spring (35.1% and 43.0%) and summer (33.1% and 62.9%) in central Wisconsin and Crex respectively. Figure 18 shows seasonal frequency of flock by size and area. The higher incidence of singles during the spring was a reflection of nest initiation by hens, as most of the radio-tagged hens during egg-laying were alone (88.5%, Mean 1.2±1.3, n=26). Occasionally small groups of hens were observed feeding together during this period. By contrast, during the pre-nesting period only 31% (Mean 2.8±3.1, n=17) of the radio-tagged hens were observed alone.

The high percentage of singles observed during the summer was partially due to the birds being in molt and their associated reluctance to take flight. Consequently not all birds flushed, resulting in deflated mean summer flock sizes and an inflated incidence of singles. One radioed bird in the summer of 1972, was known to feed and fly to and from the roost in a group of 10-12 birds during July and August. However, when this bird was flushed, only part of this flock could be accounted for unless a pointing dog was worked through the area several times.

Comparisons of mean seasonal flock sizes between the 2 areas were within 1-2 birds in all seasons except fall (Table 42). The larger flocks observed in the fall in central Wisconsin, as compared to Crex, were thought to be due to the presence of more young of the year. Yeatter

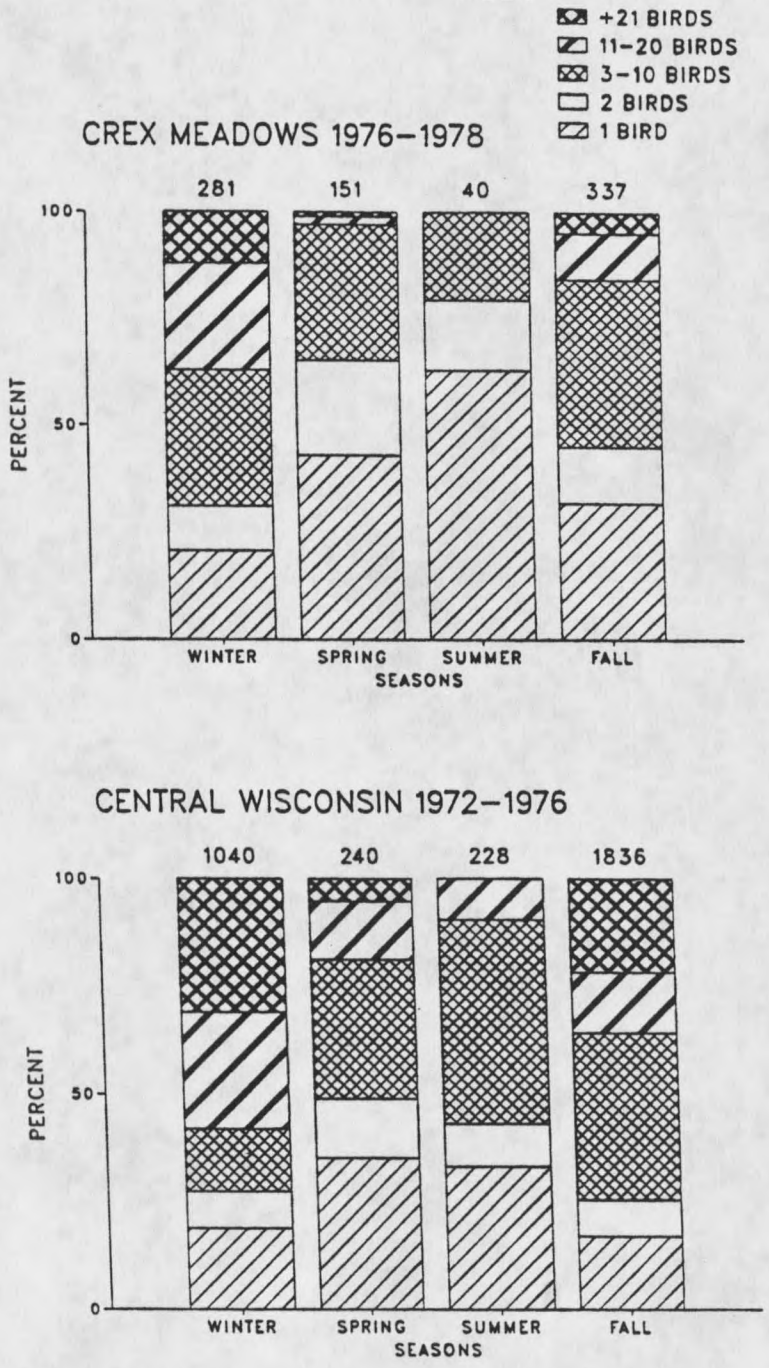


Figure 18. Seasonal distributions of prairie chicken flocks in central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78. Flocks at Crex Meadows include mixed flocks of prairie chickens and sharptails.

(1943) and Baker (1953) reported that prairie chicken flocks began to form in mid-August and September. The similarity in mean flock sizes observed in a resident and established population suggests there may be a preferred group size in prairie chickens.

Radio-tagging did not appear to influence sociality as radioed birds were observed alone as often as non-radioed birds (central Wisconsin 23.3%, n=126 versus 19.8%, n=275, CSq=0.55, df=1, P=0.458, and Crex 38.7%, n=173 versus 41.8%, n=476, CSq=1.89, df=1, P=0.169). The higher incidence of singles at Crex was thought to be the result of the established transplanted prairie chickens taking longer to form associations with other individuals during the summer of 1976. The mean flock size of radio-tagged birds was larger than those of non-radioed birds in central Wisconsin (12.5±14.7, n=540 versus 11.1±12.7, n=1386, P=0.051) and at Crex (8.0±11.4, n=447 versus 4.7±6.6, n=1140 P=0.001).

Based on radio-tagged individuals, hens, during the breeding season, were usually observed in larger flocks than cocks in both central Wisconsin (14.1±14.8, n=175 versus 12.0±15.0, n=327, P=0.132) and at Crex (11.1±12.8, n=138 versus 6.0±10.1, n=255, P=0.001) (Table 43). This pattern was also observed in the biweekly mean flock sizes with the larger flocks observed during the fall and winter (Fig. 19). The mean flock size of hens at Crex being

Table 43. Mean seasonal flock sizes for radio-tagged prairie chickens by sex, in central Wisconsin, 1972-76, and Crex Meadows Wildlife Area 1976-78. Number of flocks are in parentheses.

	Cocks		Hens	
	Central Wisconsin	Crex Meadows	Central Wisconsin	Crex Meadows
Winter	26.5±19.5 (73)^{ac}	13.9±14.6 (71)^{ab}	27.8±15.8 (51)^{a}	18.7±13.5 (38)^{c}
Spring	4.0± 4.0 (60)^{a}	1.3± 0.8 (35)^{ab}	10.5± 8.9 (39)^{ab}	3.2± 1.9 (13)^{b}
Summer	5.2± 4.0(112)^{ab}	1.4± 0.9 (68)^{a}	3.7± 3.4 (46)^{b}	1.9± 1.7 (11)^{b}
Fall	14.2±15.0 (82)^{ac}	5.0± 7.2 (81)^{ab}	12.1±13.4 (39)^{b}	6.0± 9.0 (30)^{bc}
Total	12.0±15.0(327)^{a}	6.0±10.1(255)^{abc}	14.1±14.8(175)^{b}	11.1±12.8 (92)^{c}

^{abc}Means on same line with the same superscript are significant P>0.05.

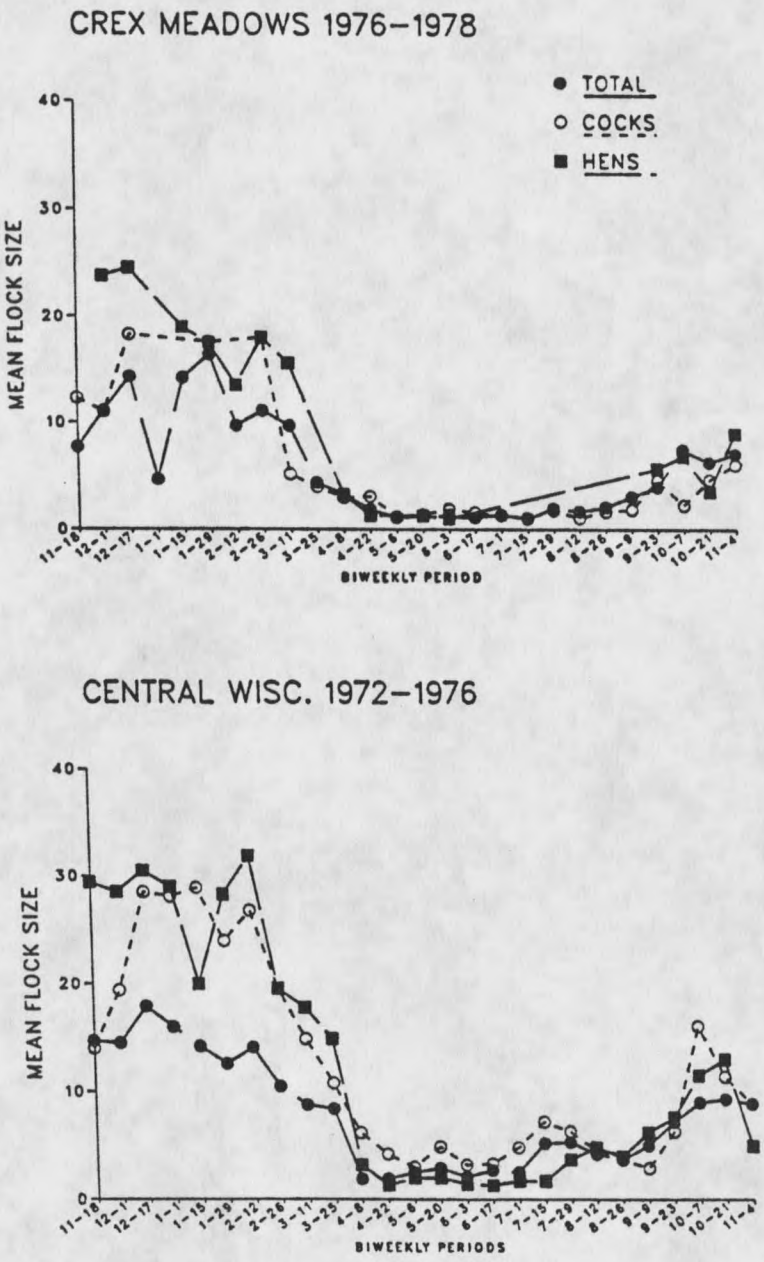


Figure 19. Mean biweekly flock sizes for all prairie chicken flocks and those containing a radio-tagged cock or hen, central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78. Flocks at Crex Meadows include mixed flocks of prairie chickens and sharptails.

larger than in Central Wisconsin, was because hens at Crex joined sharptails in mixed flocks more often than cocks. Radio-tagged cocks were believed to be in smaller flocks than hens because adult cocks remained associated with the other cocks from their home booming grounds for much of the year. Hens and immature cocks concentrated their activities near areas of readily available food. The mean size of booming grounds in central Wisconsin from 1974 to 1976 was 7.8±5.6 cocks (n=107).

In winter, after the cocks abandoned their booming grounds, the mean flock sizes peaked and flock sizes of cocks in central Wisconsin were comparable to those of hens (Table 43). Snow cover restricted the availability of food causing both cocks and hens to form larger flocks. Yeatter (1939), Schwartz (1945) and Hamerstrom and Hamerstrom (1949) noted the presence of large bisexual winter flocks (packs) that were formed by the joining of smaller flocks. That these larger flocks are smaller flocks congregated in feeding areas was corroborated by the size of feeding flocks versus flocks observed flying in central Wisconsin (Winter 18.8±16.2, n=213 versus 11.5±12.2, n=290 P=0.001, Fall 16.7±14.5 n=49 versus 12.3±11.9 P=0.072, n=95, Spring 8.3±6.6, n=38 versus 6.5±5.9, n=24 P=0.272, Summer 6.3±3.3, n=64 versus 5.8±4.2, n=28 P=0.583). All of the means for feeding flocks were larger than the total mean seasonal flock sizes (Table 42).

Although not enough flocks were observed flying at Crex to make comparisons with feeding groups, flocks observed in agricultural areas were larger than those observed away. Also, the mean flock size of birds found roosting together at night was smaller than the mean flock size observed during the day (Table 42). This difference between day and night was the result of larger flocks congregating in the agricultural areas to feed during the day in the fall and winter and separating into smaller groups to roost at night.

The most obvious shift to winter food occurred in the radio-tagged cocks from the largest booming ground in central Wisconsin (20-31 cocks). No agricultural fields were present within 1.8 km of this booming ground. With the first permanent snow cover, 6 radio-tagged cocks from this booming ground abandoned their nearby fall areas and fed in the agricultural fields near an adjacent smaller booming ground. The area around the smaller booming ground (3-11 cocks) contained several private fields and 2 food patches. A large number of birds were attracted during the winter to the abundance of feeding areas around this booming ground. The mean winter flock size for 3 years was 18.8±15.4 (n=355) which was 4-10 (Range 8.9±8.5, n=97 to 14.4-13.4, n=81) birds larger than the mean flock size from the areas of 6 other booming grounds where 20 or more flocks were observed each year. Although this area

attracted a large number of birds in the winter the booming ground was never large (3-11 cocks).

Booming grounds also appeared to be concentrations of smaller social groups. The radio-tagged cocks from booming grounds with less than 12 males were often observed as a flock away from the booming grounds. However, the radio-tagged cocks from larger booming grounds were only observed with the complete booming ground cohort when flushed from their display ground. Two of the 3 radio-tagged cocks on a booming ground of 29-31 cocks in central Wisconsin 1972, were usually observed away from the ground in a flock of 11-12 birds (n=8). The third radio-tagged cock, an immature, was observed in a group of 3-4 birds (n=10) while away from the booming ground. A third group of 10-12 cocks with no radio-tagged birds, was also observed (n=4) and accounted for the remaining cocks from this booming ground. The 2 radio-tagged cocks spent the whole summer within 0.8 km of their booming ground and were regularly observed feeding and flying to night roost in flocks of 9-12 birds (n=21).

Another booming ground with 13 cocks, 3 of which were radio-tagged, separated into smaller groups of 6, and 7 (n=7) while away from their booming ground. These 3 radio-tagged cocks spent the summer within 0.5 km of their booming ground and fed and roosted together in a flock of 4-6 birds.

Hamerstrom (1939) and Yeatter (1943) noted a group coherency by adult cocks near their booming grounds. This consistency in group sizes identified by radio-tagged cocks suggested that birds on the larger booming grounds are an assemblage of smaller social groups that probably form away from the display grounds.

Hamerstrom and Hamerstrom (1973) estimated that prairie chicken cocks spend 10% of their lives on the booming grounds. Because prairie chickens spend more time away from the booming grounds than on them, the potential for development of social associations is greater away from their display grounds. Unfortunately, not enough birds from a single booming ground were radio-tagged to determine the strength of the bond between individuals in a given area. However, several cocks from the same booming ground moved together throughout the year while others which fed and roosted together during other seasons, were apart during the winter. Hamerstrom and Hamerstrom (1939) and Schwartz (1945) also reported shifting between flocks during the winter.

Hens from the same booming ground area were only associated with each other during winter. At Crex, 4 radio-tagged hens, 3 adult prairie chicken and one sharptail moved, fed and roosted together for most of the winter of 1977-78. However, when the snow melted they moved to separate nesting areas.

Sexual segregation has been reported in prairie chickens and other grouse species (Johnsgard 1983). In this study both sexes were observed together in varying degrees during all seasons. The highest incidence of mixed flocks in prairie chickens occurred during the winter when snow limited the amount and availability of food. Based on winter trapping, the sex ratio during winter favored cocks (54.5% versus 45.5%, n=587). However, in the absence of food limitations, hens seemed to avoid the more dominant cocks.

Sexual segregation in grouse flocks has been observed in sage grouse (Patterson 1952, Beck 1977) and in capercaillie and black grouse (Koskimies 1957), all are species in which the adult cocks are larger than the hens. Sage grouse feed on sage brush (Patterson 1952) capercaillie on pine needles and black grouse on pine needles and buds during the winter (Johnsgard 1983). These are foods which are less limited in distribution and availability than the winter foods of the prairie chickens.

A review on flocking behavior by Moriarity (1976) indicated that the advantages of flocking included learning the location of food, protection from predators, mating, foraging efficiency and minimizing aggression. The two greatest advantages in prairie chickens appeared to be the location and exploitation of food resources and the detection and avoidance of predators. Evidence on survival

of radioed individuals showed that hens during periods of solitary behavior suffered higher mortality than cocks or hens in flocks, suggesting that detection of predators played an important role in flock formation.

However, the solitary nature of hens during nesting and egg-laying would appear to be a contradiction. A possible explanation is that spacing behavior disperses them into available habitat. This behavior would increase the chances of the hen being preyed upon, but it would also improve nesting success by spreading out nests. McKinney (1965) felt that in waterfowl, territoriality served to disperse nests as an anti-predator mechanism. Taylor (1976) also indicated that a function of territoriality may be to space nests to reduce egg predation.

If flocking assists in the location of food, this practice should be most prevalent when food was limited and difficult to locate. In prairie chickens flock sizes were greatest in the winter and least in summer. Thus flock formation with prairie chickens is not a function of a single factor, but a combination including the location of food and detection of predators, values of which vary with the time of day and season.

Pen-reared Birds

The pen-reared prairie chickens released in April and October did not form flocks like wild birds as only 27.1% of 501 pen-reared birds observed were in groups of 2 or

more (April 28.2% and October 25.0%). The largest number of pen-reared birds that reacted as a flock was 3 in October 1974 and 6 in April 1976. Mean flock size was 1.7±1.5 (n=93) in April 1975, 1.5±1.1 (n=123) in April 1976 and 1.7±1.4 (n=139) in October 1974.

There was no evidence that pen-reared prairie chickens formed any type of social groups once released from the pen. Observations of released birds suggested that they were almost anti-social and responded as individuals even when there were 16-50 birds in the vicinity of the pen. This lack of flocking behavior was a habit acquired as a result of living in a penned environment. Inside a pen, running singly was more conducive to survival than flushing in a contagious manner. This acquired behavior became fixed with time and continued even after the birds were released from the pen. There was no evidence that pen-reared birds became more social after release.

Transplanted Birds

The transplanted prairie chickens, when observed during orientation, were always alone (n=17). The response to being transplanted to a new area was an individual reaction and not social in nature as the transplants did not form or respond as a group. Factors conducive to survival of individuals are critical in a transplant effort and until these individuals begin to interact socially there is no population.

Establishing social interaction seems to take 3-4 months in prairie chickens as during the initial spring and summer at Crex, mean flock size was 1.1±0.62 (n=107) and 1.2±1.0, (n=95) respectively in 1976. In contrast, mean flock sizes were 3.9±4.4 (n=153) and 2.4±1.9 (n=38) during the spring and summer of 1977 and 1978 respectively. Singles made up 92.% and 88.9% of birds observed in the spring and summer in 1976 respectively, but only 40.4% and 66.4% in the subsequent spring and summer. Not until the fall, when the established transplants began to fly to the agricultural fields to feed did they begin to associate with each other and form flocks.

Movements

Wild prairie chickens are mobile birds and their major movements are made by flying. The number of movements made per day by radio-tagged prairie chickens varied with and within the seasons and was influenced most by the distribution of food and cover, breeding activities, sex, age and weather conditions. Much of the previous information on prairie chicken movements has been obtained through banding and direct observations (Hamerstrom and Hamerstrom 1949, Schwartz 1945, Mohler 1952, Baker 1953, Arthaud 1971, Hamerstrom and Hamerstrom 1973 and Horak 1985). Robel et al. (1970) working in Kansas was the first to use radio telemetry to examine the seasonal movements of prairie chickens.

Eight measurements were used to describe movements and distribution of radio-tagged prairie chickens: (1) distance to nearest booming ground and (2) home booming ground, (3) distance from nest, (4) distance between within-day locations (WD), (5) day and night/night and day locations (DN), (6) distances between successive night locations (NN), (7) consecutive daily locations (DBC), and (8) home ranges. Distances to a booming ground or a nest showed changes in prairie chicken distribution relative to biological features important to each individual and the population. DD, DN, WD movements were distances between relocations of radio-tagged birds and provided an index to the daily movements of individuals. Distances between consecutive locations were indirect movements and showed fidelity to the previous night's location. DBC were distances between consecutive daily locations. Home ranges provided an index to the size of the area prairie chickens used to meet their weekly, seasonal and yearly needs. Movement patterns were examined on a yearly, seasonal, biweekly or weekly basis to compare movements by sex, age, study areas and between different types of birds.

Home Range General

Home range was the area within which a radio-tagged prairie chicken moved during a specified time period (Baker 1978). Annual home ranges were a composite of smaller

variable seasonal ranges which in turn were a function of changes in daily movement patterns of individuals. Seasonal home ranges reflected how the daily ranges were spatially oriented relative to changes in the seasonal and daily needs of prairie chickens. Home range sizes generally reflected food and cover distribution in an area, and were influenced by age, sex, and breeding behavior. The home ranges of prairie chickens were dynamic, yet limited by their behavioral needs and movement capabilities.

Annual home ranges were calculated for 30 radioed prairie chickens, 21 in central Wisconsin (9 cocks and 12 hens) and 9 at Crex (5 cocks and 4 hens). In central Wisconsin, annual home ranges were based on 176-333 locations per radio-tagged bird (Mean 250±51) and at Crex, 216-303 locations (Mean 251±28). Annual home ranges were calculated by connecting the outer most locations to form a convex polygon (Mohr 1947, Hayne 1949). This method tends to inflate home range sizes since it encloses areas not actually used by the individual. However, it provided a better representation of the area used by prairie chickens than other methods which exclude outlying points as being less important (Jennrich and Turner 1969, Dixon and Chapman 1980). In prairie chickens these outer points are biologically important and are useful in interpreting movement patterns, particularly in immatures. Examples of

these outer points in prairie chickens include: cocks visiting their booming grounds in the late winter, exploratory moves, immature cocks and hens visiting several booming grounds in spring before establishing, hens visiting the booming ground for mate selection and cocks leaving the booming grounds to feed. These types of locations may be insignificant when standardizing home range sizes, but were important to an individual's movement and behavioral pattern.

Many sophisticated methods used to calculate home range size are attempts to standardize the area and express a multi-dimensional behavioral phenomenon in 1 dimension. Macdonald (1980) suggested that the major problem with these quantitative estimates of home range size is that they do not distinguish between the behavior at different locations.

Annual Home Ranges

Annual home ranges calculated in central Wisconsin must be considered minimum areas as only 4 of the 21 birds were followed for a complete calendar year. The rest were followed through spring, summer, fall and half or more of winter. This was believed to be a reasonable representation of annual home range because an individuals winter range usually reached its maximum by mid-winter. All the birds which established at Crex were followed for a complete year or longer.

Mean annual home ranges of radio-tagged prairie chickens in central Wisconsin were approximately 2 times larger than those at Crex (1726±2360 ha, n=21 versus 986±952 ha, n=9, P=0.166). Mean annual home ranges of hens were 3 times larger than those of cocks in central Wisconsin (2883±2046 ha, n=9 Range 440-2030 versus 859±534 ha, n=12, Range 823-10,510, P=0.001) and at Crex (1543±1290 ha, n=4, Range 841-3162 and 541±149 ha, n=5, Range 528-637, P=0.222). Both cocks and hens had larger annual ranges in central Wisconsin than at Crex (Cocks 859±534 ha, n=12 versus 541±149 ha, n=5, P=0.142 and Hens 2883±2046 ha, n=9 versus 1543±1290 ha, n=4, P=0.181).

Annual home ranges in central Wisconsin were inflated by 2 adult hens that left the Portage County area in late fall and moved 14.4 km south to the Leola Management Area. The exclusion of these 2 hens resulted in a mean annual home range for hens of 1695±1053 ha (n=10) which was still twice the mean for cocks. It was speculated that these 2 hens were moving to a wintering area. One hen made the move in a straight line in just 2 days. This direct movement plus the movement pattern once she arrived at Leola suggested that this bird had been in this area before. Hamerstrom and Hamerstrom (1973) reported movements of banded birds between adjacent management areas in central Wisconsin.

Smaller annual home ranges of cocks were due to their

7-8 month association with territories on their home booming grounds. Hens, by contrast, were associated with their home booming grounds and nesting areas for only 2-3 months during the breeding season.

Smaller annual home ranges at Crex resulted from the closer year-round proximity of food and cover. In central Wisconsin the agricultural areas used for feeding during winter (standing corn and corn platforms) were located farther from booming grounds, than at Crex (Mean 1306±490 m, n=12 versus 799±229 m, n=3, P=0.001). Fall and spring feeding areas (buckwheat, cut corn and oats) were also farther in central Wisconsin than at Crex. (Mean 918±408 m, n=12 versus 799±229 m, n=3). Thus the difference in interspersion of grassland and agriculture between the central Wisconsin and Crex study areas was responsible for these differences in movements.

Seasonal Home Ranges

Mean home ranges of radio-tagged resident prairie chickens varied with the seasons and between cocks and hens and adults and immatures (Table 44). In central Wisconsin, mean seasonal home ranges for adults were largest in winter and larger for hens than cocks (732±514 ha, n=12 versus 660±456 ha, n=14, P=0.713). Home ranges for all birds were smallest in summer and during that season larger for cocks (171±114 ha, n=20) than hens (153±87 ha, n=10, P=0.747). Mean home ranges for adults in spring and fall were

Table 44. Mean seasonal home range sizes (ha) for radio-tagged prairie chickens by sex and age central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78. Number of birds are in brackets.

	Central Wisconsin				Crex Meadows			
	Winter	Spring	Summer	Fall[a]	Winter	Spring	Summer	Fall
Adult Cocks	702±481[10]	147± 93[17]	187±117[14]	498±337 [13]	347±149[5]	153±193[5]	94±57[8]	250±183[7]
Range	231-1961	23-267	15-368	121-1428	303-404	38-484	32-187	44-551
Immature Cocks	576±437 [4]	451±312 [6]	136±105 [6]	774±463 [4]	-	-	-	-
Range	141-1101	70-891	31-316	121-1427	-	-	-	-
Total Cocks	660±456[14]	265±260[23]	171±114[20]	563±362 [17]	-	-	-	-
Adult Hens	864±654 [9]	251±134[12]	154± 53 [6]	637±1017 [6]	489±226[5]	669±628[5]	97±76[4]	422±346[5]
Range	266-1948	41-412	62-204	44-1720	213-609	41-1484	28-174	270-868
Immature Hens	600±263 [3]	936±811[11]	152±132 [4]	2535±1770 [4]	-	-	-	-
Range	117- 811	91-2850	41-329	744-4909	-	-	-	-
Total Hens	732±514[12]	563±664[23]	153± 87[10]	1480±1538 [10]	-	-	-	-

[a] 2 immature cocks and 1 immature hen with partial fall home ranges; October-November.

intermediate between summer and winter with fall larger than spring (Table 44). The greatest differences in seasonal home ranges between cocks and hens occurred in fall (563±362 ha, n=17 versus 1480±1538 ha, n=10, P=0.001). Robel et al. (1970) found a similar seasonal trend in home range sizes in radio-tagged prairie chickens in Kansas; home ranges were largest during winter and smallest during summer.

Variation in home ranges between seasons reflected seasonal changes in food and cover distribution, and behavioral differences between cocks and hens. The large home ranges in winter were related to snow cover, which reduced the availability of food and cover causing individuals to increase their home ranges to meet their daily needs. The smaller home ranges of cocks in the winter resulted from the cocks remaining closer to their home booming ground than hens. Hens were associated with a specific booming ground only during the breeding season and consequently were more likely to shift from 1 area to another when conditions changed. Gradual changes in seasonal home ranges were characteristic of cocks whereas hens were more likely to make abrupt shifts from 1 season or period to the next.

Mean home ranges of cocks in spring were smaller than hens because cocks concentrated their activities near the

booming grounds. Hens did not make regular visits to the booming grounds.

The small home ranges of radio-tagged prairie chickens observed in summer was related to an abundance of food and cover within a small area. The molting of flight and body feathers during summer also suppressed movements of adult prairie chickens at this time.

Home range sizes increased in fall as temperatures declined and birds began feeding in the agricultural fields in the mornings and evenings. Cocks had smaller home ranges than hens, again because of their tie to booming grounds for fall display. However, the fall booming ground association was not as strong as in the spring since irregular visits were made and then only during the morning. Thus fall home ranges of cocks were larger than in the spring when twice daily visits were made to their booming grounds. Although hens have been known to visit the booming grounds in fall, this was not a common occurrence. Individual hens were not associated with their nesting areas or booming grounds during fall and concentrated theiractivities near feeding and roosting areas.

Mean seasonal home ranges of immatures followed a somewhat different pattern than adults (Table 44). Although sample sizes were small, immatures had larger home ranges than adults in the spring and fall. The largest seasonal home range occurred in immature hens during the

fall (Table 44). Immature prairie chickens go through the greatest period of adjustment during their first fall following brood break-up. The lack of experience and association with a familiar area led to irregular extended movements by some immatures as they attempted to establish themselves within the population.

Robel et al. (1970) found that immatures were 35% more mobile than adults during November and December and Bowman and Robel (1977) observed that immatures were not immediately accepted into fall flocks. In this study immatures were observed shifting between several feeding areas suggesting that, unlike adults with regular patterns, they were trying to establish themselves. At least 1 radio-tagged immature cock became established on a booming ground during the fall. He appeared to move with the adults, but was killed during early winter. Two immature cocks captured in late September were not observed on a booming ground during fall and immature hens apparently did not become associated with a booming ground until the following spring. In the fall, adult hens and immatures were more likely to change areas than established cocks.

Immature cocks had larger home ranges than adult cocks and hens in the spring, a result of immature cocks attempting to establish on a booming ground. Three radio-tagged immature cocks were known to have visited at least 3

booming grounds during March before becoming established. Robel et al. (1970) observed a single radio-tagged immature cock visit at least 2 booming grounds in 1 morning in an effort to establish a territory. They also reported that in April immature cocks had home ranges 73% larger than adult cocks.

The larger mean home ranges of immature hens during spring resulted from 4 hens which covered large areas around several booming grounds before they established nesting areas.

Seasonal home ranges of both cocks and hens and immatures and adults were most comparable during summer and winter in the absence of breeding behavior (Table 44). During these periods habitat conditions appeared to have the greatest influence on the size of a birds home range. Robel et al. (1970) also found that movements of adult and immature cocks were similar from January through March.

Mean seasonal home range sizes at Crex were generally smaller than those of adults in central Wisconsin and with one exception followed the same seasonal trends (Table 44). The exception was that the mean home ranges of hens at Crex were larger in the spring than in the fall (Table 44). This exception was due to the large home range (1489 ha) of a single hen which did not nest at Crex in 1977, and was re-released in August after she wandered away from the release area. Her movement pattern, while trying to

establish a nesting area in 1978, was irregular and more like that of an immature than an established adult. The exclusion of this large home range reduced the mean spring home range at Crex to 288±92 ha for hens which was less than in the fall.

The close proximity of undisturbed cover to the agricultural areas accounts for the seasonal home ranges being smaller at Crex than in central Wisconsin. The effects of this habitat distribution on home range size can best be seen in the relationship of summer and winter home ranges to each other in the 2 areas. In central Wisconsin, an overlap existed between the summer and winter home ranges in only 2 of 14 radio-tagged birds. At Crex, overlap occurred for all radio-tagged birds. Most radio-tagged prairie chickens in central Wisconsin had discrete seasonal ranges, associated with grassland areas in the summer and agricultural areas during winter.

Weekly Home Ranges

Although seasonal ranges provide a general overview of movement patterns in prairie chickens, weekly home ranges were more sensitive to the timing of those environmental and behavioral changes which influence the daily movements of prairie chickens. Weekly home ranges were calculated only for individuals with at least 10 locations per week, 2 of which were night locations.

Changes in weekly home ranges were largest during winter and smallest during the summer (Table 45). Figures 20 and 21 show weekly changes in home ranges in central Wisconsin and at Crex. Average weekly ranges were largest and varied most in winter, early spring and late fall. The fluctuations in weekly ranges during winter were due to snow cover which changed food and cover conditions. The fluctuations observed in early spring were the result of cocks returning to their booming grounds in February and hens moving to nesting areas near booming grounds in late March or early April.

In March the hens localized their home ranges near feeding areas just after the snow melted and remained in these areas for 3-4 weeks before moving to their nesting areas in late March or early April. This reduction in movements may have allowed hens to recover weight lost during winter.

The changes seen in mean weekly ranges of immature cocks in late March resulted from several cocks moving between booming grounds in an effort to establish territories. Increased home range size in mid-April reflected movements of immature hens as they began to establish nesting areas.

During early summer both cocks and hens typically established limited daily movement patterns which they followed all summer. Fluctuations observed in

Table 45. Mean weekly home range sizes (ha) for radio-tagged prairie chickens by season, sex and age in central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-1978. Number of ranges are in parentheses.

	Central Wisconsin				Crex Meadows			
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Adult Cocks	150±115(38)	25± 18(67)	32±52(109)	108±209(100)	121± 38(21)	53± 92(51)	27±64(76)	63± 64(44)
Range	13-490	3-80	3-505	3-1961	72-162	4-365	6-526	8-215
Immature Cocks	161±165(34)	48± 41(41)	25± 27(51]	45±141 (18)	-	-	-	-
Range	16-640	3-145	3-132	3-1966	-	-	-	-
Total Cocks	156±144(72)	34±31(108)	30± 46(160)	99±194(118)				
Adult Hens	210±198(39)	44± 39(53)	17± 12(75)	81± 115(35)	87± 69(34)	99±182(39)	37±79(29)	52± 71(28)
Range	16-814	3-174	4-75	5-485	106-334	139-1140	4-345	6-264
Immature Hens	132±105(15)	78±123(49)	22± 36(40)	114±171(26)	-	-	-	-
Range	13-272	3-580	4-228	5-632				
Total Hens	194±183(54)	61± 90(102)	18± 36(40)	114±171(24)				
Total	167±156(127)	47± 68(210)	25±39(275)	97±178(178)	92± 66(55)	72±140(90)	29±67(96)	60±65(62)

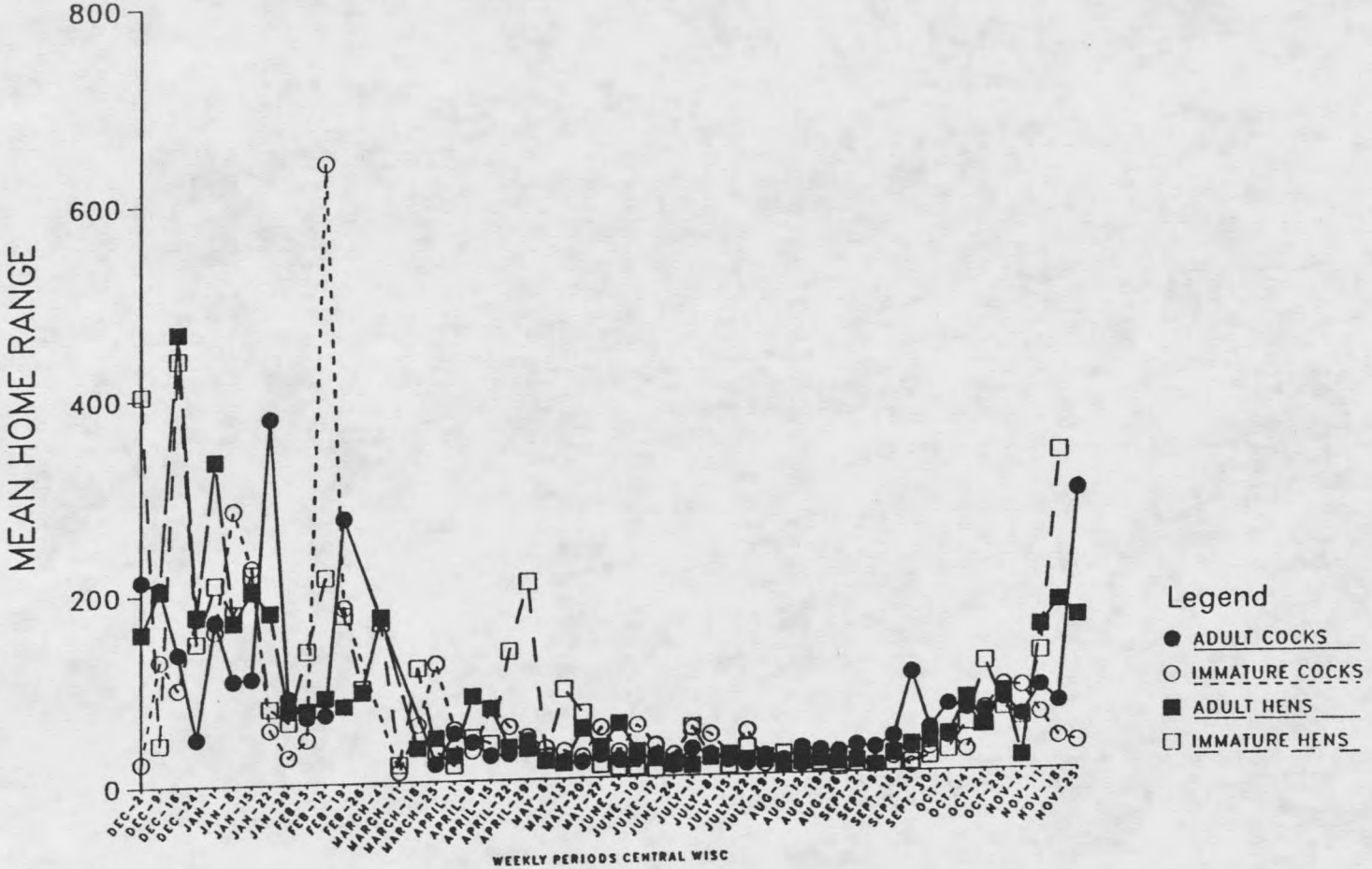


Figure 20. Mean weekly home range sizes (ha) for radio-tagged prairie chickens by sex and age in central Wisconsin, 1972-76.

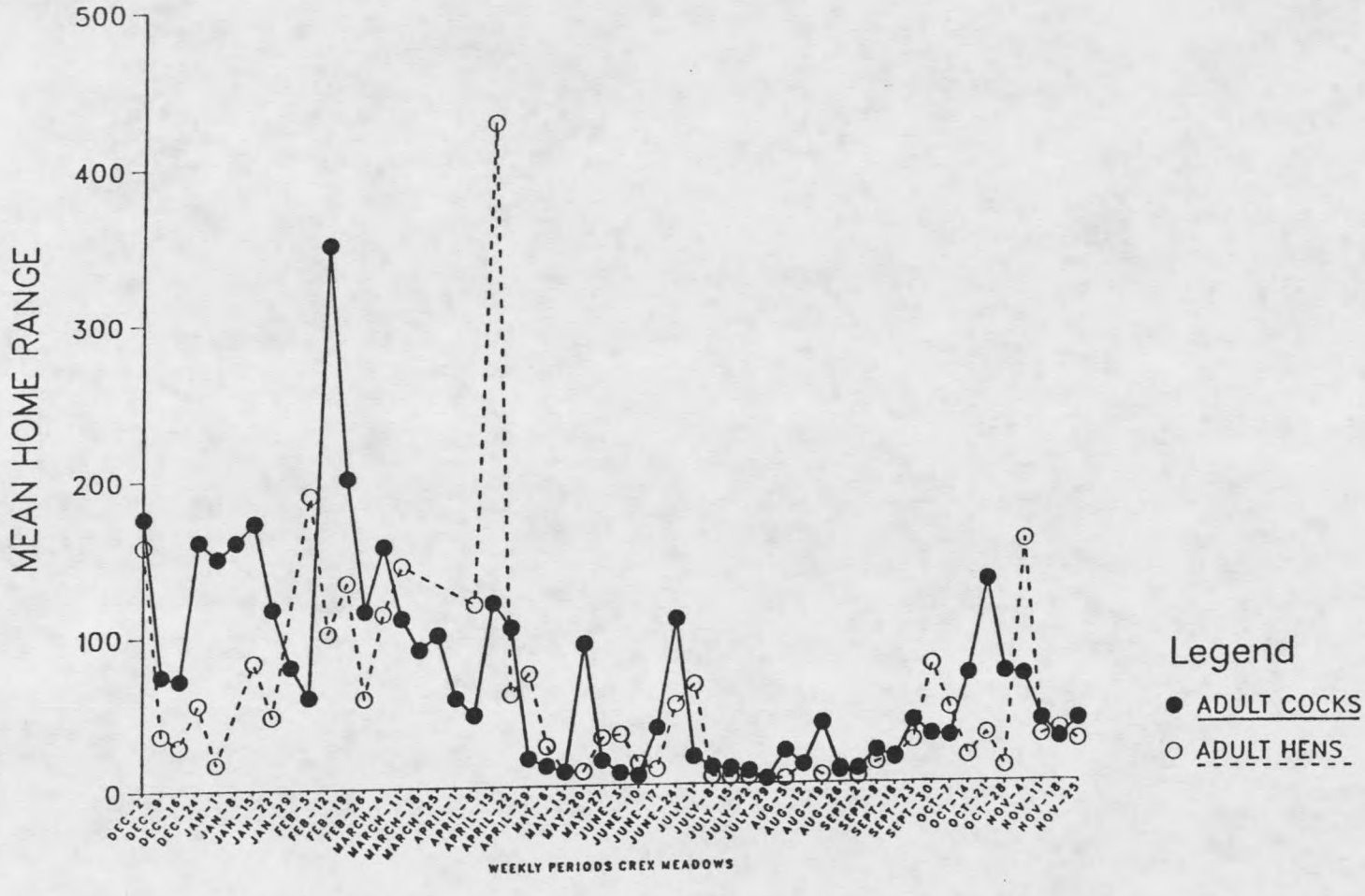


Figure 21. Mean weekly home range sizes (ha) for radio-tagged prairie chickens by sex, Crex Meadows Wildlife Area, Wisconsin, 1976-78.

mid-September were caused by the movements of adult cocks from summer areas back to their booming grounds. The fluctuations in November were initial adjustments made in response to the first snowfall. Similar yearly changes occurred in the mean weekly home ranges of radio-tagged cocks and hens at Crex except weekly home ranges were smaller than in central Wisconsin (Figs. 20 and 21).

Prenesting and Egg-Laying Home Ranges

Prenesting and egg-laying ranges were smaller portions of a hen's spring home range. These 2 ranges occurred after hens moved to the grassland habitat surrounding the booming grounds in late March or early April. Prenesting ranges of immature hens in central Wisconsin were larger than those of adults (135±75 ha, n=12 versus 751±863 ha, n=11, P=0.001) and larger than those of cocks during a comparable period (1-30 April) (Table 46). The extended prenesting ranges of immatures were the result of the exploratory nature of their first time nesting effort. The prenesting ranges of immature hens were less stable, and associated with more booming grounds than adults (Mean 3.8±1.5, Range 2-6, n=11 versus Mean 1.5±0.5, Range 1-2, n=12). Once egg-laying commenced, home ranges became very small as each hen restricted her movements near the nest (central Wisconsin, Mean 462±394 m, n=521, 80% within 1.0 km, Crex Mean 442±442 m, n=232, 81% within 1.0 km).

Egg-laying ranges in central Wisconsin averaged 35±13

Table 46. Mean home range sizes (ha) for radio-tagged prairie chicken hens by age during prenesting, egg-laying and brood rearing periods and cocks and hens without broods during comparable periods, in central Wisconsin 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78. Number of birds are in brackets.

	Hens			Cocks[a]		
	Adults	Immatures	Total	Total	Adults	Immatures
PRENESTING[b]						
Central Wisconsin	135+ 75[12]	751+863[11]	403+636[23]	158+171[23]	65+ 32[17]	249+211 [6]
Crex Meadows	637+568 [7]	-	637+568 [7]	153+193 [5]	153+193 [5]	-
EGG-LAYING[c]						
First Nest						
Central Wisconsin	40+ 12[13]	27+ 10 [8]	35+ 13[21]	68+110[18]	52+ 90[11]	75+110 [7]
Crex Meadows	37+ 27 [9]	-	37+ 27 [9]	88+154 [7]	88+154 [7]	-
Renest						
Central Wisconsin	78+ 23 [3]	32+ 35 [1]	60+ 34 [4]	-	-	-
Crex Meadows	15+ - [1]	-	-	-	-	-
BROOD REARING[d]						
Central Wisconsin	271+170 [2]	282+153 [4]	278+141 [6]	165+104[30]	177+102[20]	142+110[10]
Crex Meadows	203+ 44 [2]	46+ [1]	150+102 [3]	110+ 65[10]	110+ 65[10]	-

[a] Includes hens without broods and cocks.

[b] 1 April-30 April for cocks.

[c] 1 May-30 May for cocks.

[d] 15 June-15 Sept. for hens without broods and cocks.

ha (n=21) and were larger in adults than immatures (40±12 ha, n=13 versus 27±10 ha, n=8, P=0.001). The larger ranges of adults may be due to a greater familiarity with the nesting area and a higher social status than immatures.

The prenesting home ranges for resident hens at Crex in 1978 were much larger than those of adults in central Wisconsin (637±568 ha, n=8 versus 135±568 ha, n=12, P=0.001), but smaller than immatures (637±568 ha, n=7 versus 751±863 ha, n=11, P=0.541). Egg-laying ranges at Crex were similar to those in central Wisconsin (37±27 ha, n=9 versus 40±12, n=13, P=0.762).

The egg-laying ranges of 3 hens monitored during renesting in central Wisconsin were almost twice as large as those for first nests (Table 46). Small ranges during egg-laying appeared to be determined by behavior as the transplanted hens that nested away from Crex also established egg-laying ranges comparable to those of resident hens (41±26, n=5, Range 10-77). Svedarsky (1979) reported similar egg-laying ranges (31.4 ha) for 9 radio-tagged prairie chicken hens in western Minnesota. Newell (1987) reported egg-laying ranges for radio-tagged hens in North Dakota of 65.5±31.6 ha (n=11) with ranges of adults larger than immatures. The large egg-laying ranges in North Dakota were believed to be a result of extensive areas of heavily grazed grassland in contrast to Minnesota,

central Wisconsin and Crex where there were large blocks of undisturbed grassland.

The contraction of the prenesting range of hens into a small egg-laying range near the nest suggests that this is a critical aspect of nesting behavior in prairie chickens. A hen must maintain her physical condition for egg production, incubation and rearing of chicks. A quality egg-laying range may be as important to successful reproduction in prairie chickens as the nest site itself. The small sizes of these ranges in several different study areas strengthens this hypothesis.

Nest site selection in prairie chickens appeared to occur before copulation. This conclusion was based on the movements of 7 radio-tagged hens in both areas that were followed for 10-20 days before and after they were observed copulated. After copulation each of these hens nested in the area used prior to copulation.

Brood Home Ranges

Eight hens with broods were followed during the summer, 5 from nesting to fledging in September (3 at Crex). Total and partial brood home ranges varied from 57 -460 ha with a mean of 253±40, (n=9). Brood ranges were larger in central Wisconsin than Crex (278±141 ha, n=6, versus 150±102 ha, n=3) (Table 46), which follows a similar pattern for annual and seasonal home ranges.

Svedarsky (1979) reported a total home range size of 82.6 ha for a single hen with a brood. Newell (1987) reported mean home ranges for hens with broods in North Dakota which were 2-3 times larger than those in Wisconsin, (488.6±709.5 ha, n=15) reflecting the large portion of that area which was heavily grazed or mowed during the summer.

Mean weekly home ranges of hens with broods were variable, but seemed to increase slightly with the age of the chicks (Fig. 22). Total brood ranges were larger than summer ranges of hens without broods and cocks in both areas (Table 46). Mean weekly ranges of hens without broods were also variable, but tended to decline or remain stable through the summer (Fig. 22).

The increase in mean weekly brood ranges during the summer reflected differences in the food and cover needs of broods. Hens with broods, in contrast to broodless adults, did not have regular feeding and roosting areas. Instead they appeared to move to new areas at 2-10 day intervals. The cause of these shifts was unknown, but has been related to the availability of insects, an important food for most young gallinaceous birds (Kobridger 1965, Peterson 1970, Hurst and Stringer 1975, Martin and McGuinnes 1975, Weigand 1980, Doerr and Guthery 1983, Kimmel and Sammuel 1984 and Whitmore et al. 1986). The use of insects by young birds has been related to high protein demands necessary for development (Potts 1980, and Hurst and Poe 1985).

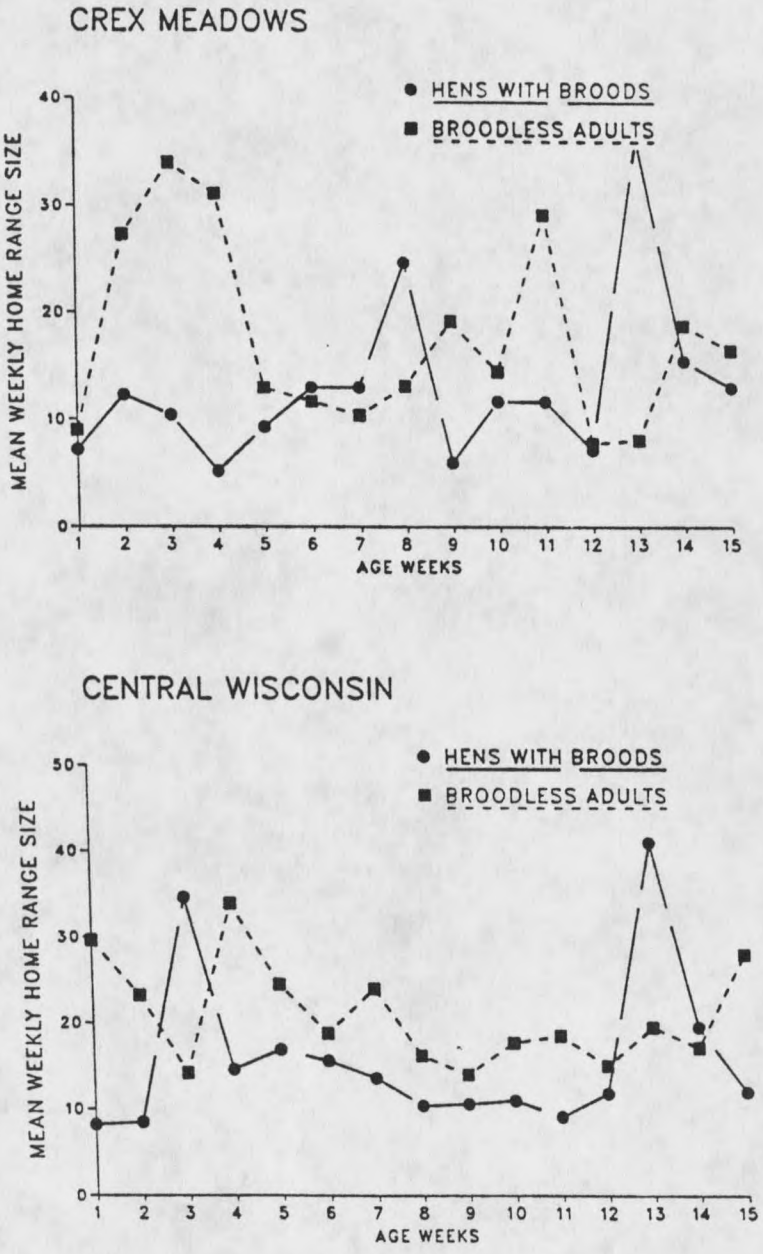


Figure 22. Mean weekly home range sizes (ha) for radio-tagged prairie chicken hens with broods by age of chicks in weeks, and hens without broods and cocks, (weeks starting 15 June), central Wisconsin, 1972 and 1974, (6 broods) and Crex Meadows Wildlife Area, Wisconsin, 1976, (1 brood) and 1977 (2 broods).

Rumble et al. (In Press) have indicated insects made up over 80% of the diets of prairie chicken chicks. This was in contrast to broodless adults where 31.5% of summer diet consisted of insects.

Home Range Transplanted Birds

Most of the transplanted radio-tagged prairie chickens exhibited an adjustment period (sedentary phase) and an orientation period (wandering phase) before localizing their movements and establishing new home ranges.

The adjustment range was a small area (0.8-38 ha) within which an individual bird remained immediately after release while it adjusted to being handled, radio-tagged and transplanted to the new area. Orientation periods were characterized by extensive wandering over a large area, and consisted of an initial period at Crex and one away from the Crex Meadows Wildlife Area. The initial period at Crex consisted of a few locations covering a relatively small area (20-483 ha), which ended when the individual either established or left the Crex area. Once individuals left, they wandered over an extremely large area which varied from 1.0-1518 sq km. The mean size of orientation ranges were larger for hens than cocks (13,123±27,392 ha, n=16 versus 440±596 ha, n=8, P=0.001) and adult orientation ranges were larger than immatures (Table 47). The orientation period ended for cocks when they began to display and for hens when they established a nesting area.

Table 47. Mean home range sizes (ha) for transplanted radio-tagged prairie chickens by sex, age and release, Crex Meadows Wildlife Area, Wisconsin, 1976 and 1977. Number of birds in parentheses.

		Orientation Period	
	Adjustment Period	At Crex Meadows Wildlife Area	Away Crex Meadows Wildlife Area
April Release			
COCKS			
Adult	7.9± 4.2 (4)	123± 32 (2)	693± - (1)
Immature	4.0± 4.5 (2)	312±259 (4)	1943± (1)
Total	4.8± 4.3 (6)	251±135 (6)	1318±884 (2)
HENS			
Adults	6.3±11.8(10)	230±150 (9)	16317±12111(10)
Immatures	6.5± 5.5 (6)	102±279 (7)	7797± 7151 (6)
Total	6.4± 9.6(16)	174±147(16)	13123±27392(16)
June Release			
Cocks	4.9± 4.0 (2)	498±148 (2)	-
August Release			
Cocks	-	141± 61 (3)	-
Hens[a]	-	79± 82 (3)	-
Total		110± 73 (6)	

[a] Hens recaptured and rereleased during molt after they established away from Crex.

Two of the 7 cocks, 1 immature and 1 adult, transplanted in April 1976 left the Crex area for periods which lasted 9 and 27 days respectively. The orientation ranges of these 2 cocks averaged 1318±884 ha and were approximately 2.9 times the mean home range size of immature cocks in the spring in central Wisconsin (Table 44). All of the other transplanted cocks exhibited orientation periods, but remained at Crex. The orientation periods of the cocks which remained were shorter (6-16 day) and their ranges smaller than the 2 that left (251±135 ha versus 1318±884 ha).

All but one of the orientation ranges for transplanted hens were larger (163-151,838 ha) than those of transplanted cocks (100-1943 ha). The mean size of the orientation ranges of 16 hens was 13,123±27,392 ha, 23 times larger than for transplanted cocks (556±509 ha, n=6) and 20 times larger than the total spring home ranges of established resident hens (Crex, 669±628, n=5, central Wisconsin, 563±664, n=23). These 11-55 day orientation ranges were 4.5-8.5 times larger than annual home ranges of resident hens in central Wisconsin and Crex.

Toepfer (1976) transplanted and radio-tagged 3 cock and 3 hen prairie chickens in April from one population to another. The cocks, during orientation periods of 6-16 days, had ranges 2.8 times larger than those of residents, while the hens, during periods of 12-30 days, had ranges 75%

smaller than those of transplanted cocks, but 1.6 times larger than the home ranges of resident hens.

The orientation ranges of adult hens transplanted in April were twice as large as those of immatures (16,317±12,111 ha, n=10 versus 7,797±7,151, n=6, P=0.100), a pattern opposite that found in resident birds (Table 44). The larger orientation ranges of adult hens was thought to be due to their association with a former home range, and in an effort to return, they covered a larger area.

Orientation ranges of hens transplanted from Minnesota in April were larger than those of hens from Wisconsin (38,718±29,911 ha, n=8 versus 27,509±26,014, n=9, P=0.4558) although the orientation periods were similar in length (20.9±10.8 days, n=7 versus 19.3±14.5, n=10). This difference was thought to be due to the similarity in habitat between central Wisconsin and the area surrounding Crex.

Resident radio-tagged prairie chickens made movements that covered relatively large areas during periods when they were adjusting to new or changing conditions. These extended irregular movements in residents occurred (1) in fall when immatures covered larger areas than adults as they attempted to establish themselves in the population; (2) in winter when new snow covered a food source and birds made irregular movements to locate a new one and (3) in

spring when some immatures moved between several booming grounds.

Transplanted prairie chickens, unlike residents, were placed in a stressful situation in an unfamiliar area. This combination apparently caused them to search for familiar terrain, which resulted in abnormally large movements. Individual birds either overcame this stress and established or wandered until they become physically spent or were killed by predators.

Cocks and hens transplanted in the summer (August) exhibited short, if any, orientation periods lasting 1-3 days. The ranges of prairie chickens transplanted in August were smaller than the total summer ranges of residents at Crex (110±73 ha, n=6 versus 153±87 ha, n=6, P=0.001) and central Wisconsin (168±103 ha, n=30, P=0.001) (Table 47). The small ranges of summer transplants were probably due to the lack of a behavioral association to the booming ground in cocks and a nest area in hens.

During summer when prairie chickens molt, home ranges of residents became restricted to a small area. Prairie chickens flew less often at this time of the year and when flushed, flew low and rarely more than 400 m. Due to the energy demands of the molt during summer, prairie chickens were in their poorest condition of the year (based on weight, and may not have been physically capable of extended flights. Toepfer (1976) also

transplanted a single radio-tagged cock during August and found its home range was comparable to those of residents.

The orientation ranges of 2 cocks transplanted on 6 June were intermediate to those of birds transplanted in April and August. The ranges of these 2 cocks were larger than the spring ranges of resident adult cocks (498±142, n=2 versus 147±30, n=17) but similar to the spring ranges of resident immature cocks (450±312, n=6) and resident adults during the fall (Table 44). These 2 birds had initiated the wing molt and were near abandonment of their booming ground which served to reduce the association with the home area.

Post-orientation ranges were similar to or smaller than those of residents. Once transplanted individuals established regular movement patterns and home range they were considered Crex residents.

The contrast between home ranges of prairie chickens transplanted during the breeding season with those of birds transplanted during the summer molt was dramatic. Behavioral and physiological factors have a strong influence on how individuals respond to being transplanted. The influence of these same factors also resulted in relatively larger home ranges of residents, during the breeding season. Thus, the best time to transplant an animal is when they are least mobile and not burdened

with the behavioral aspects of breeding or defense of a territory.

Home Range of Pen-reared Birds

Only radio-tagged pen-reared prairie chickens which lived for 10 days or longer were used to calculate home range (Table 48). Mean home ranges of all pen-reared prairie chickens released in April and October averaged 17.7±18.7 ha (n=30, Range 4-85) and were smaller than any of the mean seasonal home ranges of wild birds.

Mean home ranges of pen-reared hens were larger than those of the cocks because hens established nesting areas away from the pen, while the cocks displayed, fed and loafed near the pen. By comparison mean weekly home ranges of radio-tagged immature wild prairie chickens in central Wisconsin for the week starting 22 April were 3 times larger than those of the pen-reared birds released in April (17.7±18.7 ha versus 56±18 ha, n=3, Range 32-86). The small home ranges of pen-reared prairie chickens appeared to be the result of the birds displaying and localizing their movements near the pen.

The influence of this strong association with the pen can be seen in the home ranges of 3 radio-tagged transplanted cocks which displayed and associated with pen-reared birds at the pen from mid-April through June 1976. Mean home ranges of these wild birds were only slightly

Table 48. Mean home range sizes (ha) for radio-tagged pen-reared prairie chickens by sex and release, Crex Meadows Wildlife Area, 1974-76. Number of birds in parentheses.[a]

	Area	Range
April Release		
Cocks		
1975	14.2±20.2 (3)	10-25
1976	15.6±27.1 (9)	11-85
Total	15.0±24.0(12)	
Hens		
1975	15.9±13.0 (4)	5-17
1976	17.4± 9.3 (7)	4-25
Total	16.8±10.1(11)	
October Release		
Cocks	20.5±39.0 (7)	5-59
Total	17.7±18.7(30)	4-85

[a] Only for individuals that survived longer than 10 days.

larger than those of the pen-reared birds in the same area (20±7 ha, n=3, Range 17-29).

Mean home ranges of cocks released in fall were slightly larger than home ranges of cocks released in the spring (Table 48). The mean weekly home range sizes of immature wild cocks during the week of 21 October were twice as large (66±53 ha, n=3) as those of the pen-reared prairie chickens released in October.

The smaller home ranges observed in pen-reared prairie chickens were a function of the following factors: movements made by walking rather than flying, limited time out of pen, and the attraction and association with the release pen in the spring and the holding pen in the fall. Only during summer when wild prairie chickens were in the molt and do much of their moving by walking were any of the mean weekly home ranges of wild radio-tagged prairie chickens in central Wisconsin comparable to those of the released pen-reared birds (Range of mean weekly home ranges for wild birds; week starting 29 July, 11.3±13.9, Range 7-77 and week starting 8 July, 26.3±85.6, Range 8-98 ha versus Mean pen-reared 17.7±18.7).

Daily Movements

Because the number of birds followed each year varied (4-22) and changes in seasonal daily movements were similar between years in both areas so data for separate years were combined to produce a general overview of movement

patterns of prairie chickens. In addition to the radio locations, 17,783 and 5,282 observations of non-radioed prairie chickens in central Wisconsin and Crex respectively, were used to examine distances to the nearest booming ground.

In central Wisconsin, 54 radioed prairie chickens (28 cock and 26 hens) yielded 5,037 DD movements, 2,814 DN and 2,223 WD movements. These birds represented the areas around 12 of the 26 booming grounds in central Wisconsin 1972-76. At Crex 12 of 29 transplanted birds became residents and yielded 4,938 DD movements 2,897 DN and 2,041 WD movements. There was only 1 main booming ground at Crex during the period 1976-1978 and all the radio-tagged birds remained within the general vicinity of this ground.

DN movements typically represented the greatest movements made during a 24-hour period and reflected the distances between feeding and roosting areas. WD movements represented movements made during the day, before and after flights to and from night roosts. DN and WD distances between locations were pooled to yield a total mean to represent daily movements (DD) made by radio-tagged prairie chickens. DBC movements were used to examine the daily movements of transplanted prairie chickens because they dispersed over a large area.

DBC are often used to analyze movements of radioed animals, but are less representative of actual movements. A

comparison of the DD movements used here with the DBC method used by Robel et al. (1970), showed that mean DBC movements overestimated the mean seasonal movements of radio-tagged prairie chickens by approximately 20% (Range 1-27%). The smallest differences between the 2 methods occurred during the summer (1-6%) when movements made by prairie chickens were the least. The greatest difference occurred during the winter (18-20%) when movements were the greatest. The use of DBC movements also reduced sample sizes of movements by 32% because if a day was missed there was no movement data for 2 days.

Laundre et al. (1987) have recently suggested that, because animals establish regular feeding and roosting areas, 1 location per day was not enough to accurately appraise animal movements. Daily tracking and observations of radio-tagged prairie chickens indicated the best movement and habitat data were obtained by locating each bird 4 times a day (AM, Midday, PM and Night), for 2 days in a row to distinguish movement patterns. An alternative was to locate each bird once during the daylight and at night, rotating the daylight location between the 3 time periods. Evidence collected in this study indicated that without both day and night locations any data on movements and habitat use were incomplete.

Seasonal Daily Movements

Mean DD movements of radio-tagged greater prairie chickens in central Wisconsin were greatest in winter, (1099±839 m, n=1699) and least in summer (313±270 m, n=2459) and were a function of the seasonal extremes in the availability of food and cover (Table 49). Mean DD movements in spring (526±489 m, n=2085) and fall (711±598 m, n=1782) were intermediate to winter and summer movements and were a function of habitat conditions intermediate to winter and summer. DD movements were less in spring than fall because cocks visited their booming grounds in the morning and evening every day from mid-March to mid-June. The reduced DD movements observed in hens during spring resulted from hens localizing their movements in the vicinity of their nests. This was particularly evident as hens shifted from prenesting to egg-laying activities (Table 50). As spring progressed, mean DD movements of the cocks also became less and in early June cocks abandoned the booming grounds (Table 50).

Mean DD movements for both radio-tagged cocks and hens without broods were least during summer (Table 50). Schwartz (1945), Hamerstrom and Hamerstrom (1949), Baker (1953), Robel et al. (1970) and Horak (1985) all noted that summer was the season of least movements in prairie chickens.

During fall and winter, habitat influenced the

Table 49. Mean distance moved (m) by type of movement for radio-tagged prairie chickens by season and age, in central Wisconsin 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78. Number of moves are in parentheses and number of birds in brackets.

	Adults			Immatures		
	Day to Night	Within-Day	Total	Total	Day to Night	Within-Day
COCKS						
WINTER						
Central Wisconsin	1084±839(277)	952±803(241)	1046±830(518)[12]	1152±1030(311) [5]	1068±1220(164)	1178±974(147)
Crex Meadows	626±538(182)	604±468(153)	618±512(235) [5]	-	-	-
SPRING						
Central Wisconsin	484±342(253)	495±431(344)	490±393(597)[17]	551± 482(441) [9]	466±379(210)	627±549(231)
Crex Meadows	325±480(487)	230±186(279)	249±248(766) [5]	-	-	-
SUMMER						
Central Wisconsin	382±277(573)	296±282(340)	350±285(913)[14]	333± 317(674) [8]	323±301(285)	341±328(389)
Crex Meadows	238±182(484)	210±273(362)	222±186(846) [8]	-	-	-
FALL						
Central Wisconsin	898±605(449)	696±709(322)	814±658(771)[15]	535± 542(287) [4]	479±567(125)	558±534(162)
Crex Meadows	448±338(457)	411±454(258)	436±381(615) [7]	-	-	-

Table 49. Continued.

	Adults			Immatures		
	Day to Night	Within-Day	Total	Total	Day to Night	Within-Day
HENS						
WINTER						
Central Wisconsin	1259±780(276)	940±726(225)	1140±774(501)[13]	1189±722(369) [5]	924±565(186)	1323±728(183)
Crex Meadows	833±766(235)	773±539(207)	805±671(442) [5]	-	-	-
SPRING						
Central Wisconsin	571±569(391)	536±569(277)	561±616(668)[19]	491±468(379)[15]	463±416(194)	552±562(185)
Crex Meadows	549±557(262)	544±411(213)	546±555(475) [5]	-	-	-
SUMMER						
Central Wisconsin	338±214(286)	236±178(256)	290±205(542) [6]	279±280(330) [4]	231±378(119)	307±200(211)
Crex Meadows	208±235(383)	216±336(362)	211±276(745) [6]	-	-	-
FALL						
Central Wisconsin	745±652(309)	514±533(218)	649±616(527) [7]	578±576(197) [4]	512±610 (95)	644±102(102)
Crex Meadows	590±462(407)	502±591(207)	558±513(614) [6]	-	-	-

Table 50. Mean distance moved (m) by type of movement for radio-tagged prarie chickens during prenesting, egg-laying and brood rearing by sex and age in central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78. Number of moves are in parentheses and number of birds in brackets.

	Hens			Cocks[a]		
	Day to Night	Within-Day	Total	Total	Day to Night	Within-Day
PRENESTING[b]						
Central Wisconsin						
Adults	639+929(142)	800+740(146)	721+830(188)[13]	540+530(211)[17]	530+350 (166)	554+721 (145)
Immatures	630+501(127)	541+396(128)	586+451(155)[10]	548+473(144) [6]	646+448 (183)	478+360 (161)
Total	636+785(269)	702+642(274)	670+713(143)[23]	542+499(455)[23]	594+411 (249)	509+572 (206)
Crex Meadows	627+413(156)	730+468(203)	667+565(258) [5]	457+173(289) [5]	482+160 (161)	401+190 (128)
EGG-LAYING[c]						
Central Wisconsin						
Adults	379+266(134)	630+897 (71)	480+505(205)[13]	365+331(330)[11]	410+296 (106)	343+345 (224)
Immatures	389+370(185)	476+463(131)	432+408(316) [8]	435+382(323) [7]	597+467 (175)	353+302 (248)
Total	384+321(319)	538+669(202)	420+432(521)[23]	398+348(494)[23]	501+374 (181)	345+328 (372)
Crex Meadows	260+220(108)	310+309(124)	288+274(232) [9]	264+374(435) [8]	350+527 (190)	201+173 (245)
BROOD REARING[d]						
Central Wisconsin	196+148(360)	208+199(349)	202+182(707) [6]	328+268(2631)[30]	355+272(1555)	289+290(1076)
Crex Meadows	191+119(230)	230+175(280)	208+153(510) [3]	230+241 (846) [8]	234+207 (484)	225+207 (362)

a During brood rearing includes hens without broods.
b 1 April-30 April for cocks.
c 1 May-30 May for cocks.
d 15 June-15 Sept. for hens without broods and cocks.

movements of prairie chickens more than behavior during fall and winter. Cocks made only occasional visits to the booming grounds and only in the morning, weather permitting. The visits to booming grounds by cocks increased their mean DD movements because most of the agricultural areas used for feeding in central Wisconsin were located away from the booming grounds on the edge of the grassland reserves.

Mean DD movements of radio-tagged residents at Crex followed the same seasonal pattern as in central Wisconsin with spring (384±277 m, n=1241) and fall (497±564 m, n=1230) movements being intermediate to the large movements of winter (712±592 m, n=677) and summer (216±211 m, n=1591)(Table 49). However, mean DD movements at Crex were 28-36% less than those of the radio-tagged prairie chickens in central Wisconsin. These shorter movements at Crex were due to a closer proximity of food and undisturbed cover. The main habitat disturbances at Crex occurred in spring when typically one-third of the area was burned and 1% of the area was plowed and planted to agriculture. In central Wisconsin the planting of crops and grazing of private grasslands occurred from May to at least October. Private grasslands were grazed as continuous pastures and at most 1/3 of the grassland reserves were grazed after 1 August. The large amounts of private land in central Wisconsin (76.5%) produced a more patchy distribution of disturbed

habitats which caused individuals to cover larger areas in central Wisconsin to meet their daily and seasonal needs. Robel et al. (1970) also believed that seasonal changes in movements were due to food and cover availability.

Movements of immatures and adults followed the same seasonal patterns, although their movements were greater than adults in spring (Table 49). Some immatures covered larger areas as they attempted to establish in an existing population of adult prairie chickens. Based on seasonal movements of 1,372 banded prairie chickens, Hamerstrom and Hamerstrom (1973) found that immatures usually moved farther than adults, and hens farther than cocks. Toepfer and Tesky (unpubl. data) in the same area 1972-74 observed a similar pattern based on movements of 456 banded birds.

During spring, mean DD movements of hens declined 37-57% from prenesting to egg-laying as individual hens localized their movements in the vicinity of their nests (Table 50). DD movements of adult hens were greater than immatures during both periods. This was in contrast to home range sizes during prenesting which were larger for immatures than adults. The larger home ranges of immatures during prenesting were attributed to several immatures that made a few large movements which increased home range size, but did not affect mean DD movements.

Mean DD movements of radio-tagged cocks declined 27-47% during comparable prenesting and egg-laying periods

(Table 50). This decline was associated with the breeding peak which concentrated the activities of cocks near the booming grounds.

Habitat distribution and breeding related behavior influenced DD movements of prairie chickens in both areas. Mean DD movements, of cocks and hens and immatures and adults, were most similar during winter in the absence of breeding related behavior (Table 49). During these times habitat distribution seemed to dominate movement patterns. Conversely, differences in DD movements between sexes and ages varied most in spring and fall when breeding behavior and dispersal of immatures had the greatest influence on daily movements (Table 50).

Home ranges of immatures were larger than those of adults in fall, yet mean DD movements were less (Table 44 and 49). Immatures were inexperienced and made extensive shifts between areas in an apparent effort to establish. Large but infrequent exploratory movements increase home range sizes but not necessarily DD movements. During the fall most adults, established regular feeding areas but the DD movements of cocks were larger because of occasional visits to the booming grounds.

Day-to Night and Within Day Movements

Mean DN and WD movements of radio-tagged prairie chickens, like overall movements, were greatest in winter and least in summer (Table 49). Mean DN movements, with

one exception, were greater than mean WD movements during all seasons. The exception resulted from some of the adult cocks during spring roosting on or next to the booming ground. These individuals typically moved 300-1200 m from the booming ground during the day to feed which made their WD movements greater than their DN movements.

Mean DN movements were greater than WD movements because of differences in habitat and height of cover used during the day and night. Prairie chickens usually fed in short disturbed habitats (agriculture and grazed fields) and roosted in the larger blocks of taller undisturbed vegetation. DN and WD movements of radio-tagged prairie chickens were less at Crex than in central Wisconsin because disturbed and undisturbed cover were in closer proximity (Table 49). DN movements, like DD movements were greatest in winter because of a reduction in the availability of food and cover above the snow.

DN movements were least during the summer, because food was always in close proximity to undisturbed cover. Consequently, flights were short and a few individuals even walked to and from night roosts.

WD movements were typically centered around feeding areas for much of the year. However, during spring, hens moved between feeding areas and their nests. Cocks in the spring and to a limited degree in the fall, moved between their booming grounds and feeding areas. The typical WD

movement involved a move from a feeding area during midday to a day roosting area(s) followed by a movement back to a feeding area in the evening before going to roost.

The DN and WD movements of radio-tagged prairie chickens at Crex showed the same pattern and seasonal trends as birds in central Wisconsin except the means were less (Table 49). The shorter DN movements at Crex were a direct function of the closer proximity of feeding and night roosting cover. Based on movements of radio-tagged birds in central Wisconsin and Crex, movements made by prairie chickens during the day and between day areas and night roosts were directly related to differences in habitat distribution.

Distance Between Successive Night Locations

Mean distances between successive night locations showed fidelity to the previous nights roost and served as a seasonal index to distribution and availability of night roosting cover. The mean NN distances varied between seasons and were greatest in winter and least in summer and like daily movements, were influenced by seasonal changes in cover conditions (Table 51).

Distances between successive night roosts indicated that prairie chickens changed roost areas from one night to the next when possible. This shifting of night areas was most evident in the winter and may have been a form of predator avoidance. Some individuals did use the same area

Table 51. Mean distance (m) between successive night locations for radio-tagged prairie chickens by season, sex and age in central Wisconsin 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-1978. Number of locations are in parentheses.

	Winter	Spring	Summer	Fall
CENTRAL WISCONSIN				
Adult Cocks	756+864 (55)	517+497(111)	231+267(171)	347+354(124)
Immature Cocks	1060+999(135)	595+624(125)	322+306 (93)	733+670 (35)
Total Cocks	879+922(190)	572+582(236)	262+285(264)	658+654 (59)
Adult Hens	1118+734 (47)	619+513 (61)	235+211 (85)	516+654 (25)
Immature Hens	1016+628 (30)	438+309 (38)	286+528 (59)	770+1031(14)
Total Hens	1016+628 (67)	549+452(216)	260+387(267)	667+892(101)
CREX MEADOWS				
Adult Cocks	1120+824 (55)	534+722(160)	236+211(131)	464+433(147)
Adult Hens	840+743(109)	676+779(110)	301+420 (96)	488+451(148)

many times during the course of the winter, but usually not on successive nights. Shifting between roosting areas was one of the main reasons for the larger home ranges seen during the winter.

Different night roosting areas used during the winter by radio-tagged individual ranged from 3-8 in central Wisconsin and from 2-16 at Crex. The larger number of roosting areas used at Crex reflected the greater amount of vegetated wetland habitat, which provided more cover above the snow. Because the large amount of vegetated wetland cover at Crex, all radio-tagged individuals could have roosted every night within 200 m of their feeding areas. Instead these birds shifted roosting areas and on numerous occasions flew 3200 m to a night roost. By contrast individuals in central Wisconsin, with only 2 roosting areas available near their winter feeding area, often roosted in the same general area on successive nights, but shifted locations within the roost area.

The size of winter night roosting areas varied from 0.1-100 ha. These areas provided cover above the snow or trapped enough snow for snow burrowing. The closer mean distance NN in non-snow seasons, particularly in summer reflected increased security due to the abundance of taller cover. Mean NN distances in spring and fall were between the 2 extremes in cover security seen in winter and summer. During the spring and fall, use of roosting areas was

variable as the radio-tagged birds used the same area for several nights then shifted. These changes were not as far as those observed in winter, because of a greater availabiltiy of roosting cover.

The pattern of using the same roosting area on successive nights increased in spring due to increasing cover security provided by growing vegetation and declined in the fall as a result of a reduction in security due to weathering of cover. During summer, when cover was seasonally most abundant, several groups of radio-tagged birds used the same 16-40 ha undisturbed grass areas every night for roosting. The seasonal pattern of mean NN distances at Crex were similar to those in central Wisconsin (Table 51).

Biweekly Movements

Mean DD movements for biweekly periods for radio-tagged prairie chickens are presented in Figures 23, 24 and 25. The means for biweekly periods were calculated only for those periods for which at least 2 radio-tagged individuals and 15 WD and DN movements (Mean DN 24±32, WD 20±18) were available. The mean DN movements of both cocks and hens peaked during early winter when snow reduced the distribution and availability of food and cover. Mean DD movements remained high and fluctuated throughout the winter as birds adjusted their movement patterns whenever

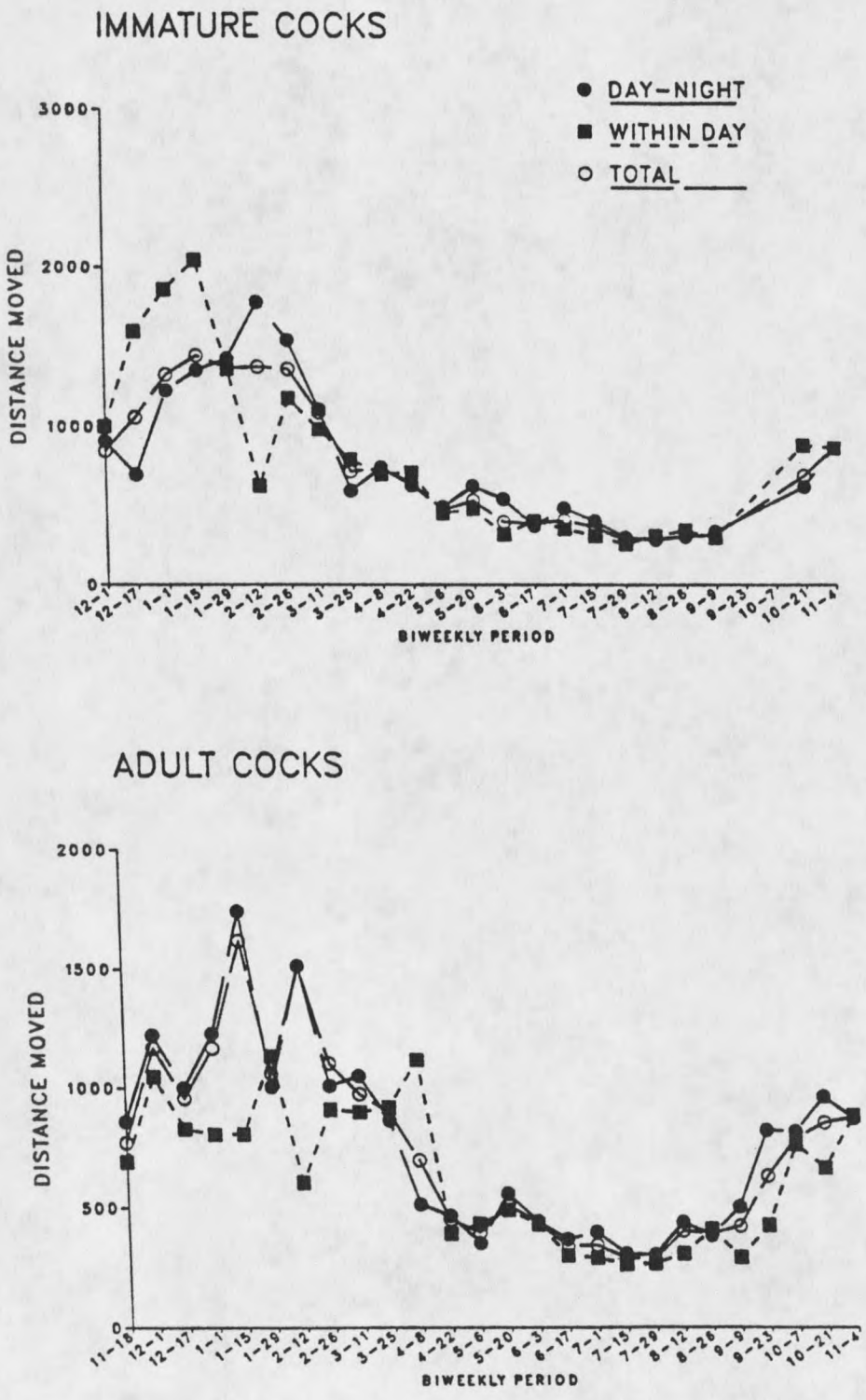


Figure 23. Mean biweekly daily movements (m) of radio-tagged immature and adult prairie chicken cocks in central Wisconsin, 1972-76.

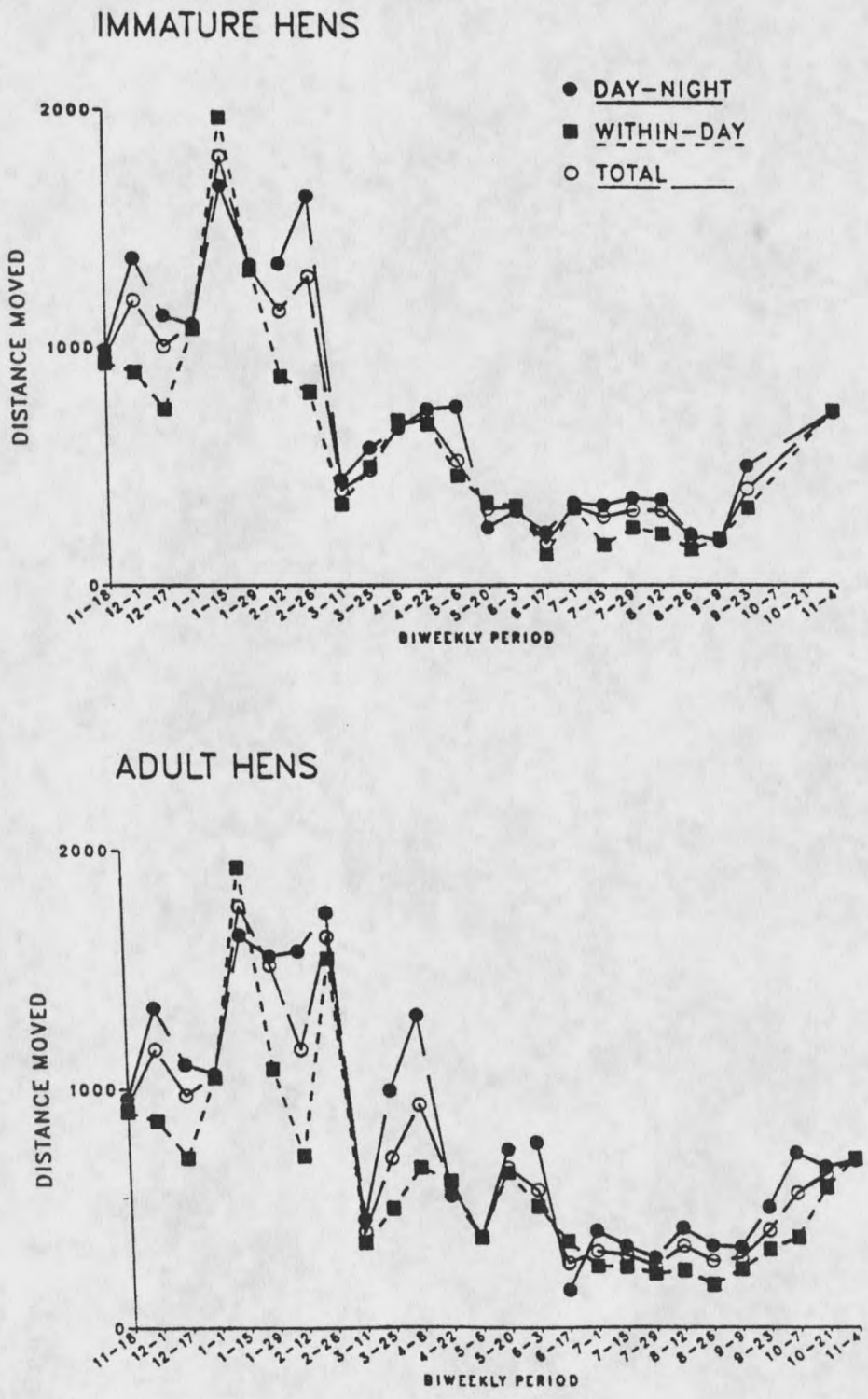


Figure 24. Mean biweekly daily movements (m) of radio-tagged immature and adult prairie chicken hens in central Wisconsin, 1972-76.

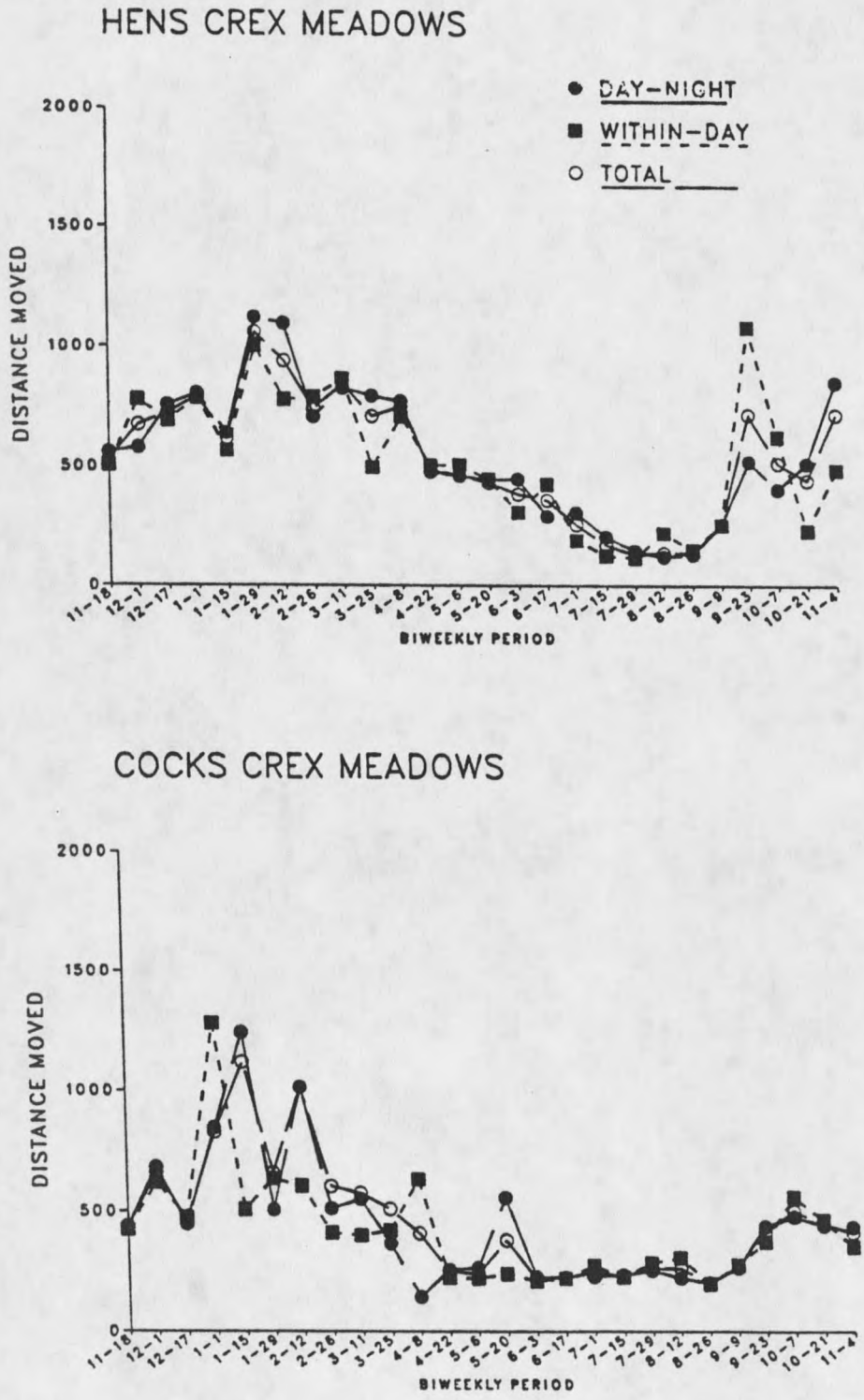


Figure 25. Mean biweekly daily movements (m) of radio-tagged prairie chicken cocks and hens Crex Meadows Wildlife Area, Wisconsin, 1976-78.

fresh snow altered food and cover conditions. The magnitude and patterns of daily movements during winter were comparable between the sexes and ages and reflected the strong influence that habitat distribution had on movements.

The daily movements of hens declined sharply in central Wisconsin during early March with the loss of snow when hens localized their activities in feeding areas before the prenesting period. This localization of activity in early spring was thought to be related to the need to regain weight lost during winter. The movements of cocks also declined at this time, but was due to their moving from winter areas to their booming grounds. Daily movements of cocks declined through March and were lowest during the breeding peak in mid-April.

On a yearly basis, the movements of cocks were smallest during mid to late July during the peak of molt. The smallest daily movements of hens occurred in August, due to later molting following nesting. The daily movements of adults cocks and hens increased as the temperatures declined in mid-September and the birds began feeding in the agricultural fields instead of the grasslands.

Adult cocks returned to their booming grounds in fall and hens localized their movements around feeding and roosting areas. Fall movements increased as daily temperatures declined and cover deteriorated.

Radio-tagged prairie chickens at Crex showed comparable general biweekly movement patterns to radio-tagged prairie chickens in central Wisconsin, except mean DD, WD and NN movements were less.

Unlike the seasonal mean of daily movements, WD movements of prairie chickens for biweekly periods were at times greater than the day to night movements. The greatest variation occurred in winter and was due to new snow which caused birds to move more frequently and farther during the day in search of food.

Feeding patterns were usually consistent, especially in the winter when birds were feeding in the agricultural fields or on corn platforms. Regular feeding areas were also used during the summer in central Wisconsin where individual birds fed in the same heavily grazed field all summer. At Crex, most radio-tagged birds fed all summer in the agricultural strips.

Prairie chickens usually fed during the morning and evening throughout the year. However, this twice daily feeding pattern stopped in winter during periods of sub-zero weather. During periods of cold weather radio-tagged birds and their flock members remained in roosts longer in the AM, fed in agricultural fields later or during midday, flew to roosts earlier than normal (as early as 1400 hours), and remained there until the following day (15-17 hrs).

Visual observations were obtained of radio-tagged birds and flock members in snow burrows several hours before they normally would have gone to roost. Reduced activity during cold weather is believed to be an energy conservation mechanism. Several days of very cold weather are necessary for prairie chickens to initiate this behavior. Hamerstrom and Hamerstrom (1949) observed similar behavior in prairie chickens during very cold weather in Wisconsin. Radio-tagged prairie chickens have been known to remain in snow burrows after a heavy snow storm for 36 hours.

Relationship to Booming Ground

One of the most striking behavioral characteristics of the prairie chickens is their communal display grounds or booming grounds. The display and activities of prairie chickens on booming grounds has been described by Breckenridge (1929), Schwartz (1945), Hamerstrom and Hamerstrom (1941), Hamerstrom and Hamerstrom (1960), Robel (1965), Hjorth (1970), and Hamerstrom and Hamerstrom 1973). It is likely that every bird in a population visited a booming ground at some time to obtain a territory and display (cocks) or to breed (hens). The booming sound made by the cocks can easily be heard by humans from a distance 1.6 km and farther on calm mornings. Prairie chicken cocks in Wisconsin attend the booming grounds consistently in spring (March-June) and sporadically in fall.

In central Wisconsin, prairie chickens have been observed on the booming grounds every month except July and August. In Wisconsin, the cocks abandon the booming grounds with the onset of cold temperatures and snow, usually in late November or December. Cocks have been observed displaying on snow in late February and March. These early visits to booming grounds in winter appeared to be related to the availability of food and cover near the booming grounds. Hamerstrom and Hamerstrom (1949) also noted prairie chickens displaying on the snow in January and February.

In early spring, cocks visit the grounds only in the morning in early spring. As the breeding season progresses, the cocks begin to attend the booming grounds in the morning and evening. Individual cocks abandon the booming grounds in early June, while some continue to visit until the last week of June. Yeatter (1943), Schwartz (1945) and Hamerstrom (1939) all noted that cocks gradually disappeared from the booming grounds in late spring.

Cocks in central Wisconsin abandoned the booming grounds on 10 June$\pm$9.1 days (n=21, Range 28 May-30 June). Immatures abandoned the booming grounds 3 days earlier than adults (13 June$\pm$9.8 n=12, 28 May-27 June versus 16 June$\pm$8.3, n=9 Range 6-30 June). The Wisconsin cocks transplanted to Crex in 1976 stopped displaying on 28 May$\pm$8.3 (n=7, Range 16 May-4 June). The early abandonment

by the transplanted cocks may be related to the stresses of being transplanted.

Within the distribution of booming grounds there were several locations behaviorally important to each prairie chicken and the population. For cocks it was their home booming ground or the ground they used for displaying. For hens it was their nest location and nearby booming grounds.

Booming Ground Distribution. Prairie chicken booming grounds in central Wisconsin were spatially oriented relative to distribution of habitat, specifically to the grassland reserves (Fig. 2). The mean distance between regular booming grounds in central Wisconsin 1972-76 was 1793±1794 m (n=98) and increased with the decline in the population from 1692±606 m in 1972 (n=25, 234 cocks) to 1843±576 m in 1976 (n=17, 126 cocks). Horak (1985) reported a mean distance between 22 booming grounds of 1200 m in his Kansas study area.

When the cock numbers declined in central Wisconsin, so did the number of regular booming grounds, and the distance between the grounds increased. The loss of booming grounds did not occur equally across the area. This may indicate the presence of a core of booming grounds, around which smaller booming grounds developed with increases in the cock cohort of the population.

The locations of interior booming grounds (1972-76) were more closely associated with others than were exterior

grounds (1420±530 m, n=35 versus 2000±794 m, n=63, P=0.001). Interior booming grounds were those that had adjacent grounds within all 4 quadrants. As one moved away from the center of the distribution, booming grounds were farther apart. This suggested that a core of larger booming grounds was associated with better habitat around which the population expands and contracts. The larger booming grounds were those associated with the largest blocks of undisturbed grassland.

The mean number of cocks was greater on the interior booming grounds than the exterior (10.5±6.8, n=35 versus 6.4±3.9, n=63, P=0.001). When the population declined from 1972-76 the loss of cocks was greater on regular exterior grounds than on the interior grounds (Interior 11.0±8.7, n=11, to 11.2±6.5, n=5, Exterior 7.7±5.1, n=14 to 6.2±2.9, N=12). Hamerstrom et al. (1957) indicated a strong relationship between the amount of "permanent" grass and the number of cocks. Horak (1985) noted that where grassland habitat was relatively stable, booming ground numbers and locations remained constant. Westemeier (1971) felt that the number of cocks was related to the amount of undisturbed grass and felt that the number of cocks on a booming ground should provide an index to the quality of nesting and brood rearing habitat that surrounds that booming ground.

Bradbury (1981), using mathematical calculations

proposed that the spacing of display grounds may be determined by the movements of the hens. Several biological points suggest otherwise. Prairie chicken and sharptail cocks display in the fall when hens are in larger flocks away from the booming grounds. Bradbury (1981) worked with sage grouse which do not display in the fall (Patterson 1952). In the spring, hens do not orient towards the display ground until late March or early April, after the cocks have been displaying for at least a month.

Distance Nearest Booming Ground. In central Wisconsin, all locations of radio-tagged prairie chickens (n=7809) (n=8094) and observations of non-radioed birds (n=17,783) excluding booming ground and nest observations were within 7.2 km of a booming ground. The weighted mean distance from the locations of radio-tagged prairie chickens to the nearest booming ground was 1010±989 m, with 90% within 2 km. The weighted mean for non-radioed birds was 893±989 m with 92% within 2 km. The mean distance from the nearest booming ground to 8,000 random points located within the Portage County Management Area was 2630±895 m which was greater than the mean for the locations of radio-tagged birds (P=0.001) and observations of prairie chickens (P=0.001). This indicated there was a real association between the locations of prairie chickens and the distribution of booming grounds.

At Crex Meadows, all locations of radio-tagged

(n=3898) and non-radioed (n=5282) prairie chickens not on nests or booming grounds were within 6.4 km of the booming ground and 96% were within 2 km. The weighted mean distance from radio locations to the nearest booming ground at Crex was 839±708 m and 859±912 m for non-radioed prairie chickens, both closer than those in central Wisconsin ($P>0.05$). The mean distance from the locations of radio-tagged prairie chickens at Crex to the booming ground was less than the mean of random points within 4 km of the booming ground (839±708 m, versus 2669±1022 m, $P=0.001$). The mean distance for observations of non-radioed prairie chickens (859±912 m, $P=0.001$) was also less than the mean distance to 4000 random points.

Using yearly weighted means, radio-tagged cocks were located closer to the booming grounds than hens in central Wisconsin (961±855 m versus 1060±635 m, $P=0.001$) and adult cocks remained closer than immature cocks (823±597 m versus 1663±1110 m, $P=0.001$). Adult hens remained closer to the booming grounds than immature hens (1006±607 m versus 1115±642 m, $P=0.001$), although the number of immatures followed through the fall and winter was small. Cocks were located closer to the booming grounds than hens at Crex (564±959 m versus 1145±758 m, $P=0.001$). Immatures followed at Crex were followed for only 3 months during the summer so data from these birds were combined with adults to simplify presentation.

The mean distance from radio-tagged prairie chickens to nearest booming ground varied with the season. Prairie chickens were farthest away during the winter and fall and closest during the spring and summer (Table 52). The distances from the booming grounds in fall and winter reflected movements away from the grassland habitat which surrounded the booming grounds to the agricultural areas for feeding. Hamerstrom and Hamerstrom (1949) found that fall packs of prairie chickens formed as close to booming grounds as their food supply permitted. Although adult cocks remained relatively close to the booming grounds in the fall the relationship was not as strong as in the spring as they visited sporadically and only in the morning.

The fall attendance of cocks on booming grounds was variable. During the fall of 1972 cocks were first observed on the booming ground on the morning of 23 September. Daily observations from 23 September-23 November indicated that cocks were present on 24 of 62 days (38.7%). All booming grounds were not used on the same mornings and all 4 radioed cocks were present on the 2 booming grounds (each with 2) only 41.6-50% of the days when cocks were observed displaying. When not on the booming ground with other birds, the radio-tagged cocks were either active in their roost area or in one of their usual feeding areas 1.0-1.6 km away. On 2 occasions the radio-tagged cocks flew to the

Table 52. Mean seasonal distance (m) to nearest booming ground by sex and age for radio-tagged prairie chickens, central Wisconsin 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78. Number of locations are in parentheses and number of birds in brackets.

	Winter	Spring	Summer	Fall
Central Wisconsin				
Cocks				
Adults	1385± 800(387)[12]	698± 497(497)[17]	769± 431(1146)[14]	1246± 666 (936)[15]
Immatures	2087±1635(851) [5]	962± 756(343) [9]	1051± 616 (743) [8]	2098±1432 (320) [4]
Total	1713±1276(572)[17]	809± 615(850)[26]	924± 520(1889)[22]	1511±1045(1017)[19]
Hens				
Adults	1390± 691(272)[13]	1114± 476(476)[19]	1306± 653 (531) [6]	1513± 607 (355) [7]
Immatures	1244± 740(198) [5]	1364± 744(369)[15]	1070± 531 (432) [4]	1329± 552 (238) [4]
Total	1336± 712(470)[18]	1213± 608(845)[34]	1218± 620 (936)[10]	1439± 592 (593)[11]
Crex Meadows				
Cocks	898± 624(266) [5]	373± 309 (474) [5]	855±1088 (906) [8]	881±1658 (606) [7]
Hens	1684± 881(357) [5]	1321± 777 (674) [5]	1477± 596 (551) [6]	1218± 780 (254) [6]

booming ground area but did not join the birds on the display ground. The mean number of cocks present on booming grounds in the fall was 9.1±5.5 (n=24, Range 1-25). Baker (1953), Schwartz (1945) and Horak (1985) reported that cocks in their areas made daily visits to the booming grounds in both morning and evening.

The first permanent snow cover greater than 6 cm caused the cocks to abandon their booming grounds and center their daily activities around a food source. Hens were associated with booming grounds only during the spring when they localized their activity within the vicinity of the ground for nesting.

The biweekly mean distances to nearest booming ground (Fig. 26) showed that radio-tagged birds moved towards the booming grounds in early March with the disappearance of snow. Hens began to move toward the booming grounds in late March. Adult cocks and hens moved to the booming grounds earlier than immatures. Hamerstrom and Hamerstrom (1949) pointed out that during booming season prairie chickens remained within 1.6 km or less of their booming grounds.

Cocks and hens gradually moved away from their booming grounds and nesting areas in late June. During summer the adult cocks remained the closest, followed by immature cocks and hens.

In fall, adult hens moved away from the booming

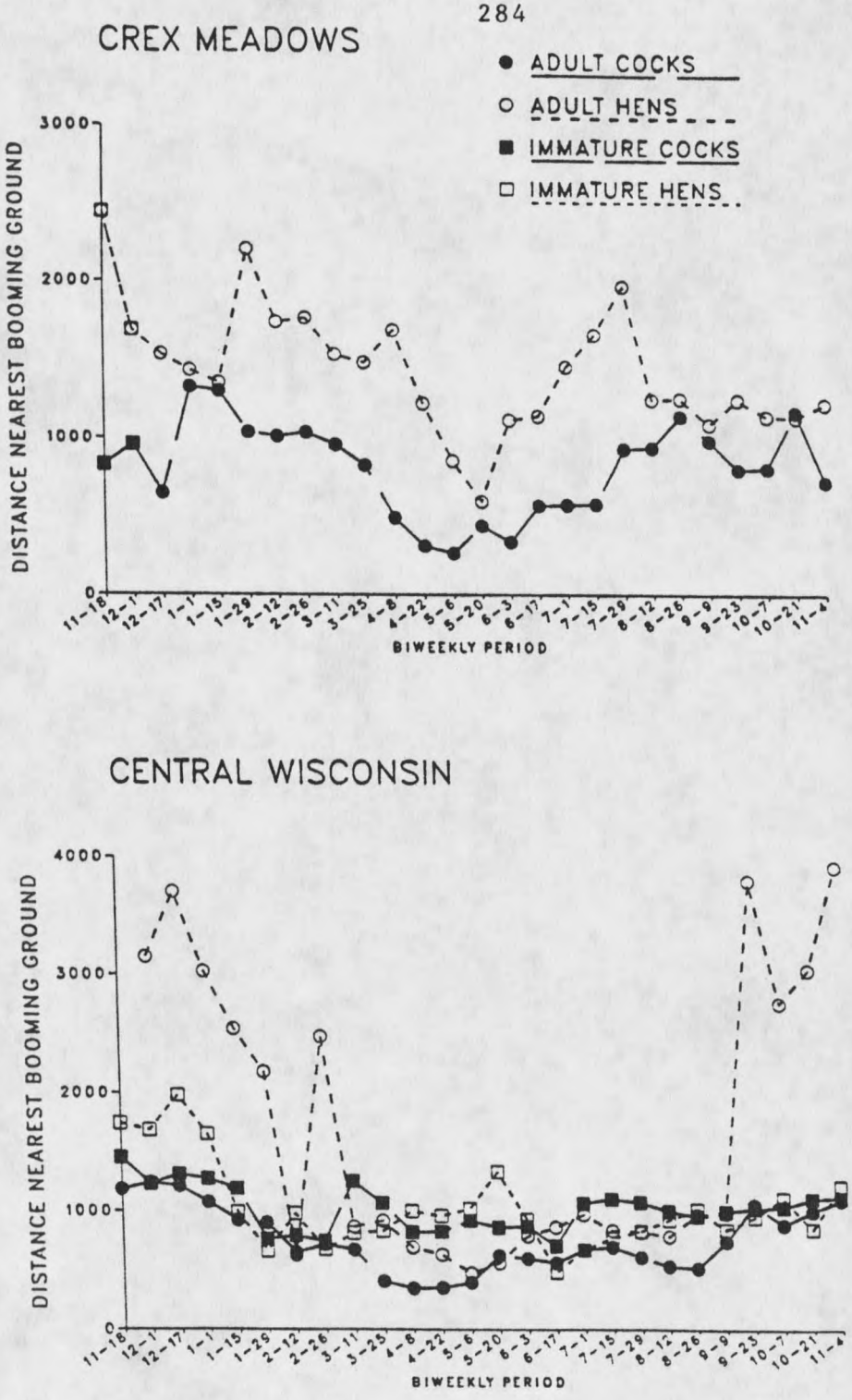


Figure 26. Mean biweekly distances (m) to the nearest booming ground by sex and age for radio-tagged prairie chickens in central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78.

grounds with the first heavy frost as they began to feed in agricultural areas. Cocks, especially adults, remained closer to the booming grounds due to the fall display. Hamerstrom and Hamerstrom (1949) estimated that cock prairie chickens spent 10% of their lives on the booming grounds. Based on observations of radio-tagged cocks in this study, it was estimated that cocks spent 6-7% of their time on the booming ground. In most snow-free parts of the country the cocks apparently spend more time on booming grounds. Baker (1953), Schwartz (1945) and Horak (1985) observed daily visits to the booming grounds in both the morning and evening during fall. In Illinois cocks have been observed on the booming grounds all through the fall and winter (Westemeier pers. comm.).

The seasonal changes in the distribution of radio-tagged prairie chickens was one of shifting to and from the areas within 1.6 km of the booming grounds. Radio-tagged prairie chickens were farthest from the booming grounds during the winter and fall (81.8% and 82.0% within 1.6 km) and closest in the spring and summer (93.3% and 92.9% within 1.6 km)(Fig. 27). This seasonal distribution also varied with the sex and age. Cocks were closer to the booming grounds during all seasons, except in the spring when hens remained closer than immature cocks. These changes corresponded to seasonal changes in behavior, and the availability and distribution of food and cover.

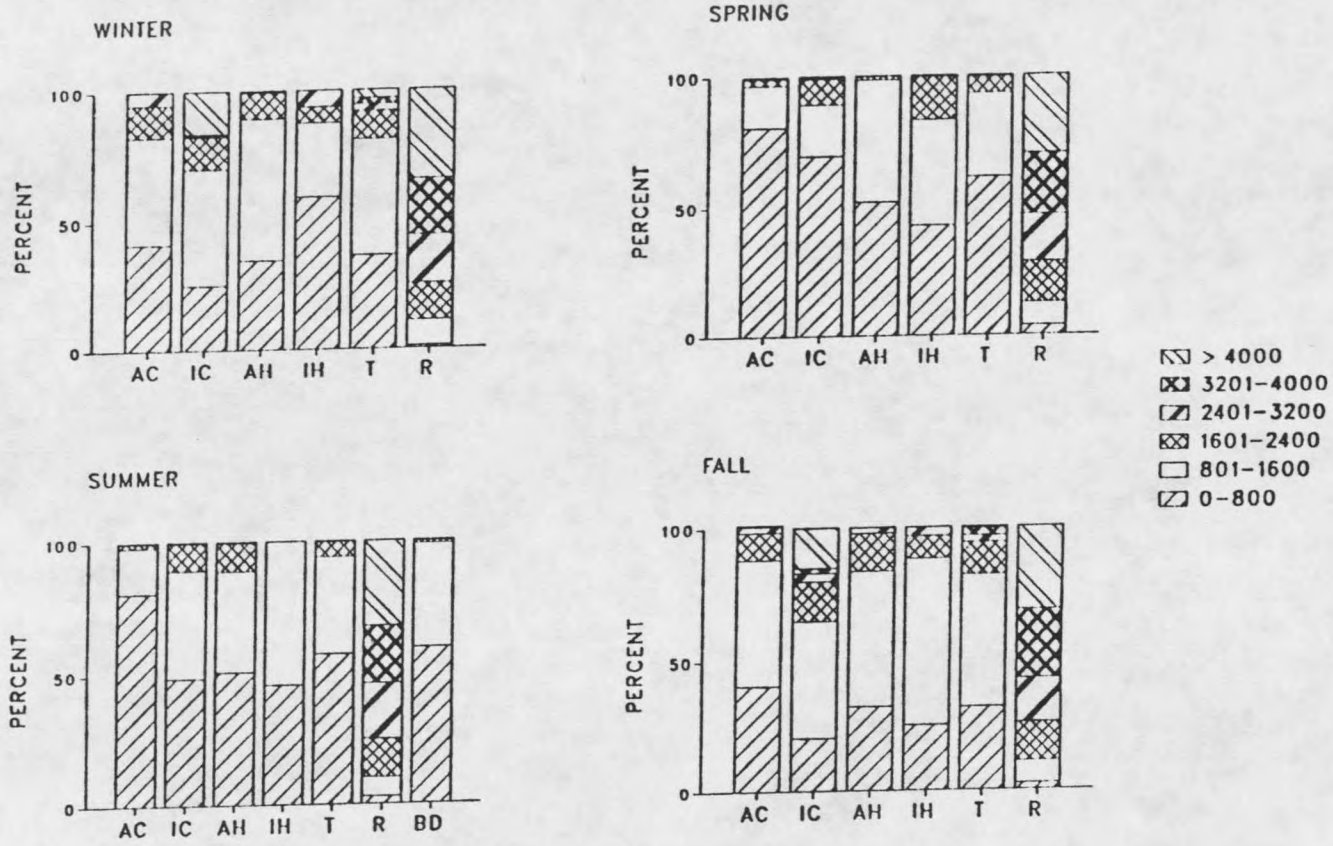


Figure 27. Seasonal distribution of locations by sex and age for radio-tagged prairie chickens and random points relative to the nearest booming ground in central Wisconsin, 1972-76. (AC=Adult cocks, IC=Immature cocks, AH=Adult hens, IH=Immature hens, T=Total, R=Random points and BD=Broods).

Radio-tagged hens with broods also remained within the vicinity of the booming grounds (98.6% within 1.6 km). The seasonal distribution of the locations for all groups of radio-tagged prairie chickens was different from the seasonal distribution of random points (Fig. 27).

At Crex, radio-tagged cocks and hens showed the same general seasonal pattern of association with the booming ground as birds in central Wisconsin, except mean distances and distribution of locations were closer (Table 52)(Fig. 27, 28 and 29). Hens with broods were farther from the booming ground at Crex, but 60% of the locations were still within 1.6 km. Biweekly changes in the mean distance to nearest booming ground for non-radioed prairie chickens showed the same general trends as radio-tagged birds (Fig. 30).

Based on mean distances and distribution of radio locations and observations, yearly movements and distribution patterns of resident prairie chickens in central Wisconsin and the established prairie chickens at Crex Meadows can best be characterized as occurring within and on the edge of the distribution of booming grounds. Even during winter, when radio-tagged individuals were located over 12,020 m from their nest or home booming ground, they were located within the vicinity of a booming ground.

The relationship to the booming grounds seen here

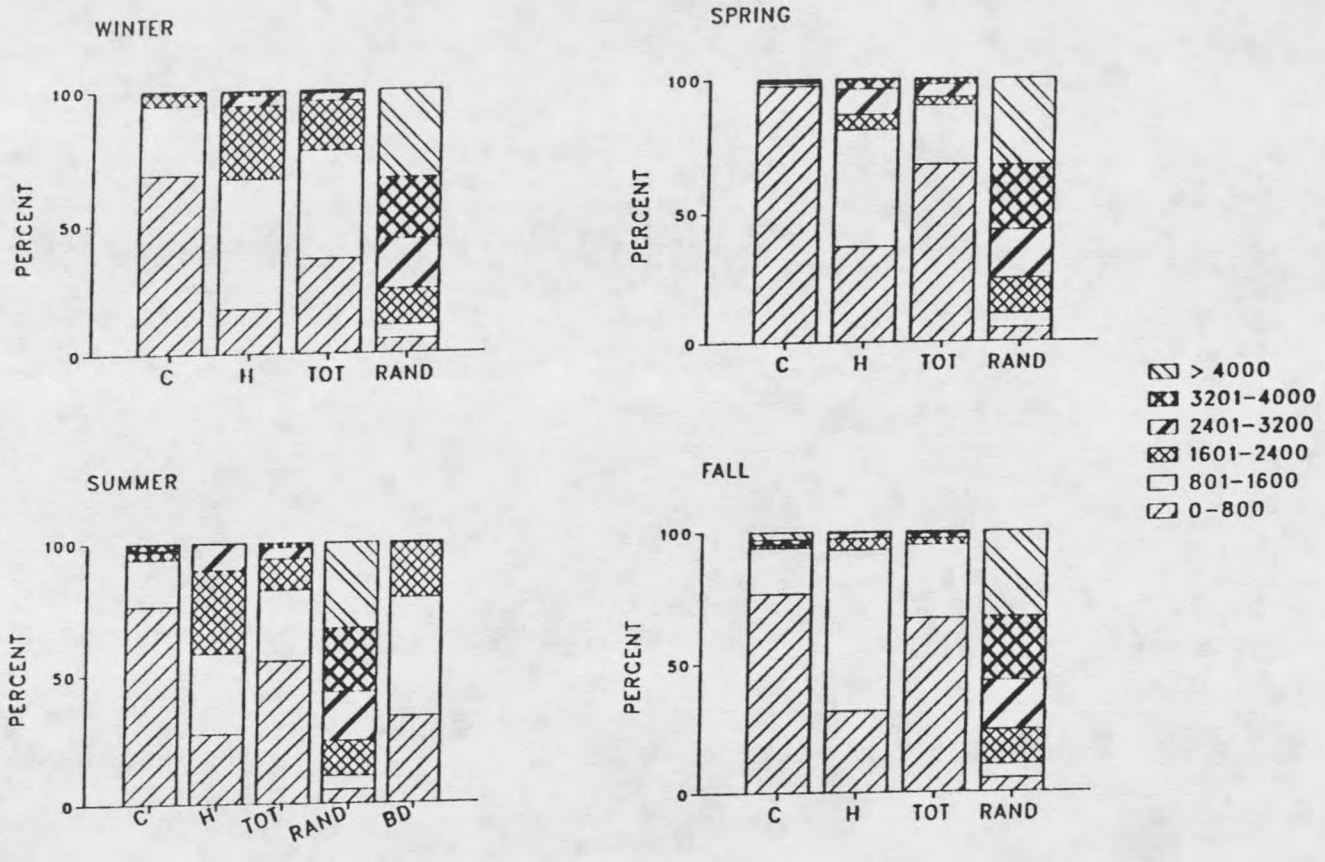


Figure 28. Seasonal distribution of locations by sex and age for radio-tagged prairie chickens and random points relative to the nearest booming ground Crex Meadows Wildlife Area, Wisconsin, 1976-78. (C=Cocks, H=Hens, T=Total, R=Random points and BD=Broods).

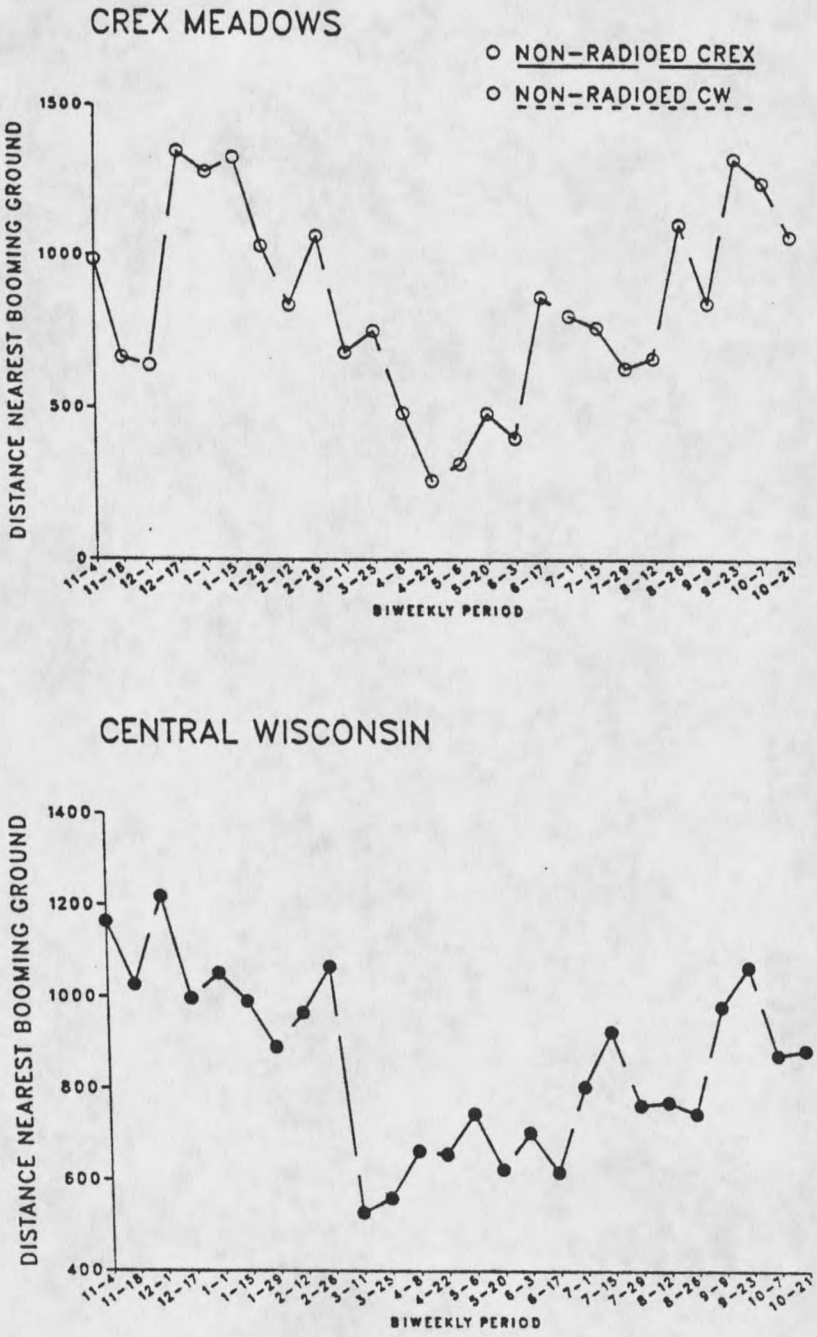


Figure 29. Mean biweekly distances (m) to the nearest booming ground for non-radioed prairie chickens in central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78.

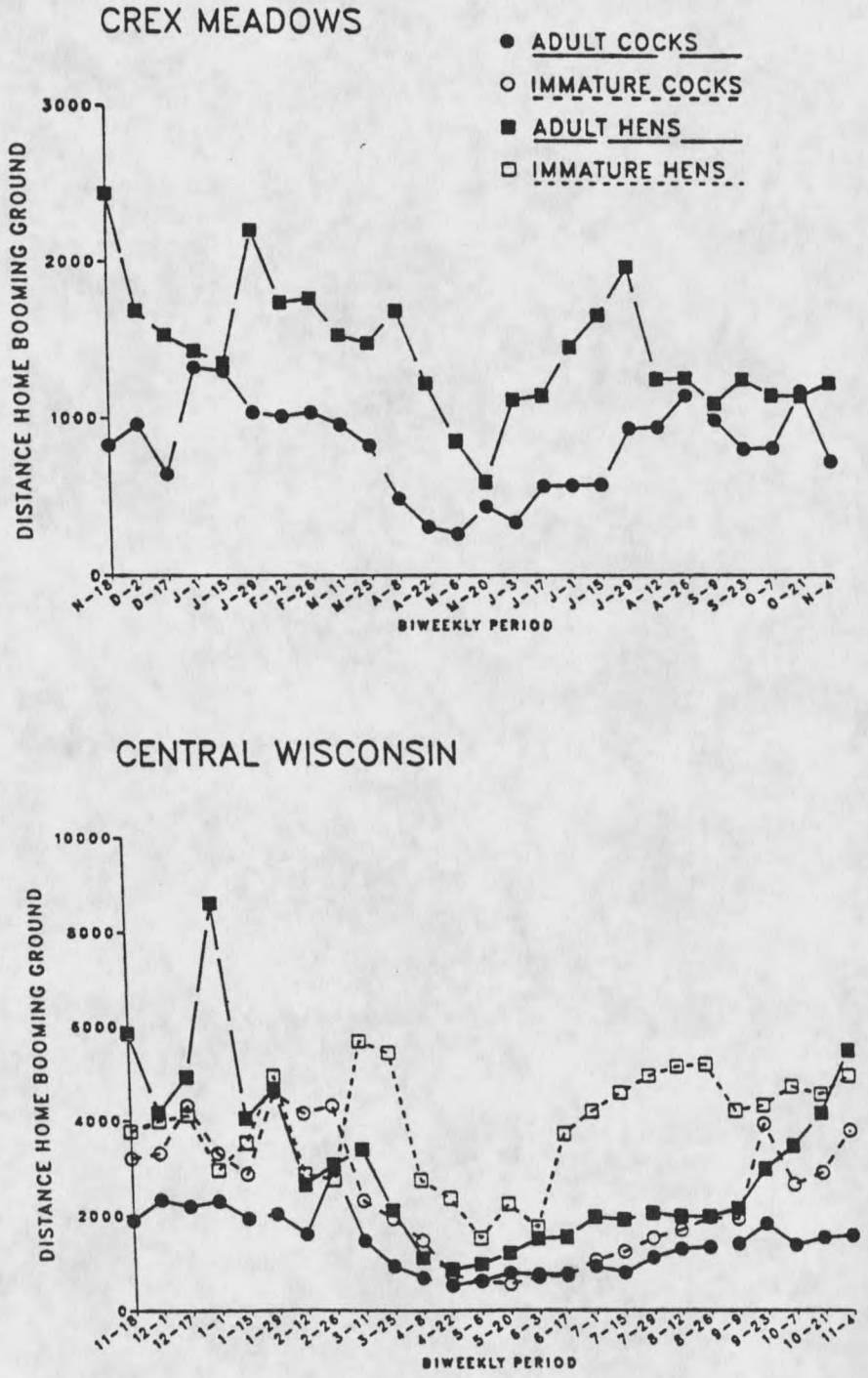


Figure 30. Mean biweekly distances (m) to home booming ground by sex and age for radio-tagged prairie chickens in central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78.

should not be perceived as a simple association to the grounds themselves, but to the habitat surrounding them. The shifts to and from the booming grounds were influenced by the distribution of food and cover used by prairie chickens at various times of the year. The association of the transplanted prairie chickens that established at Crex with the area around the booming ground emphasized this relationship. This strong association and change in distribution of prairie chickens relative to the nearest booming ground implied that booming grounds are spaced relative to the available habitat.

Booming Ground Association. The number of different booming grounds with which each radio-tagged prairie chicken was associated, varied between seasons, sex and age of the bird. A radio-tagged bird was considered associated with a booming ground if it remained within 1.0 km of it for 2 or more days. Table 75 (Appendix) presents the number of booming grounds that radio-tagged prairie chickens were associated with according to sex, age and season in central Wisconsin.

In general, hens were associated with more booming grounds than cocks, and immatures with more than adults. Hens and immature cocks were associated with more booming grounds because of their larger home ranges. Immature hens were associated with more booming grounds during the course of the year (Maximum=7) than were adult hens (Maximum=5) or

cocks (Maximum=4). Cocks were associated with fewer booming grounds during the year because of their smaller home ranges and strong relationship with their home booming ground.

Cocks were associated with the most booming grounds during winter when they expanded their home ranges after abandoning their home booming grounds and shifting to wintering areas. The highest seasonal associations occurred in immature radio-tagged hens during fall (Maximum=7) when they were dispersing and again in the spring, when immature hens visited areas around several grounds during prenesting (Maximum=6). Adult hens were associated with at most 2 booming grounds during the spring, a result of their smaller home ranges during prenesting. The lowest seasonal association with booming grounds occurred in adult cocks during the spring and was related to their daily use of their home booming ground.

The association with the booming ground for cocks during the summer was almost the same as in the spring as cocks spent most of the summer near their home booming ground. Hens with and without broods moved away from their nest areas and hence were associated with more booming grounds than cocks.

Relationship to Home Booming Ground. The closer proximity of cocks than hens to the nearest booming ground was related to the cocks strong year-round relationship to

their home booming ground. All locations of radio-tagged cocks in central Wisconsin away from the booming ground were within 7 km of their home booming grounds and 74.7% were within 2 km. Hens showed less of an association with their home booming ground than cocks with only 47.7% of their locations within 2 km and all within 12.2 km. Schmidt (1936) stated that male prairie chickens wintered within a few miles of their booming grounds while hens migrated to locate winter food. Hamerstrom and Hamerstrom (1973) also found that cocks tended to winter closer to the booming grounds than hens and that hens moved more widely in search of winter food. They concluded that cocks have a stronger attachment to the booming ground than hens and will tolerate poorer conditions in order to remain close to them. They also suggested that booming grounds were the year-long center of activities for cocks.

The mean distance to the home booming ground changed during the year and followed the same general pattern as the mean distances to the nearest booming ground except the means were greater in winter and fall (Table 53, Fig. 31). However, unlike the mean distance to the nearest booming ground, cocks remained closer to their home booming grounds than hens.

Radio-tagged prairie chickens were located closest to their home booming ground in the spring (78.6% within 1.6 km), followed by summer (66.8% within 1.6 km), fall (41.6%

Table 53. Mean seasonal distance (m) to home booming ground by sex and age for radio-tagged prairie chickens, central Wisconsin 1972-76. Number of locations in parentheses and number birds in brackets.

	Season			
	Winter	Spring	Summer	Fall
COCKS				
Adults	2151± 954(377)[11]	749± 438 (497)[15]	1111± 774(1146)[13]	1663± 957(936)[15]
Maximum	4243	2122	2105	4148
Immatures	3419±1514(135) [4]	940±1076 (343) [9]	1749±1184 (743) [8]	2978±1203 (81) [2]
Maximum	4296	4110	4668	3780
Total	2486±1257(512)[15]	826± 768 (850)[24]	1334± 989(1889)[21]	1768±1041(1017)[17]
HENS				
Adults	5022±4612(230)[10]	1233±1154 (393)[13]	1818±1457 (531) [5]	3993±1524(731) [9]
Maximum	12200	3819	4615	12000
Immatures	3060±2155(169) [3]	2402±1862 (369)[12]	4555±1591 (432) [4]	2978±1203(181) [2]
Maximum	8912	8487	6366	7050
Total	4569±4253(399)[13]	1799±1645 (762)[25]	3046±2039 (936) [9]	4248±3305(567)[11]

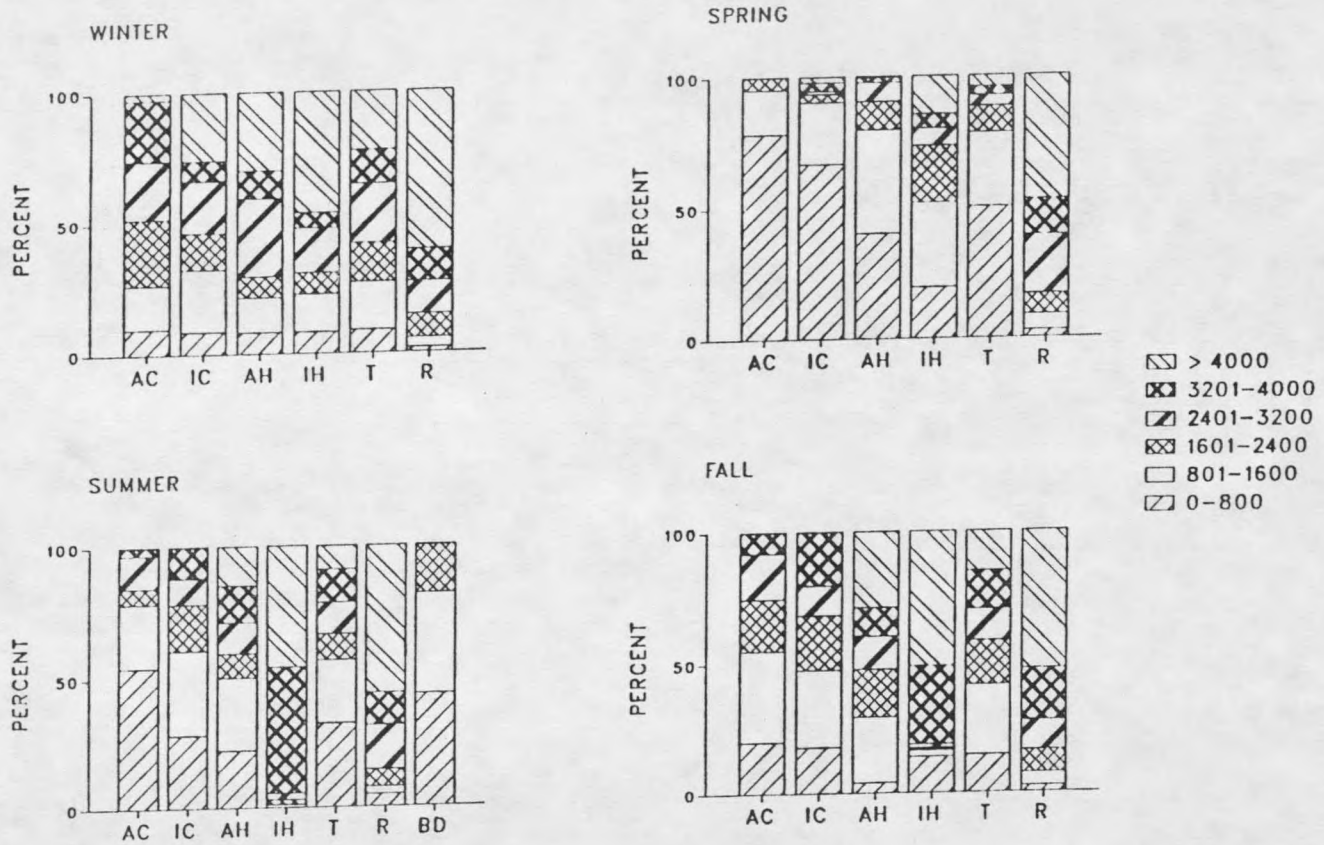


Figure 31. Seasonal distribution of locations of radio-tagged prairie chickens relative to their home booming ground and random points relative to 20 fixed locations in central Wisconsin, 1972-76. (AC=Adult cocks, IC=Immature cocks, AH=Adult hens, IH=Immature hens, T=Total, R=Random points and BD=Broods).

within 1.6 km) and winter (26.8% within 1.6 km). The distribution also varied by sex and age and in all seasons the adult cocks remained the closest to their home booming grounds, followed by immature cocks, adult hens and then immature hens (Table 53 and Fig. 32). The relationships to home booming ground was one of seasonal shifts within the habitats surrounding them.

Because there was only 1 booming ground at Crex, data for home booming ground were the same as for nearest booming ground (Table 52 and Fig. 29). Prairie chickens in central Wisconsin have a much larger area of habitat available to them than the birds at Crex. Hence they have habitat they can and do use farther away from their home booming grounds. The closer mean distances to the booming ground at Crex should not be interpreted as there being better habitat for a prairie chicken population; rather better habitat existed within a limited area. The habitat at Crex did not contain enough upland grass habitat for nesting and brood rearing to support a population.

Booming Ground Fidelity. Once established, cock prairie chickens maintained a strong fidelity to a particular booming ground. Hamerstrom and Hamerstrom (1949) and Robel et al. (1970) have reported cocks shifting between booming grounds. Banding data for 144 cocks (44 immatures), 66 with booming ground records for 2 or more years, yielded 130 bird years during the period 1972-76

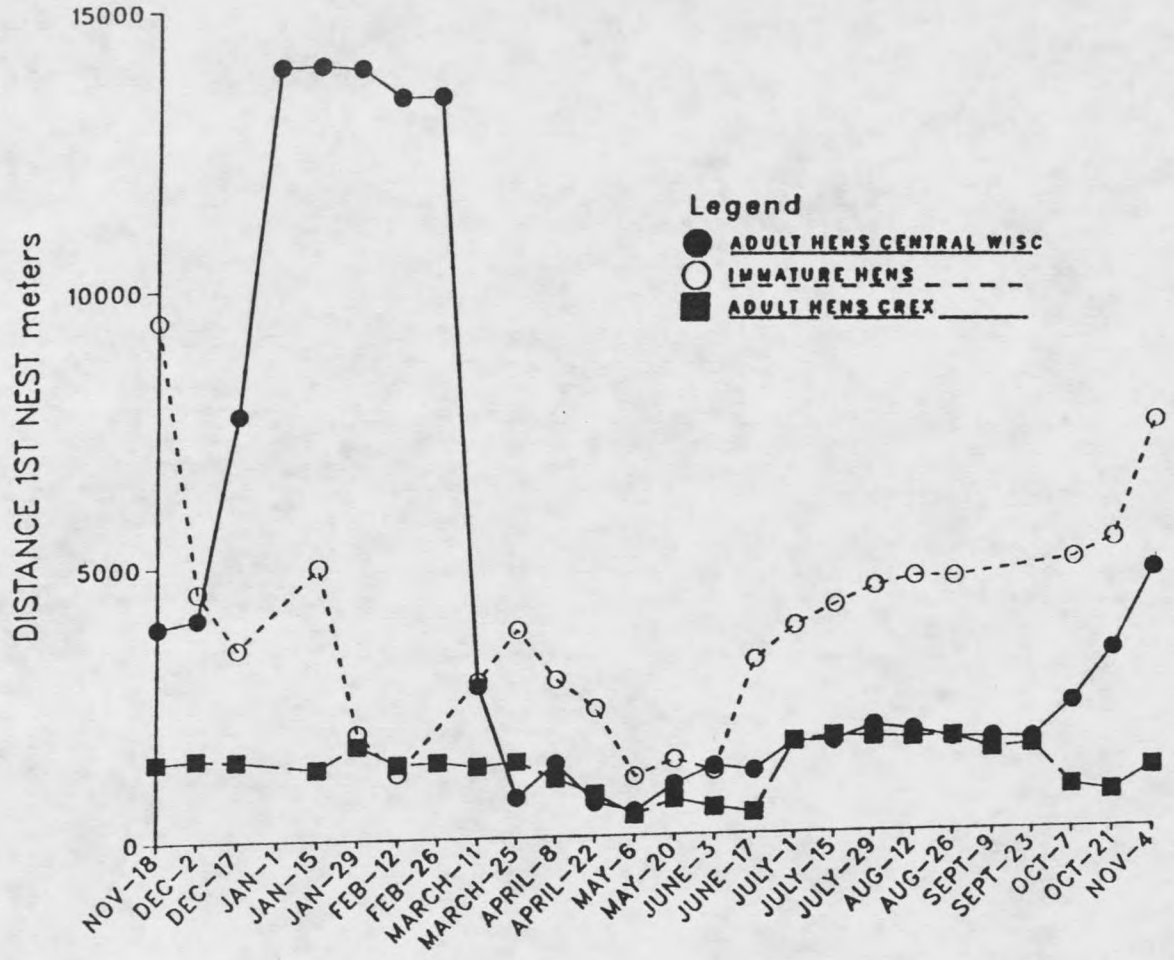


Figure 32. Mean biweekly distances (m) to nest for radio-tagged prairie chicken hens by age in central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78.

(bird year equalled 1 bird surviving from 1 spring to the next). In 130 opportunities, 20 shifts to new booming grounds were recorded, 80.0% of which occurred between the first and second booming season and 20% were made by adults. None of the birds that shifted were interior cocks or birds that were known to have bred with hens. Overall, 84.6% of the cocks remained on the booming ground on which they displayed the previous spring.

Records for adults $\geq$3 yr showed that 96.7% (29/30) returned to the booming ground they used the previous year. The 1 adult cock that changed booming grounds, did so on 2 occasions, the first as an immature and the second as an adult between his third and fourth year. Once an established cock reaches the age of 2, it is likely that he will remain on that booming ground for the rest of his life. There appeared to be a slight advantage in shifting booming grounds, as those individuals that moved at least once lived slightly longer (3.19 ± 1.68 years, n=16 versus 3.07 ± 1.67, N=27, P=0.827).

Several trends emerged with regard to these changes in booming grounds: 12 of 15 cocks left declining booming grounds, 13 of 20 moved to the center of the booming ground distribution and 12 of 20 shifted to larger grounds. The mean distance moved to a new booming ground was 4634 ± 5632 m (n=20, Range 1.7-25.7 km). Movements to new booming grounds within the Portage County Management Area averaged

3525±4575 m (n=19, Range 1620-6700 m).

Once established none of the radio-tagged adult cocks were known to visit other booming grounds during the spring. The greatest shift was made from a booming ground located in the West of Stevens Point Management Area to the Portage County Area (25.7 km). Hamerstrom and Hamerstrom (1973) have recorded movements from the Portage County Area, but not the reverse. The movement reported here indicated that movement between these areas is not just one way. Survival of cocks was higher on those grounds in the center of the booming ground distribution than on the edge (Interior 55.7%, 34/61 versus Exterior 49.5%, 83/168, Csq=0.63, df=2, P=0.232) and suggests that interior booming grounds have better habitat available to them.

Only 1 of the wild cocks transplanted in 1976 that survived to the following spring, displayed in the same area used in 1976. This cock initially displayed at the pen booming ground in 1977 with the single surviving pen-reared cock. In late April he moved between the pen area and the booming ground where the first year cocks and 3 of the previous years transplants displayed.

Two other transplanted cocks established on a dancing ground located 3.2 km from where they displayed in 1976. There apparently were adjustments that occurred between the initial release and the second spring, which caused birds to shift between booming grounds. Three of the cocks

transplanted during the summer of 1977 established on the main booming ground and 1 displayed alone. The shifting of displaying cocks stabilized as those individuals that survived for 2 or more years (n=3) remained on the booming ground they displayed on in their second year.

Relationship to Nest

Hens, as a group showed more year-round affinity for the booming grounds than their nests in central Wisconsin (1060±642 m, versus 3397±3075 m, P=0.001) and Crex (1145±758 m, versus 1320±656 m, P=0.001). Adult hens remained closer to their nests than immatures (3827±2770 m, versus 4002±2771 m, P=0.001) with 62.9 and 47.0% within 2 km respectively. The mean distances between radio-tagged hens and their nest were less at Crex than in central Wisconsin, with 88.0% within 2 km. The closer proximity to nests by the hens at Crex, as with other habitat related movements reflected the closer proximity of year-long habitat requirements.

Mean biweekly distances from the locations of radio-tagged hens to their nests showed that hens began localizing activities near eventual nesting areas during late March or early April, and away from their nest areas after nesting activities. Hens were located farthest from their nests during the fall and winter (Fig. 33).

The seasonal relationship and distribution of radio-

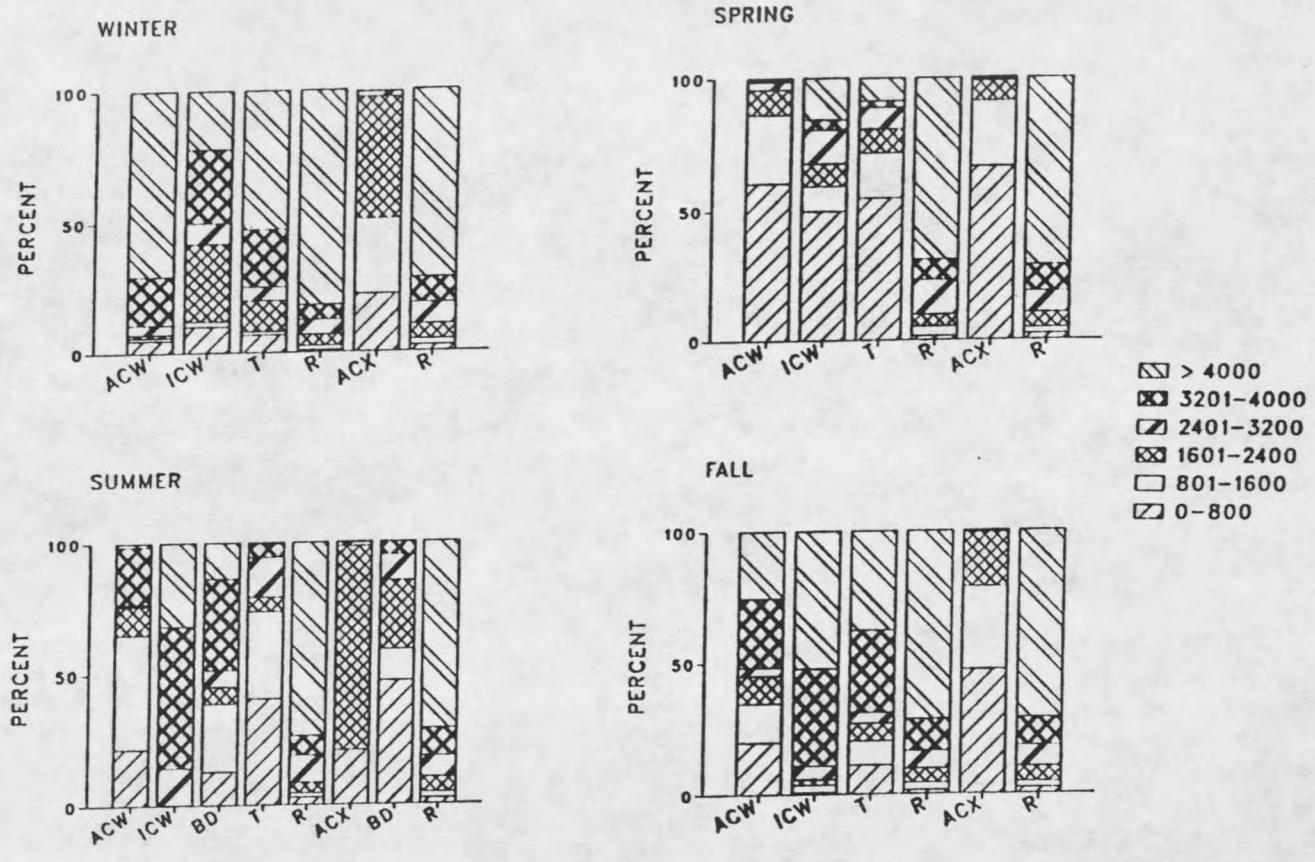


Figure 33. Seasonal distribution of locations of radio-tagged prairie chicken hens relative to their nest's and 20 fixed location in central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78 (central Wisconsin, ACW=Adult hens, ICW=Immature hens, T=Total and first R=Random points and Crex Meadows, ACX=Adult hens, BD=Broods and second Random points).

tagged hens in both areas also showed that hens were closest to their nests during spring in central Wisconsin and Crex (74.7% and 94.0% respectively, within 1.6 km) followed by summer (51.1% and 54.3% within 1.6 km), fall (24.5% and 75.0% within 1.6 km) and winter (8.1% and 51.1% within 1.6 km). Adult hens in central Wisconsin were closer to their nests than immatures in all seasons except winter (Table 54, Fig. 33). Hens were located closer to their nests than 3000 random points in central Wisconsin (3397±3075 m, and 4201±3879 m, P=.0001) and at Crex (1146±652 m, and 3839±2789 m, P=0.001).

Analysis of the locations of hens by weeks during prenesting, egg-laying and postnesting showed that radio-tagged adult hens localized their movements near their nests earlier than immatures (Fig. 34). Adult hens were closer during prenesting than immatures (722±529 m, n=210, versus 2528±2149 m, n=197) and were located closest to their nests during egg-laying (461±394 m, versus 538±506 m, P=0.002).

The hens at Crex also shifted closer to their nests from prenesting (1083±876 m) to egg-laying (442±424 m). Movements of radio-tagged hens that were followed before and after copulation indicated that nest sites were selected before because in all instances the nest was eventually located in the area used prior to copulation.

Data from this study were supplemented by Toepfer and

Table 54. Mean seasonal distance to nest (m) for radio-tagged prairie chickens hens by age, central Wisconsin, 1972-76 and Crex Meadows 1976-78. Number of locations are in parentheses and number of birds in brackets.

	Season				
	Winter	Spring	Summer	With Brood	Fall
Central Wisconsin					
Adult	7814±4988(272)[10]	884±1187 (525)[13]	1669±1240 (554) [6]	1884±1159 (244) [9]	4394±3667(731) [9]
Maximum	12405	3918	4813		12420
Immature	5331± 402(160) [3]	1850±1919 (621)[12]	4291±1446 (378) [4]	1009± 818 (570) [5]	6037±4145(180) [2]
Maximum	8985	8896	6733		7400
Total	6801±5119(432)[13]	1339±1623(1146)[25]	2732±1849 (932)[10]	1271±1015 (814) [9]	4693±3901(911)[11]
Crex Meadows					
Adults	1413± 662(430) [5]	709± 681 (565) [5]	1486± 663 (262) [3]	1030± 779 (588) [3]	976±619 (213) [5]
Maximum	3819	1592	2546		3055

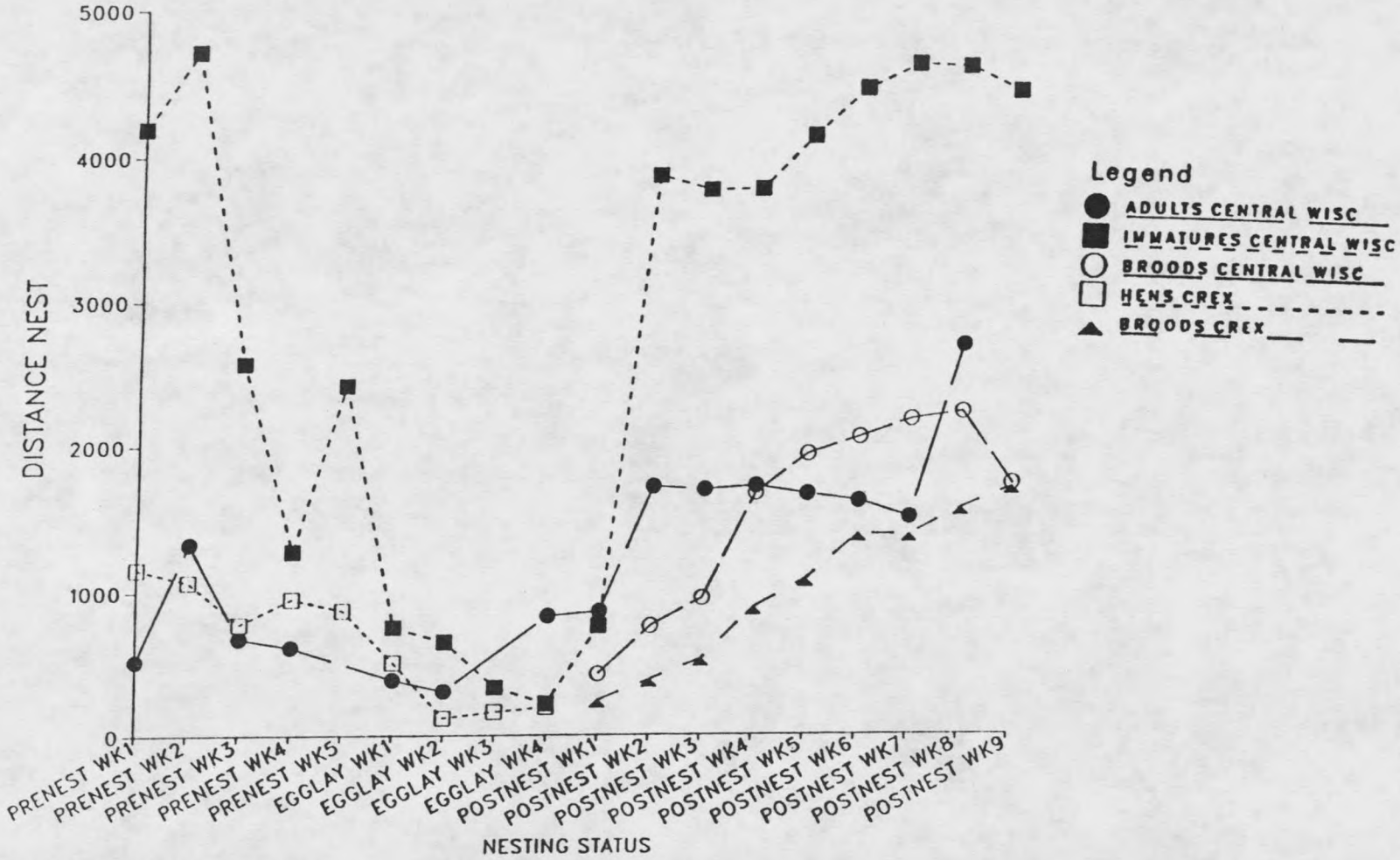


Figure 34. Mean weekly distances (m) to nest for radio-tagged prairie chicken hens by nesting status, central Wisconsin, 1972 and 1974 and Crex Meadows Wildlife Area, Wisconsin, 1976-77.

Newell (unpubl. data) which suggested that in early April adult hens moved to the booming grounds to return to or establish nesting areas. Immature hens then occupied nesting areas vacated as a result of mortality or shifts by hens from the previous years nesting season. Immature hens unable to establish a nesting area at 1 booming ground, shifted to another which explains their larger prenesting ranges. This behavior could regulate the number of hens that nest in the habitat surrounding each booming ground. Those booming grounds with more undisturbed grass allowing for a higher annual survival will have more carryover hens and should attract more immatures. Successful nesting and brood survival would promote a high recruitment rate of young cocks to nearby booming grounds. Cocks that cannot recruit would disperse and establish on other booming grounds or display alone.

Of 8 hens that lost their nest in central Wisconsin, 4 (3 adults) renested. All the adults renested within 800 m of their first nest (597±402). The immature renested 8046 m from her initial nest. Two hens renested at Crex, 1 within 60 m of her initial nest, and the other within 380 m. Toepfer and Newell (unpubl. data) working with 50 hens in North Dakota found that adults were more prone to renest than immatures (79.5% vs 38.5%) and renested closer to their initial nests than immatures (Mean 1223±1969 m, Range 200-2454 vs 3472±3188 m, Range 220-9958).

Hens with broods gradually moved away from their nests after hatching. Unsuccessful hens also moved away from nests and the movements of immatures away from an unsuccessful nest were more abrupt and greater than those of adults (Fig. 34). Immature hens, as first time nesters may have lacked tradition to a specific area whereas adult hens tended to remain and renest in the area with which they were familiar. This implies that adults may be returning to the general vicinity of a previous nest. Patterson (1952) recaptured 2 marked sage grouse hens on nests that were located less than 60 m from their previous years nest and frequently found new nests in old nest cavities or within several feed of old nests. Berry and Eng (1985) recently demonstrated fidelity to nesting and brood areas in sage grouse based on the movements of a radio-tagged hen followed for 3 years. Svedarsky (1979) reported 2 radio-tagged hens nested within 4.6 and 29.8 m of their previous years successful nest. Toepfer and Newell (unpubl. data) found that 9 hens whose nests were located at least 2 years in a row, nested within 800 m of their previous years nest.

At Crex the successful hens also moved their chicks away from their nest after hatching (Fig. 34) which suggested that differences exist between nesting and brood rearing habitat in prairie chickens. Two hens renested at Crex, 1 within 60 m of its initial nest, and the other within 380 m.

Nests Relative to Booming Ground

The movements in spring by adult and inexperienced immature hens toward the booming grounds and localization of movements nearby indicated that the habitat within the vicinity of the booming ground was the main nesting area for prairie chickens. The earlier movement by adult hens and the larger prenesting home ranges of immature hens implied that hens actively established nesting areas. Schwartz (1945) believed that there was a "sphere of influence around each booming ground".

There was strong evidence based on the spring locations of 9 radio-tagged hens surrounding 1 booming ground (31 cocks) in 1972 that individual hens were orienting to particular areas around a booming ground. Chi-square analysis of the distribution of 155 non-booming ground locations from 15 April-10 May for these hens showed that as a group the locations of the hens were randomly distributed within 4 quadrants surrounding the booming ground ($CSq=8.2$, $df=3$, $P=0.42$). However, individual hens were oriented to 1 or at most 2 of the 4 quadrants ($df=3$, $P>0.05$).

The locations of the 5 radioed hens that established at Crex and survived to the spring of 1978, showed the same distribution pattern as hens in central Wisconsin: random as a group ($CSq=7.2$, $df=3$, $P=0.35$) and oriented as individuals ($df=3$, $P>0.01$, $n=4$ hens).

The distribution of non-booming ground locations (n=194) of 4 radio-tagged cocks from this same booming ground during the same period were oriented both as a group (CSq=17.3, df=3, P>0.05) and as individuals (df=3, P>0.01). The orientation of the cocks in a particular direction was due to their use of regular feeding areas. Hens around this booming ground did not share a common feeding area.

Home ranges of the 9 hens oriented around the booming ground showed overlap, but each had areas that were isolated from adjacent hens. Although sample sizes were small, only 9 of a maximum 23 hens that visited this booming ground were radioed. However, the random distribution of hens and the existence of some exclusive areas suggested the presence of a behavioral mechanism working to spread nesting hens into available nesting habitat.

Little information was available on the distribution of groups of radioed individuals in a common area during the other seasons. However, cocks when not displaying and hens after nesting moved away from the booming grounds and established regular patterns that appeared oriented to feeding and roosting areas. The locations of adult cocks that used the booming grounds in fall were oriented in the direction of their fall feeding area(s).

There was no evidence that prairie chicken hens

defended specific areas although aggressive encounters between hens were observed on booming grounds in the spring and in feeding flocks during the winter. Hamerstrom and Hamerstrom (1949) and Schwartz (1945) also observed competition and aggression between hens while on the booming grounds. Territoriality has been documented in the females in many of the grouse species (spruce grouse, Herzog and Boag 1977; blue grouse, Bergerud and Butler 1985a; willow ptarmigan, Hannon 1983). Territoriality is strongly suspected in female ruffed grouse (Maxson 1978), black grouse (Angelstam et al. 1985) and capercaillie (Wegge 1985). In view of the close relationships between grouse genera based on hybridization (Peterle 1951 and Johnsgard 1973), it is difficult to believe that some form of regulated dispersal or territoriality does not exist in prairie chicken hens.

All 29 nests of the radio-tagged prairie chickens located in central Wisconsin in 1972 and 1974 were within 2500 m of a booming ground (Mean 893±362 m, 75% within 1500 m). Successful nests were slightly closer than unsuccessful nests (825±354 m, n=13, versus 1017±344 m, N=14, P=0.001). The nests of adults were closer than those of immatures (904±928 m, n=12 versus 1190±1120 m, N=14).

The mean distance from the nest to the booming ground on which individual hens were observed copulated was 933±435 m (Range 302-1271 m, n=12) in central Wisconsin and

563±394 m (n=6) at Crex. Of the 12 hens observed copulated in central Wisconsin, 3 nested nearer a different booming ground than the one on which they were copulated. All of the adult hens that renested were copulated the second time on the same booming ground.

Other researchers have reported that prairie chicken nests were located within the vicinity of a booming ground. Hamerstrom (1939) noted that grouping of nests near the booming ground was not by chance. Yeatter (1943) found most within 400 m, Hamerstrom (1941) most within 800 and all within 2000 m, Jones (1963) most within 800 m and all within 1600 m, Arthurud (1977) all within 805 m (Mean 315 m) and Svedarsky (1979) all within 1600 m (Mean=1063 m). Lehmann (1941) found nests of Attwater's prairie chicken in Texas were within 800 m of an active booming ground. Robel et al. (1970a) reported that all prairie chicken nests they found in Kansas were within 1850 m (Mean 1094 m). Newell (1987) found that 75% of 44 initial nests of radio-tagged prairie chicken hens were within 1500 m of a booming ground (Range 100-3800 m) and the first nests of adults were closer to a booming ground than immatures (985±345 m, n=19 versus 1244±453 m, n=10, P=0.001).

The nests of the pen-reared prairie chicken hens and established transplanted hens at Crex were also located in the vicinity of the booming ground. All pen-reared hens nested within 1200 m (Mean 869±322, n=10) of the

pen/booming ground and all nests of transplanted hens that established at Crex were within 1078 m (555±386, n=10).

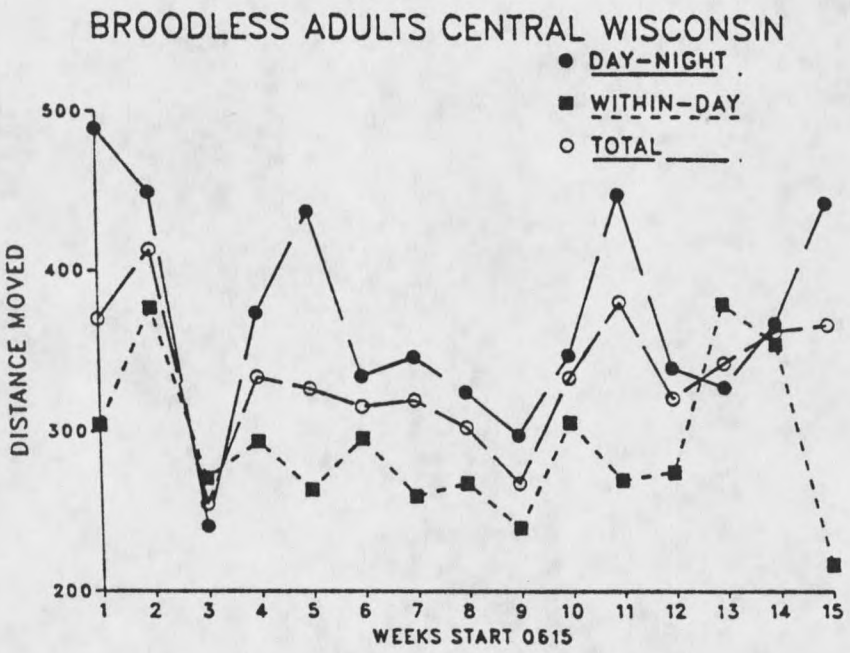
Some researchers have emphasized that not all hens nested nearest the booming ground at which they were copulated on and that hens visited more than 1 booming ground (Robel 1970). In this study at least 4 radioed hens were known to have visited more than 1 booming ground and 1 immature hen visited 3. This does not decrease the importance of the habitat around the booming grounds relative to the location of nests. How many booming grounds a hen visited and on which she was copulated was irrelevant when one considers that in this study and so many others, most prairie chicken hens nested within 1600 m of a booming ground. It is apparent that this is the primary area used by prairie chickens for nesting and should be managed accordingly. This means that agricultural areas created for winter feeding should not eliminate grassland and when possible should be located on the edge or make up a small portion of this nesting area. When nesting areas must be disturbed, only a portion should be disturbed at any one time.

Daily Movements Broods

The daily movements of hens with broods were different than those of cocks and hens without broods (broodless adults) during the summer. Mean daily movements of hens

with broods were 30-43% less than those of adults in central Wisconsin and 20-50% less than movements of adults at Crex (Table 50). Daily movements of hens with broods increased with the age of the chicks in weeks, from 127±97 m during the first week to 291±153 m in the 14th week in central Wisconsin and from 110±97 to 283±217 m at Crex (Figs. 35 and 36). Mean daily movements of broodless adults over a comparable 14 week period (10 June-9 September) remained relatively stable in both central Wisconsin and at Crex (Figs. 35 and 36).

Hens with broods moved differently than adult birds. Mean WD distances of hens with broods were greater than DN movements. This was opposite to the pattern seen in adults during the summer. DN movements of adults were also greater than those of hens with broods (Table 50). These differences in movement patterns between adults and hens with broods were believed to be related to food and cover needs of hens with broods in relation to their movement capabilities. Hens with broods were ground oriented and appeared to move throughout the daylight period. Adults exhibited a bimodal activity pattern and fed in the morning, loafed during midday and fed again in the evening. Because most activity and movements of broods occurred during the day and since hens with broods walked to and from night roosts, WD movements were greater than DN movements. Adults usually flew between their feeding and



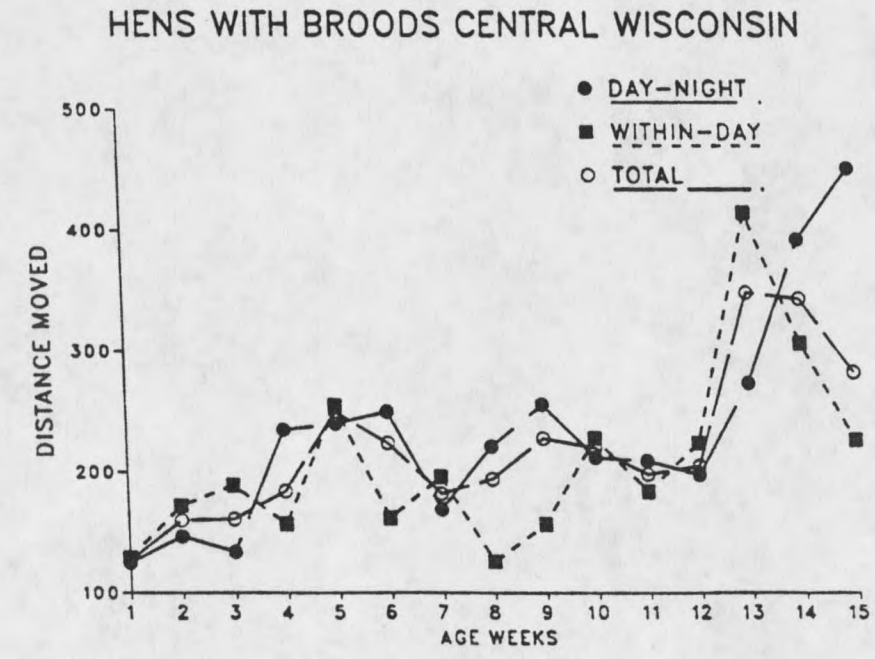


Figure 35. Mean daily movements (m) for radio-tagged prairie chicken hens with broods (n=5) by age of chicks in weeks, hens without broods and cocks (weeks starting 15 June), central Wisconsin, 1972 and 1974.

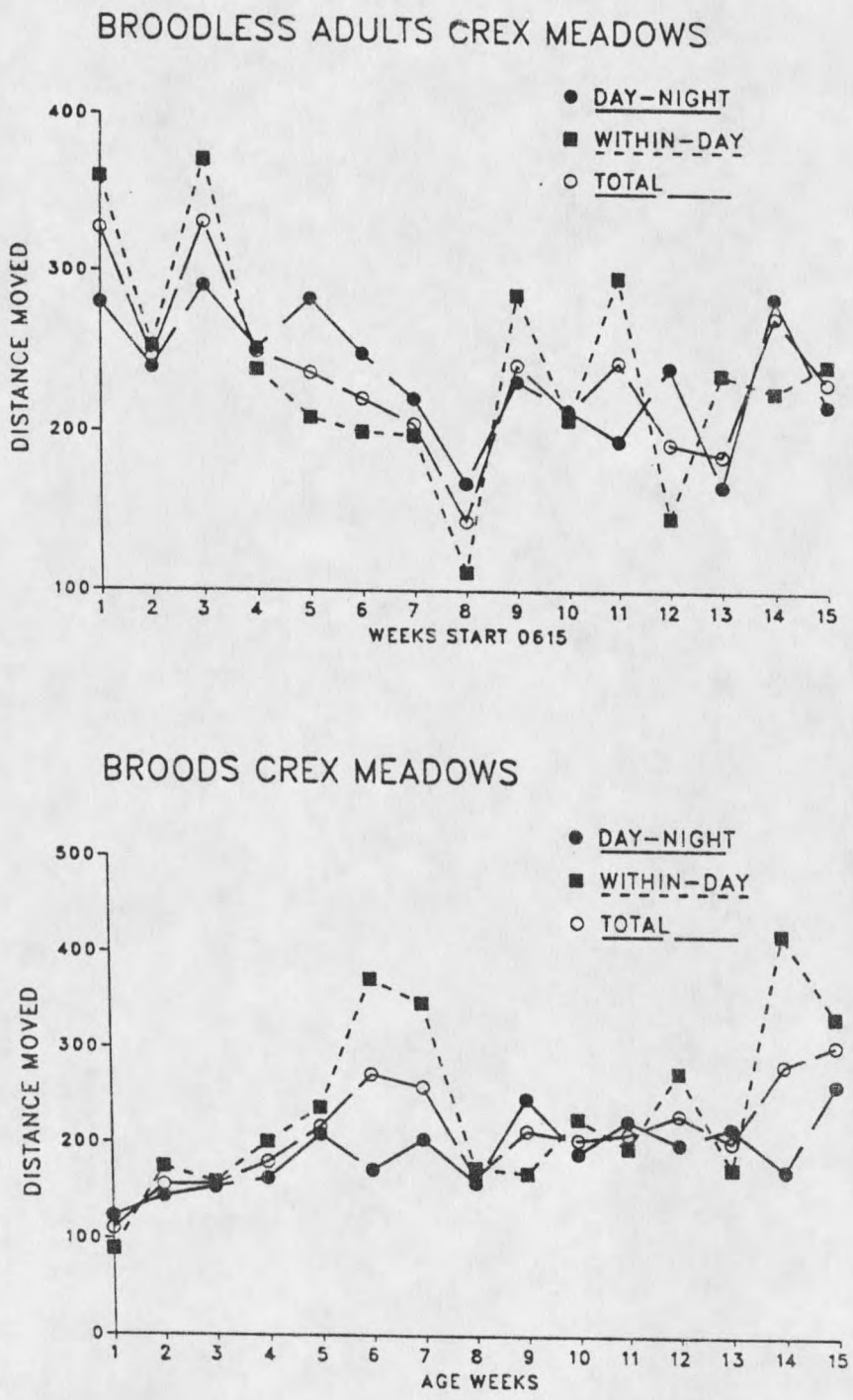


Figure 36. Mean daily movements (m) by radio-tagged prairie chicken hens with broods (n=3) by age of chicks in weeks, hens without broods and cocks (weeks starting 15 June), Crex Meadows Wildlife Area, Wisconsin, 1976 and 1977.

roosting areas and during the day walked to and from loafing cover.

Adults, in contrast to hens with broods have regular feeding and loafing areas that were established early in the summer. Hens with young chicks did not have regular feeding areas and did not establish them before the chicks were 12 weeks of age. This movement pattern was believed to be due to the limited mobility of younger chicks and the heavy use of insects for food. Observations of adults indicated they were feeding on vegetation during the summer. Adults were regularly observed feeding in short cover in the heavily grazed fields whereas hens with broods remained in taller cover. Hens with younger broods appeared to feed and roost in the same type cover while adults, due to greater mobility, shifted between tall and short cover.

General Movements Transplanted Birds

Six of the 7 radio-tagged transplanted cocks released in April established new ranges in the Crex refuge, within 0.2-0.8 km of their initial release sites. Four of the cocks moved up to 3.2 km from their release sites before they established regular movement patterns inside the refuge 0, 6, 7 and 9 days after their releases. A fifth cock remained unstable and was located 4.2 km southwest, 6.4 km north and 7.2 km south of the release area. He

returned to the refuge after each of these excursions. This cock eventually established a new range in the refuge 27 days after his release. The sixth cock moved 13.2 km south, returned to the next day, remained for 2 days, then moved 8.9 km northwest into Minnesota, returned the next day and established a new range 16 days after his release.

The non-radioed cocks also established rapidly after being released inside the refuge. One cock was observed displaying at the holding pen the morning after his release and 2 other individuals displayed at the pen within 2 days. A total of 9 of the 12 non-radioed cocks were observed displaying in the refuge between 19 April and 30 May.

The presence of 77 hens and the displaying cocks inside the pen were believed responsible for the high percentage of cocks establishing in the release area. Twelve of the 19 wild cocks were observed displaying to the pen-reared cocks and hens at the release pen. Four wild cocks (3 radioed) established territories and fought with the pen-reared cocks through the wire before the birds were released from the pen. Seven of the transplanted cocks were observed displaying at the pen on 19 April, 2 days before the release of the pen-reared birds. Wild cocks transplanted in central Wisconsin (Toepfer 1976) did not remain near their release sites and were not attracted to the display ground. Only 1 of the 3 returned and established at his initial release site.

In 1976, 1 of 7 radio-tagged hens transplanted from central Wisconsin established in the Crex refuge 0.2 km from her release site. The other 5 hens made extensive movements away from the release area and ended up 5.8, 6.1, 13.2, 16.9, 24.1 and 56.3 km from the release site. Two other hens initiated nests with infertile eggs 10 and 21 km south of the release area. Two non-radioed transplanted hens were observed in the release area in July with a brood.

In 1977, 3 of the 10 radio-tagged hens transplanted from Minnesota established (2 nested) in the Crex refuge. Radio signals were lost from 2 hens and the remaining 5 ended up 15.5, 15.8, 17.1, 17.7 and 56.8 km from Crex. Two hens were nightlighted in early May and re-released at Crex. One hen established in the Crex refuge and remained within 1.6 km of her second release site. The 3 hens that were nightlighted and re-released at Crex in August remained within 1.7 km of their release sites. All of the surviving radio-tagged cocks transplanted from Minnesota during August 1977 (n=3) remained within 4 km of their release sites.

Daily Movements of Transplants

All discussion of the daily movements of transplanted birds, except where indicated refers to DBC movements. The large areas that the transplanted radio-tagged birds dispersed over, made it difficult to locate each bird

during the day and night. The daily movements of the transplanted radio-tagged prairie chickens were characterized by an initial adjustment period, an orientation period, and a post-orientation period. These periods were based on the movements of each radio-tagged bird and were delineated by changes in behavior and movement patterns. The adjustment period was characterized by limited movements and the orientation period by extensive wandering covering an unusually large area. The post-orientation marked the end of the orientation period and began when each bird established a regular home range and movement pattern.

Adjustment Period. The adjustment period in the transplanted prairie chickens appeared to be a reaction to being captured and moved to a new area. The length of this period for radio-tagged prairie chickens transplanted in April was variable and greater for hens than cocks (3.1 ± 1.6, Range 0-8 days, versus 1.3 ± 1.6, Range 0-3 days). Wild residents also exhibited adjustment periods when captured and released in place. Hens took longer to adjust to handling and radio-tagging than cocks (0.9 ± 0.64, n=11, Range 0-2 versus 1.1 ± 0.63, N=16, Range 1-3). The longer adjustment periods observed in the transplants were probably due to the stresses of being moved to an unfamiliar area. However, several of the cocks transplanted in April 1976 showed no discernible adjustment period. These birds

showed up at the release pen and displayed to the pen-reared birds being held inside the pen the day after their release. There was no evidence of any adjustment period for the 6 birds transplanted in August.

In both cocks and hens the level of breeding and territorial drive appeared important in overcoming the stresses of handling. Resident cocks captured during the peak of breeding typically returned to their booming grounds that evening or at most, the following morning. Cocks captured during March took longer but eventually did return to their booming ground (1.6±1.1, Range 1-3 days, n=5). Hens captured on the booming grounds were often not at the same behavioral level as cocks and took longer to adjust. However, hens in breeding condition adjusted faster to handling. One resident hen returned to the booming ground and was copulated the morning following her capture; a second returned the evening of her capture and was copulated the next morning. Hens captured on nests showed the shortest adjustment and all returned to their nest within 2 hours (n=4).

Residents captured during the fall and winter exhibited the longest adjustment periods (Fall 1.8±2.0, Range 1-3, n=4, Winter 2.5±2.2, Range 1.5 to 4 days, N=18). High mortality was associated with longer adjustment periods in winter as 8 of 22 birds died. No mortality occurred during adjustment periods in the other seasons.

The cause of the adjustment period may be due more to the radio package than to handling and banding since recaptured resident radio-tagged birds showed at most a half day adjustment period. At least 3 cocks recaptured early in the morning on booming grounds in mid-April were back displaying in their territories within 25 minutes of their release. Two radioed cocks recaptured during the winter, exhibited adjustment periods of only a half day. The adjustment period ended when the radio-tagged bird joined with other birds and began moving in a "normal" fashion. Based on the lengths of the adjustment period and survival, the best time to radio-tag prairie chickens was in the spring near the breeding peak and the worst during the winter.

Orientation Period. The orientation period occurred when a radio-tagged individual made relatively large irregular movements away from the release site. The daily movements of 15 radio-tagged prairie chickens transplanted in April, that left the Crex Meadows are presented in Figures 70-73 (Appendix). It was speculated that these large movements were efforts to locate a familiar area. Prairie chickens transplanted during April exhibited orientation periods of 0-55 days. Orientation periods were longer for hens than cocks (20 ± 12.7 versus 11.7 ± 6.8 days, $P=0.001$) and slightly longer for immatures than adults (Table 55).

Table 55. Mean distance moved (m) by transplanted radio-tagged prairie chickens released in April, Crex Meadows Wildlife Area, Wisconsin, 1976 and 1977. Number of moves are in parentheses.

	Hens			Cocks		
	Adults n=9	Immatures n=8	Total n=17	Total n=7	Adults n=5	Immatures n=2
ADJUSTMENT PERIOD						
Length (Days)	3.3+2.2	2.9+1.5	3.1+1.6	1.3+1.6	1.2+1.3	1.5+2.1
DBCL	280+ 209 (17)	288+ 160 (12)	285+ 198 (29)	268+ 177(12)	287+ 194 (8)	233+ 166 (4)
ORIENTATION PERIOD						
Length (Days)	19.6+11.4	21.6+15.1	20.0+12.7	11.7+6.8	11.6+7.9	11.7+5.7
Type of Movement						
Within-Day	3304+3861 (13)	2513+1995 (5)	2700+3342 (18)	1562+ 959(21)	985+ 674 (9)	1995+ 368(12)
Day-Night	829+ 933 (39)	777+ 829 (20)	808+ 907 (59)	868+874 (44)	725+ 700(33)	1296+1321(11)
Total	1218+2151 (52)	1114+1321 (25)	1183+1881 (77)	912+1018(55)	777+ 933(42)	1347+1296(13)
Night-Day	1762+1814 (39)	1451+1114 (23)	1646+1554 (62)	1646+1808(48)	1296+1218(35)	2591+3187(13)
DBCDL	3550+5260(126)	4975+5700 (80)	4229+5149(206)	2266+2515(75)	1632+1762(52)	3705+4223(23)

All but one of the April transplants wandered about the open treeless refuge before leaving or establishing new ranges. Hamerstrom and Hamerstrom (1951) found that winter transplanted sharptails moved farther than resident birds. Ammann (1957) noted "an innate tendency" for transplanted sharptails to wander "indiscriminately in all directions". Jacobs (1959) reported some success in reestablishing prairie chickens using winter trapped and transplanted birds, but found that most dispersed rapidly from their release site. Patterson (1952) also found that transplanted adult sage grouse dispersed widely from their release sites. Grange (1948) reported that transplanted willow ptarmigan "did not tarry where released" and that 3 of 24 released in central Wisconsin ended up 20.9, 167.4 and 241 km from the release site. Radio-tagged Attwater's prairie chickens, tranplanted during the fall, also made large movements as they wandered away from their release sites (Silvy pers. comm.).

Ruffed grouse populations have been successfully reestablished through transplants (Lewis et al. 1962, Ammann and Palmer 1962, Back 1984, and Woolf et al. 1984) which may reflect the limited mobility of this species. White and Dimmick (1979) reported a tendency for transplanted radio-tagged ruffed grouse to disperse from their release sites, although the distances moved (Mean 1735 m, maximum 4400 m), were considerably less than

those observed in the more mobile species of grouse.

An attraction to the pen-reared hens held in the pen was thought to be the reason for the shorter orientation periods and rapid establishment observed in the transplanted cocks. Two of the 6 transplanted cocks left the Crex area but returned and established at the release site 20 and 27 days later. All other cocks began displaying 7-16 days after their release. The 2 cocks that left the area and several others were located in the morning during orientation and none were heard displaying even though the cocks at and in the holding pen were booming. The orientation periods of the cocks ended when they began to display as the breeding drive overrode the stress of being in a new area. Figure 74 (Appendix) shows movements of radio-tagged cocks transplanted in April relative to the release site.

Orientation periods in hens ranged from 8-55 days and 16 of 17 hens left Crex. Although the response varied it took hens longer than most cocks to overcome the stresses of being in a new area. The orientation period in hens ended with the initiation of egg-laying. Figure 37 shows mean distances from the release site by days for radio-tagged cocks and hens transplanted in April.

Radio-tagged prairie chickens transplanted in April that left the Crex area directed their movements into open habitat. While in the open, treeless refuge they were

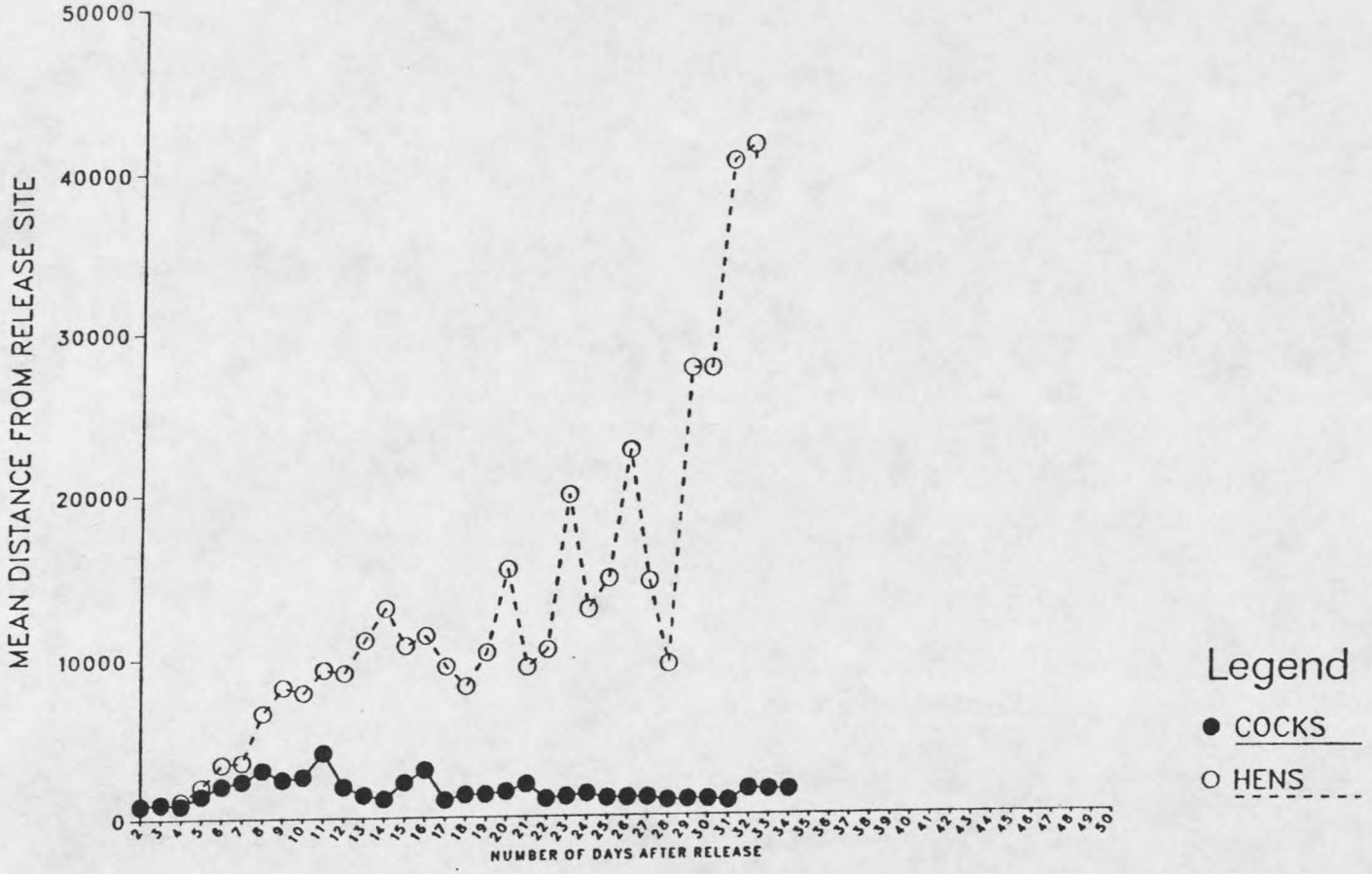


Figure 37. Mean distance (m) from release site relative to the number of days after release for radio-tagged prairie chicken cocks and hens transplanted in April, Crex Meadows Wildlife Area, Wisconsin, 1976 and 1977.

randomly oriented relative to the 4 cardinal directions (CSq=1.62, df=3, P=0.657, n=75 locations). However, once the birds left the refuge their movements were no longer random (CSq=15.4, df=3, P=0.006, n=125 locations) since they appeared to avoid the area to the north and northeast (10.4%) and oriented to the south (69.6%) (CSq=9.95, df=1, P=0.002, n=125 locations). The habitat immediately to the north was solid woodland, while the area just to the south was open marshland which gave way to open agricultural land with scattered woodlots (Fig. 3). A number of the locations (20.0%) were to the northwest into the wooded area. However, when in an airplane over this area open habitat could be seen to the west across the St. Croix River from an airplane. The area to the north and northeast of Crex was forested for at least 40 km and none of the birds that moved in that direction remained for more than 2 days.

Comparisons between mean DBC movements of transplants during orientation with DD movements of residents during the spring showed that movements of the transplants were 1.5-6.7 times greater than those of resident cocks and 1.5-9.6 times greater than those of resident hens during orientation. The movements during orientation of hens transplanted in April were 1.9 times greater than those of the transplanted cocks (Table 55). The greater DBC movements of transplanted hens appeared related to the

tendency for hens to be more mobile than cocks and to the rapid establishment of cocks due to the attraction to the pen. It appeared that transplanting in April intensified the normal movement patterns of hens.

In the transplants, WD movements were much greater than DN movements (Table 55). This is a reversal of the pattern observed in residents where WD movements were usually less than DN movements (Table 49). The transient nature of transplants did not permit establishing regular feeding and roosting patterns like residents.

Typically, large movements of transplants were generally restricted to the morning since birds located during midday or afternoon were usually relocated at night within 1.6 km. The magnitude of some of these DBC movements were very large when compared with those of resident hens. Overall, 6% of the DBC movements were between 15.9 km and 23.9 km. One hen covered at least 103.4 km in 3 days. These large movements were greater than those recoded for residents at any time of the year. The maximum DBC moved by resident prairie chickens in central Wisconsin were 6.0 km and 7.1 km and were made by an adult and immature hen respectively during the winter. The maximum distance moved by a resident at Crex was 5.8 km and was made by a hen during the fall. Overall, only 1% of all DBC movements by resident birds in both areas exceeded 3.0 km, most of which occurred in winter.

On 5 occasions, 3 separate radio-tagged hens were followed from their night roosts through the day. These birds made 2-4 flights of 800-6365 m during the morning. The flights that were actually observed were high and in a straight line. Subsequent flights were usually not in the same line as the initial flight and appeared to be made in a disoriented manner. There was no evidence to suggest that any of the transplants oriented towards home. Prairie chickens apparently are not capable of long distance homing seen in some birds (Welty 1975) without having made the initial move themselves.

Several individuals which left Crex, moved at least 10 km away for 5-9 days only to return and establish at Crex. One hen followed the same route used when she left and several of the locations in each direction were within 200-400 m of each other.

Different movement patterns were noted between hens transplanted from central Wisconsin and western Minnesota. Although orientation periods of hens transplanted from these areas were similar (20.9$\pm$10.8, n=7 versus 19.3$\pm$14.5, n=10) the mean DBC of the Minnesota hens were greater than those for Wisconsin hens (4636$\pm$5095 m, n=240 versus 3446$\pm$5206 m, n=121). This difference was believed related to differences in the habitat at the birds point of origin. The Minnesota study area was more open with larger grassland areas than in central Wisconsin. Thus habitat

surrounding Crex was more like that in central Wisconsin.

Daily movements of prairie chickens transplanted in April were also influenced by age since mean DBC movements of immature hens were 1.4 times greater than adult hens (Table 55). The larger DBC movements of immature hens than adults was the reverse of that seen in home range sizes (Table 47).

Two hens were recaptured during their orientation periods and re-released at Crex in May to see if they would establish at Crex. One hen did while the other left Crex a second time but eventually returned on her own only to leave again (Fig. 73, Appendix).

The long DBC movements made by transplants were risky and energetically costly. Not only was mortality higher for hens during orientation, but individuals lost weight. Three hens that were recaptured 17, 19 and 24 days after leaving Crex weighed 804.2, 814.5 and 800.0 g and lost 15.8%, 16.5% and 14.0% respectively. Weight losses of this magnitude have only been observed in the winter or during incubation. This weight loss may have influenced egg production in at least 2 hens that laid small clutches of 6 and 8 eggs, 24 and 39 days after their release. The normal clutch size for first nests in prairie chickens ranges from 10-16 eggs. Two hens that wandered away from Crex and returned 8 and 9 days after their releases in 1977 nested and laid normal clutches.

The influence of a hen's physiological state on movements

was tested in 1977 by transplanting 3 hens that were copulated just before they were captured. This did not stop them from leaving Crex, but 2 of 3 returned to Crex to nest and hatch broods. The orientation periods and movements of these hens were less than those of 3 others that completed orientation (15.3±11.8 days and 4351±3211 m versus 20.3±11.0 days, 5907±5078 m). One of the 3 non-copulated hens also returned to Crex but did not nest.

The sample sizes were small, but it does imply that movements and the eventual establishment of transplanted prairie chickens are strongly influenced by the physiological condition of the individual. Overall, 6 of 7 (85.7%) radio-tagged cocks released in April established at Crex and 4 of 17 (23.5%) radio-tagged hens established with 3 nesting and fledging chicks.

The relationship of the breeding and physiological state to movements of transplants can also be seen in 2 cocks transplanted on 15 June in 1977. These 2 cocks were still visiting the booming ground in Minnesota, although most others had abandoned. Both birds had started the wing molt. When released at Crex, both birds circled the open area at Crex for 8-11 days and then established within 0.8 km of the release site. Movements (855±933 m) were intermediate between those of cocks transplanted in April and resident cocks (2266±2515 m versus 551±482 m). It was believed that breeding behavior was waning making them less

likely to attempt to return home.

Three cocks transplanted in August during the molt exhibited 2-5 day orientation periods with movements 2-3 times greater than residents during the summer (Table 56). The 3 cocks that survived orientation established new home ranges within 4 km of their respective release sites. The 3 hens that left Crex during April that were nightlighted and re-released in August showed no orientation period and their movements were similar to those of residents during the summer (Table 49 and 56). Figure 38 shows daily distances from the release site for radio-tagged cocks and hens transplanted in mid-June and August.

The presence of resident birds did not appear to reduce wandering in hens transplanted during April. The survivors from the 1976 release and their young were present when hens were released in April 1977. The radio-tagged hens released in the presence of the residents still wandered away from Crex.

Of all the prairie chickens transplanted to Crex, those transplanted in the summer while molting moved most like wild resident birds (Figs. 38 and 39). Thus summer appeared to be the best season to transplant prairie chickens to a new area based on survival and movement patterns. During the summer molt, when food and cover were abundant transplanted birds were behaviorally and physically more sedentary and more likely to accept a new

Table 56. Mean distance moved (m) by transplanted radio-tagged prairie chickens released during late spring and summer Crex Meadows Wildlife Area, Wisconsin, 1976 and 1977. Number of moves are in parentheses.

	Cocks Late Spring n=2	Cocks August n=3	Hens August n=3
Adjustment (Days)	1.5	0	0
DBC Adjustment	176±166 (4)	-	-
Orientation Period			
Within-Day Movements	1218±1814 (3)	1555± - (1)	-
Day to Night Movements	570± 622(39)	674±648 (12)	-
Total	700± 725(15)	741±640 (13)	-
Night to Day Movements	544± 881(12)	363± 259 (10)	-
DBC	855± 933(18)	907± 777 (20)	233±140(44)
Length (Days)	8.5±4.2	2.0±1.7	0

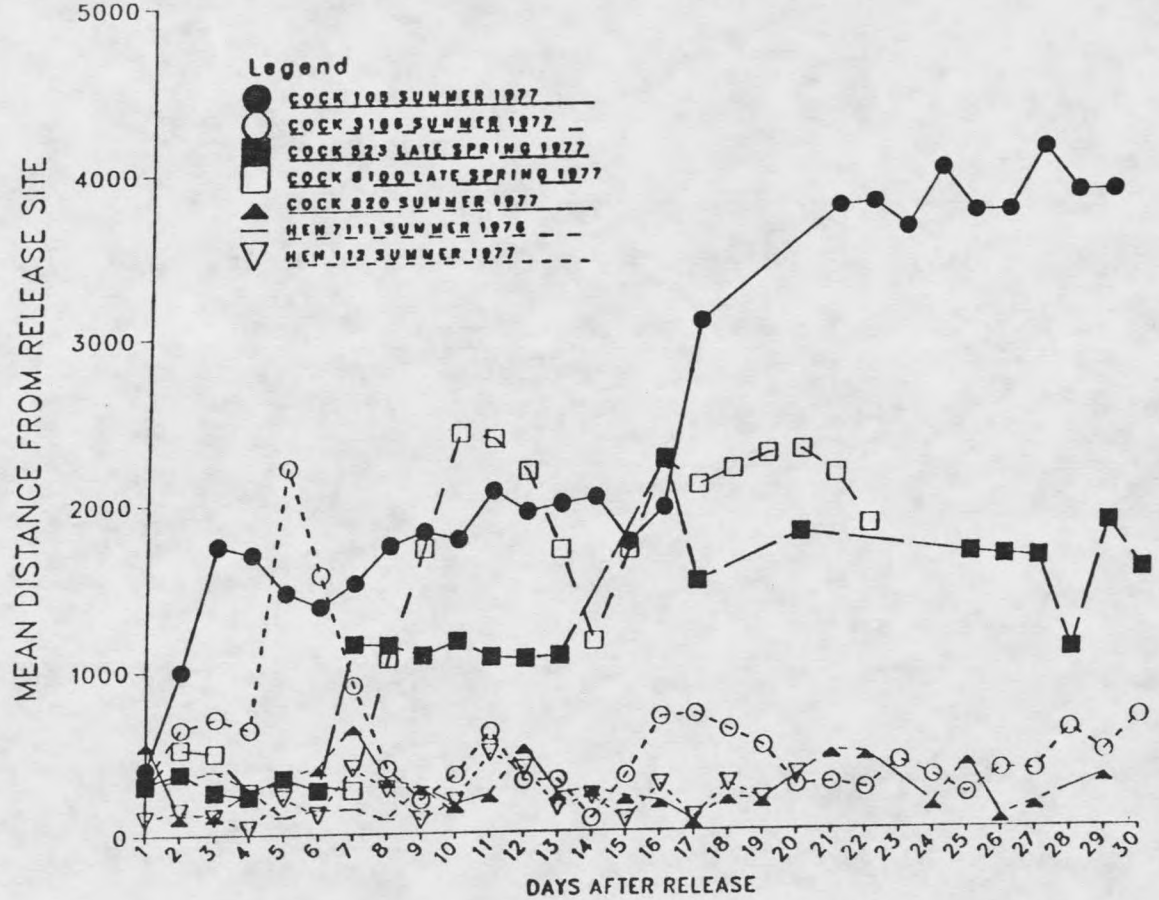


Figure 38. Mean distance (m) from release site relative to the number of days after release for radio-tagged prairie chicken cocks and hens transplanted to the Crex Meadows Wildlife Area, Wisconsin June 1977 and August 1976 and 1977.

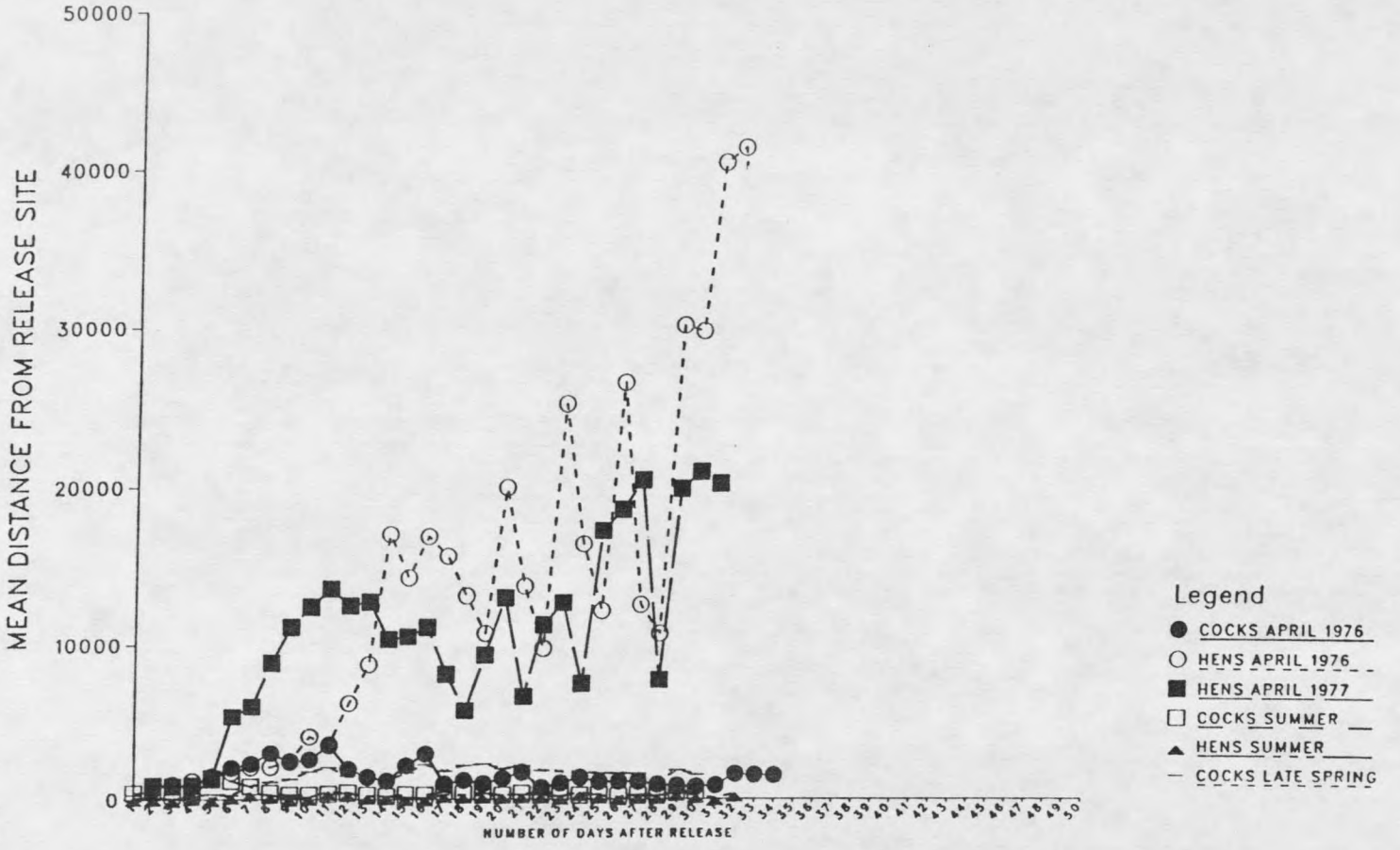


Figure 39. Mean distance (m) from release site relative to the number of days after release for radio-tagged prairie chickens transplanted different times of the year, Crex Meadows Wildlife Area, Wisconsin, 1976-78.

area. This is in contrast to winter when conditions are difficult even for resident birds. Transplanting birds during the winter because they are easy to catch will only compound the high natural mortality that resident prairie chickens experience at this time. Prairie chickens transplanted during the summer are not burdened by the stresses of the reproductive season. It is also possible that during the summer molt prairie chickens are not capable of the long sustained flights made at other times of the year. Ruffed grouse have been successfully reestablished by transplanting birds in the summer (Lewis et al. 1962, Ammann and Palmer 1962, Back 1984 and Woolf et al. 1984) and so have ptarmigan (Braun et al. 1979).

Daily Movements Pen-reared Birds

Nine radio-tagged pen-reared prairie chickens yielded 495 DD, 145 DN and 350 WD movements. The mean DD movements made by these birds released in April 1975 (196±265 m, n=242) and 1976 (220±265 m, n=258) were 15-25% less than those of wild resident prairie chickens during the spring. In both years, mean DD movements of the pen-reared cocks were less than those of hens (Table 57). The smaller mean DD movements of cocks were due to their association with their display areas near and in the release pen.

The mean DD movements of the pen-reared birds released in October 1974, were a third those of birds released in April (41±49 m, n=183 versus 148±174 m, n=280, P=0.001)

Table 57. Mean distance moved (m) by type of movement for radio-tagged pen-reared prairie chickens by sex by release, Crex Meadows, Wildlfe Area Wisconsin, 1974-76. Number of moves are in parentheses.

Release	Type of Movement			
	Day to Night	Within-Day	Total	Successive Nights
Cocks Oct. 1974	37± 48(49)	43± 29 (29)	41± 49(183)	95± 72 (66)
Cocks April 1975	100±172(50)	216±199(123)	182±198(178)	
Cocks April 1976	58±141(42)	138±139 (65)	107±145(107)	
Cocks Total April	77±151(92)	174±161(188)	148±174(280)	192±303 (92)
Hens April 1975	244±518(15)	264±261 (49)	258±339 (64)	
Hens April 1976	295±230(38)	309±300(113)	285±259(151)	
Hens Total	278±290(53)	288±285(162)	281±301(215)	119±149 (33)

and 92% less than DD movements of immature wild birds during fall (Table 49). Movements of pen-reared birds were less in fall than spring because the release was not gentle and released cocks spent a great deal of time at the pen walking the fence in an effort to rejoin the birds being held for the spring release.

Mean DD movements of pen-reared prairie chickens were most like DD movements of wild birds during the summer (Table 49). Mean WD movements of pen-reared birds were greater than their DN movements. This was the opposite of movements patterns observed in wild birds during the summer when DN movements were greater than WD movements. The small movements and reversed pattern of greater WD than DN movements seen in pen-reared birds were the result of their walking to and from night roosts.

The released pen-reared birds were observed flying without being flushed on only 2 occasions. Walking rather than flying was a behavioral habit acquired as a result of living in a pen. The shorter movements and greater WD than DN movements of pen-reared birds were comparable to the movements made by wild prairie chicken hens with broods which also walked to and from their night roosts.

Mean NN movements of pen-reared prairie chickens released in April were half those seen in wild birds during the spring. Mean NN movements of pen-reared birds were greater in the fall than in spring, but still less than

those of wild birds (Tables 49 and 50). The NN movements, like other movements of pen-reared birds, were comparable to those made by adults and hens with broods during summer.

The release pen was also the nearest booming ground for the pen-reared prairie chickens. All non-booming ground radio locations (n=666) and observations (N=737) of birds released from the pen in April 1975 and 1976 were within 1.8 km of the pen, 89.7% within 1000 m. The association with the pen was stronger in cocks (Mean 170±306 m, n=325, 90.4% within 1000 m) than hens (Mean 257±346 m, N=412, 77.2% within 1000 m), because they displayed and fed at the pen, whereas hens only fed there. Pen-reared birds released in October remained closest to the pen (42±165 m), all within 1200 m and 74.7% within 400m.

The locations of radio-tagged pen-reared hens that survived for at least 10 days were randomly distributed around the booming ground/pen (1975 CSq=2.25, df=3, n=49, 1976 CSq=2.16, df=3, n=149, Total CSq=3.29, df=3, N=198, $P<0.10$). There were only 5 radio-tagged pen-reared hens that established nests in 1976, and the locations of each hen were oriented relative to the booming ground/pen (CSq, df=3, $P>0.040$, n=117). Individual ranges of pen-reared hens showed considerable overlap, but the overlap occurred at the release pen where hens came to feed. The random distribution of nesting pen-reared hens and the orientation of individuals suggested that the mechanisms that disperse

wild hens may have been operating similarly to space the pen-reared hens around the booming ground/pen.

The presence of the pen appeared to localize movements of pen-reared birds near the pen as both cocks and hens regularly visited the pen to feed. However, the pen may not have been the only factor limiting movements of pen-reared birds since DD movements of radio-tagged birds released 1.6 km from the pen in 1976 were comparable to those released at the pen (231±223 m, n=65 versus 214±247 m, N=495). Two radio-tagged birds and 1 banded cock released away from the pen returned to the release pen within a week.

This tendency for released pen-reared birds to remain near the release site has been reported by others. Hessler et al. (1970) reported that most radioed pen-reared pheasants remained within 400 m of the releases site. Roseberry et al. (1987) and Krauss et al (1987) also found that pen-reared quail and pen-reared pheasants respectively remained closer to their release sites than transplanted birds. Burger (1964) and Hessler (1970) felt that this limited movement was due to the pen-reared birds susceptibility to predators. The lack of movement observed in the radio-tagged pen-reared prairie chickens in this study was not due to mortality, but to a combination of factors that included physical condition, the association with the pen and behavior learned while inside the pen.

Habitat Use

Quality prairie chicken habitat must provide cover for year-round feeding, loafing and day roosting, display, night roosting, nesting, brood rearing and escape cover. Four major habitat components: type, height (form), disturbance and space (open treeless area) appeared to determine the quality of prairie chicken habitat. All 4 are closely related to each other and associated with structure and form.

Height or form created by vegetation appeared to be the most important habitat feature of the cover which prairie chickens used for various activities. The concept of birds responding to the structure of vegetation rather than species is not new and has been examined by previous researchers (Pitelka 1941, Elton and Miller 1954, Emlin 1956, and Schemnitz 1961). This life form concept has been related to prairie chickens by Hamerstrom et al. (1957) and Jones (1959 and 1963). However, from a management perspective, disturbance relative to land ownership and land-use practices were the key factors as they determined height of vegetation and influenced the amount and distribution of cover used by prairie chickens.

A total of 10,110 radio locations were used to analyze habitat use of radio-tagged prairie chickens: 6,662 for wild residents in central Wisconsin (4,224 day and 2,438

night) and 3,448 locations for the established transplants at Crex (2,382 day and 1,066 night). A total of 645 locations were used for habitat analysis for radioed pen-reared prairie chickens (426 day and 219 night) and 518 for transplanted prairie chickens during orientation periods (337 day and 181 night).

Not all radio locations were used because information was not complete for all variables for all locations. Locations of birds on booming grounds and nests were also excluded from habitat analysis. Data were stratified by day and night and into weekly and selected periods for comparisons. Habitat use between pen-reared and transplants were compared during the common period 1 April to 30 May. Data from different years were combined for residents in central Wisconsin (1972-76), established residents at Crex (1976-78), transplants during orientation (1976 and 1977) and pen-reared released in April (1975 and 1976). Habitat analysis was not conducted on late spring or summer transplants, because of their short orientation periods.

In addition to the locations of radio-tagged birds, 16,620 and 5,239 habitat observations of prairie chickens were collected in central Wisconsin and at Crex respectively. These data were excluded from habitat analysis as they favored more open habitat and lower height classes and reflected this bias.

Habitat use varied between radio-tagged individuals, particularly in their use of agricultural fields. Areas used by individuals were influenced by available habitat types within the normal cruising radius of a particular radio-tagged bird. The method of comparing habitat use by radio-tagged animals with the amount available in a selected area (preference versus avoidance)(Robel et al. 1970, Neu et al. 1974) has not been incorporated into this study. The day to day and yearly movements of radio-tagged prairie chickens indicated that the habitats used by individuals were related more to what was available within a familiar area than the amount in the entire study area or home range. In this sense, individuals moved to meet their daily or seasonal need and did not actively seek better conditions. At no time did adult radio-tagged prairie chickens move through the study area in a manner that would suggest they were selecting the "best" available habitat. Conversely, immatures at times did move over large areas in a manner that could be perceived as evaluating habitat. However, these movements appeared to be efforts at becoming part of an established population. The presence of other individuals in the population ultimately determined where individuals, particularly immatures, could go and what habitats they can "select".

In this study, habitat availability has been assumed to mean present within the cruising radius of the

individual. Examination of cover types in central Wisconsin and Crex showed that all the major habitat, disturbance types and height classes were located within 1.2 km radius of every radio-tagged bird. In this study efforts have been made to describe seasonal habitat requirements on a year-long basis. Relative density of prairie chickens over time would seem to be a better measure of habitat quality than movements of a few individuals because it reflects the habitats ability to sustain a population at a given level.

The dominant species associated with various habitats was based on ocular estimates from cover type maps. The frequency of different plant species varied between the seasons and between the two areas. The variation in plant species identified in seasonal cover reflected their structural form and their ability to provide cover at different times of the year, particularly the ability to withstand the weight of snow. Appendix Tables 76 and 77 show frequency of plant species associated with day and night locations of radio-tagged prairie chickens in central Wisconsin (1972-1976) and Crex Meadows (1976-1978) for winter/spring and summer/fall respectively.

Annual Habitat. An annual habitat use index was calculated separately for the two areas by weighting the seasonal and day and night locations to equalize differences in the number of locations between seasons and day and night. Annual habitat used by radioed prairie

chickens in central Wisconsin was dominated by grass and grass-forbs types (61.1%) followed by agriculture (17.6%) and wetland/shrub (9.6%) (Fig. 40). The grass-forbs habitat was dominated by grass.

The main habitat types used by radio-tagged prairie chickens which established at Crex were grass (upland, and wetland grass/sedge), grass-shrub and the edge between agriculture and grass-shrub (69.6%) and agriculture (23.9%). The grass-shrub habitat, like the grass-forb habitat was also dominated by grass. The annual ratio of grassland habitat to agriculture used by radioed prairie chickens was similar between central Wisconsin and Crex (68:18 versus 70:18).

Grassland habitat has been reported as the factor limiting prairie chickens in most of their original and acquired range (Yeatter 1943, 1963, Schwartz 1945, Ammann 1957, Hamerstrom et al. 1957, Hamerstrom and Hamerstrom 1973, Kirsch 1974, Cannon and Christisen 1984, Horak 1985 and Westemeier and Edwards 1987). The necessary percentage in grassland habitat reported by other investigators fell within the range reported here: Leopold (1933) 50%, Yeatter (1943) 20-30%, Schwartz (1945) 39%, Baker (1953) 33% minimal, 66% optimal, Ammann (1957) 17-33% and Hamerstrom et al. (1957) 33-73% grass with 7-30% suitable for nesting and brood rearing. Hamerstrom et al. (1957) stated "total grassland appears to be a rough index to habitat quality in

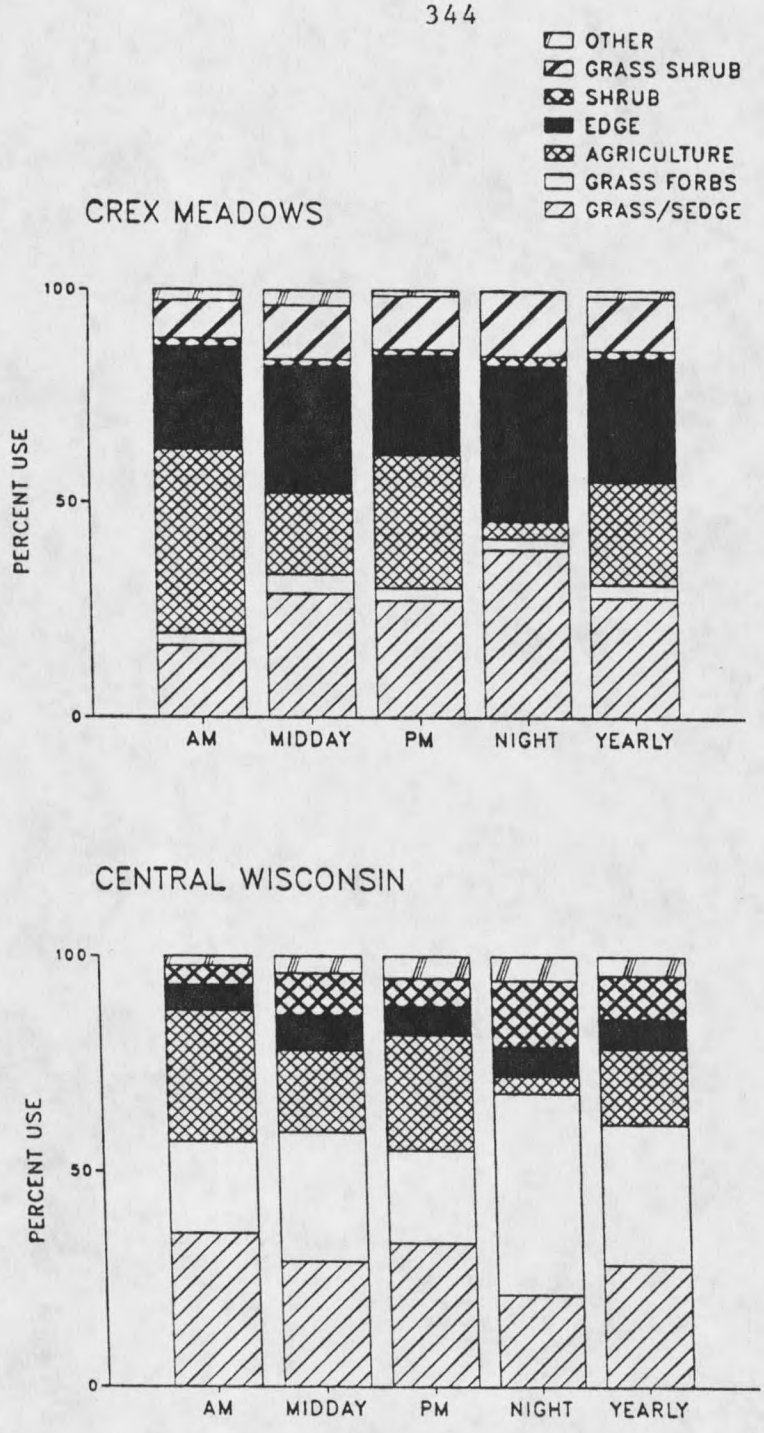


Figure 40. Annual weighted habitat use for radio-tagged prairie chickens by time of day, in central Wisconsin 1972-76 and Crex Meadows Wildlife Area Wisconsin, 1976-78.

that densest populations are shown to be those which are 55-60% grassland".

Habitat used by radioed prairie chickens varied between day and night. Jones (1963) and Hamerstrom et al. (1957) indicated that grasslands were used for night roosting cover in all seasons except when flattened by snow. In central Wisconsin and at Crex those cover types that provided the most secure ground cover increased in use from day to night. Less secure cover which was used during the day for feeding, was used less at night (agriculture 25.5-4.0% and grass 32.6-21.4%). At Crex, radio-tagged birds also shifted to the more secure cover types from day to night (edge between wetland and grass-shrub 26-36.6%, wetland grass 17.2-34.2 and grass-shrub 11.5%-15.3%). Use of the agricultural types for feeding declined from day to night (Fig. 40).

A shift in habitat use was noted between AM, midday and PM periods. This pattern was not as obvious as the shift from day to night and was related to the daily pattern of using shorter disturbed habitat during the AM and PM for feeding and taller less disturbed cover for day roosting. Hamerstrom et al. (1957) found that undisturbed grassland and edges of agricultural fields were used for loafing and day roosting. Jones (1963) stated that prairie chickens in Oklahoma loafed along the edges of the tall grass and midgrass associations. There appeared to be a general

pattern of prairie chickens using taller more secure cover for day and night roosting, nesting and brood rearing and shorter less secure cover for feeding.

Prairie chickens used shrubs for cover in central Wisconsin and Crex only 9.6% and 0.8% respectively. The use of shrubs increased from day to night in central Wisconsin as the complex of lowland shrub and wetland grass became seasonally important for night roosting during winter. Shrubs were readily available at Crex, but their use as cover by prairie chickens was low even at night (2.3%) and suggested that wetland grass sedge cover was preferred over brush.

Trees were used only 1.4% of the time in both areas although readily available in the form of woodlots. Trees were used some for budding, but primarily as perches before entering or after leaving a feeding area. Of 1,214 observations of prairie chickens using trees, 2% were under them, 67.8% were in lone trees and the rest were in woodlots.

Seasonal Habitat Use

Habitat requirements of prairie chickens cannot be expressed easily on a yearly basis. The yearly habitat composite provided a general overview, but distorted the between and within season changes and differences in the habitat needs of prairie chickens. It appeared that prairie chickens use habitat based on their daily needs, environmental conditions at the time and the proximity of

various cover types within an individuals familiar area.

Habitat-- Winter. Winter was the most difficult season for prairie chickens because snow reduced the amount and availability of food and cover. Each new snowfall changed conditions and altered the distribution of food and cover which caused prairie chickens to increase their movements and energy demands. Habitat types which provided cover and food above the snow were utilized most by birds in both areas.

In central Wisconsin, 81% of the radio locations during the winter were associated with 3 cover types, agriculture, shrub/wetland and grass-forbs (Table 58). The shrub/wetland habitat was a lowland type with a mixture of willows (1-2.5 m) and lowland grasses, sedges and forbs. Examination of this habitat showed that individual prairie chickens used only the grass/sedge and forbs for cover. The snowfence effect of the willows caused an accumulation of snow on the lee side that was used for snow burrowing. This accumulation of snow also kept some of the leeward vegetation from being covered by snow. Willows over 3.0 m lacked the understory of grass-forb, but the edges of these taller willow patches were used for day loafing. The shrub/wetland complex was important only in the winter, and was used little during other times of the year (2-3%). The grass-forbs habitat consisted of a mosaic of grass and goldenrod which provided most of the cover above the snow.

Table 58. Habitat type use by day and night (%) for radio-tagged prairie chickens during winter, in central Wisconsin 1972-1976 and Crex Meadows Wildlife Area, 1976-1978. Number of locations are in parentheses.

Habitat Type	Central Wisconsin						Crex Meadows					
	Daylight		Night		Total		Total		Daylight		Night	
Agriculture	52.3	(268)	5.2	(16)	34.7	(284)	24.8	(149)	34.3	(146)	1.7	(3)
Edge	6.6	(34)	3.6	(11)	5.5	(45)	20.8	(125)	17.4	(74)	29.1	(51)
Upland Grass	3.1	(16)	4.2	(13)	3.5	(29)	1.7	(10)	2.1	(9)	0.6	(1)
Grass Forbs	10.5	(54)	27.0	(83)	16.7	(137)	-		-		-	
Grass Shrub	0.2	(1)	1.0	(3)	0.5	(4)	10.3	(62)	10.6	(45)	9.7	(17)
Shrub[a]	17.8	(91)	51.8	(159)	80.5	(250)	1.3	(8)	1.2	(5)	1.7	(3)
Wetland	-		-		-		36.4	(219)	27.9	(119)	57.1	(100)
Trees	6.4	(33)	1.0	(3)	4.4	(36)	4.5	(27)	6.3	(27)	-	
Forbs	2.5	(13)	5.9	(18)	3.8	(31)	0.2	(1)	0.2	(1)	-	
Other	0.4	(2)	0.3	(1)	0.4	(3)	-		-		-	
Total	62.5	(512)	37.5	(307)	100.0	(819)	100.0	(601)	70.9	(426)	29.1	(175)

[a] Wetland shrub complex, mixture of shrubs usually willow with sedges and forbs.

Habitat types used by radio-tagged prairie chickens during the winter varied between day and night, based on their ability to provide food above the snow and protection and security at night. Agriculture, especially corn (46.2%) and buckwheat (7.3%) were used during the day, primarily for feeding. Standing corn was used most (25.4%), although corn piles (16.9%) were used regularly in the absence of another source.

Agricultural crops appear to be necessary for prairie chickens to survive winter in the northern part of their range (Schmidt 1936, Hamerstrom et al. 1941, Yeatter 1943, Hamerstrom and Hamerstrom 1949, Ammann 1957). Wetland/shrub (17.8%) and grass-forbs (10.5%) habitats were also used by prairie chickens during the winter for loafing and day roosting. The main non-agricultural species used during the day were Carex spp. (9.0%) Solidago spp. (8.0%), Salix spp. (7.2%), Agropyron sp. (7.0%) and Poa spp. (5.0%)(Table 76, Appendix). All except Poa provided cover above the snow. Standing corn and forb areas were also used for day roosting.

At night 78.8% of the roosting by radio-tagged prairie chickens occurred in the shrub/wetland (51.8%) and the grass-forbs (27.0%) habitats. The use of these two habitat types for night roosting were nearly double their use during the day (Table 58). The main species used at night were Salix spp. (20.3%), Solidago spp. (18.5%), Carex spp.

(12.6%), Agropyron sp. (8.8%) and Spirea spp. (8.3%)(Table 76, Appendix). Agriculture, usually standing corn was occasionally used for night roosting (8.1%).

Some habitat types used at other times of the year were not used during winter because of snow cover. Upland grass was used during periods without snow, but used very little during winter (3.5%). Most species which made up the grass cover (quackgrass, bluegrass and timothy) became matted in the winter and provided little cover for the birds above the snow.

Prairie chickens used trees most during the winter in central Wisconsin, but their use was low (4.4%). Trees used were aspen, pine, oak and elm (Table 76, Appendix).

The habitat use patterns of prairie chickens at Crex during winter were similar to those observed in central Wisconsin. Agriculture and the agricultural edge and wetland grass/sedge habitat types received 82% of the use during winter (Table 58). This high use and a lack of shrub use supported the contention that sedges and not the shrubs, were the preferred component of the shrub/wetland type in central Wisconsin. Shrubs (hazel, oak, sweetfern and willow) were readily available at Crex, but made up only 1.3% of the use. Grass-shrub constituted only 10.3% of the habitat used during winter. Hamerstrom et al. (1957) observed that prairie chickens night roosted in grasses and sedges as late into the winter as possible, suggesting a

preference for grassland over woody cover.

The role of shrub habitat in the overall ecology of the prairie chickens is not clear as other forms of vegetation associated with the shrubs appeared to be used by the birds for cover. The only true shrub habitat used by the prairie chickens was Spirea in central Wisconsin which made up only 0.8% of day use and 8.3% of night use. However, shrub habitat may play an important role in providing cover when snow becomes crusted or unusually deep reducing the amount of wetland vegetation and grass-forbs. Grange (1948), Ammann (1957) and Hamerstrom et al. (1957) reported use of brush patches and the edges of woods for winter night roosting when grasses and sedges were buried by snow.

At Crex during the winter, agriculture and its edge received the most day use (51.7%), primarily for feeding. Corn was the main species followed by buckwheat with corn platforms being used at a higher rate than standing corn (Table 76, Appendix). The wetland areas and the grass-shrubs were used for loafing and day roosting. The sedges (24.6%) and wetland grasses (8.0%) were the nonagricultural species used during the day.

At night, the use of agriculture declined dramatically as prairie chickens at Crex shifted to taller more secure wetland and grass-shrub/wetland edge habitats for night roosting. The grass-shrub habitat type at Crex was

structurally similar in form to the grass-forb habitat (golden rod, bluegrass) in central Wisconsin. Night locations at Crex during the winter were dominated by Carex spp. and reed grass (Table 76, Appendix).

Upland grass habitats at Crex, like those in central Wisconsin, were rarely used during winter since they provided little cover for a prairie chicken when snow was present. Trees received little use during the winter at Crex (4.5%) and were used for perching before moving to a feeding area or day roost area.

Habitat-- Spring. Upland grass and grass-forbs habitat types made up 79.4% of the habitat used by radio-tagged prairie chickens in the spring in central Wisconsin (Table 59). Agriculture made up only 18% of spring habitat use as birds shifted from winter areas to the grassland habitat surrounding the booming grounds. Use of upland grass was greatest during the day and higher than grass-forbs. However, the grass forb type which provided taller and better screening cover was used more at night for roosting (Table 59). Both grass and grass-forbs were used during the day for feeding, with bluegrass, quackgrass, Solidago spp. and timothy being the dominant components. Corn and buckwheat were the main agricultural species used during the day. At night the use of the taller species increased; quackgrass and Solidago spp. approximately doubled (36.8%) while bluegrass declined (Table 76, Appendix).

Table 59. Habitat type use by day and night (%) for radio-tagged prairie chickens during spring, in central Wisconsin 1972-76 and Crex Meadows Wildlife Area, 1976-1978. Number of locations are in parentheses.

Habitat Type	Central Wisconsin			Crex Meadows		
	Daylight	Night	Total	Total	Daylight	Night
Agriculture	10.2 (109)	1.6 (9)	7.2 (118)	29.2 (269)	36.6 (242)	10.4 (27)
Edge	7.8 (83)	5.9 (33)	7.1 (116)	26.5 (244)	23.8 (157)	33.6 (87)
Upland Grass	45.7 (488)	29.8 (167)	40.2 (655)	10.1 (93)	10.9 (72)	8.1 (21)
Grass Forbs	30.7 (328)	55.3 (310)	39.2 (638)	5.2 (48)	4.8 (32)	6.2 (16)
Grass Shrub	0.9 (10)	0.5 (3)	0.8 (13)	14.6 (134)	12.9 (85)	18.9 (49)
Shrub	2.4 (26)	3.2 (18)	2.7 (44)	2.9 (27)	2.6 (17)	3.9 (10)
Wetland	0.2 (2)	-	0.1 (2)	10.3 (95)	7.0 (46)	18.9 (49)
Trees	0.5 (5)	-	0.3 (5)	0.4 (4)	0.6 (4)	-
Forbs	1.4 (15)	3.2 (18)	2.0 (33)	-	-	-
Other	0.2 (2)	0.5 (3)	0.3 (5)	0.6 (6)	1.0 (6)	-
Total	65.6(1068)	34.4 (561)	100.0(1629)	100.0 (920)	71.8 (661)	28.2 (259)

Agriculture, when nearby was used during the spring by both cocks and hens. Hens typically fed in agriculture during early spring until they shifted to their nesting areas. Only those hens with agriculture within 400-800 m of their nesting areas during egg-laying used it on a daily basis during the spring. Cocks flew 800-1600 m to feed in agricultural fields in early spring but as spring progressed they began feeding near the booming ground. These shifts from agriculture were associated with the greening of vegetation. Drobney and Sparrowe (1977) in Missouri observed prairie chickens feeding in grassland from February-May in short vegetation where new growth was available. However, the presence of agriculture nearby may aid in maintaining the condition of cocks during the display period and hens during egg-laying.

At Crex, agriculture and the agricultural edge made up 60.4% of the habitat used by radio-tagged prairie chickens, 4 times greater than in central Wisconsin (Table 59). This high use of agriculture at Crex was due to its close proximity to the booming ground and the areas used by hens for nesting. Agricultural fields were used for feeding in the morning and evening. The agricultural edge and grass-shrub areas were used for day roosting during midday. A wide variety of species were used at Crex during the day: rye (16.8%), corn (13.9), sedges (11.7%), buckwheat (9.0%),

big bluestem (9.8%), sweetfern (6.8%) and reed grass (5.5%)(Table 76, Appendix).

At night use of agriculture declined and the use of taller cover increased, primarily edge, grass-shrub and wetland (Table 59). Carex spp., reed grass, Scirpus sp. (7.1%) and sweetfern were the main species used at night at Crex. Big bluestem and hazel brush were the other important species associated with night locations (Table 76, Appendix).

Habitat-- Summer. Habitat use patterns of individuals were most variable during the summer. Grass and grass-forbs were the main habitats used by the radio-tagged prairie chickens in central Wisconsin during the summer (Table 60). Agriculture was used by some individuals all summer, but it made up a small part of the habitat used by all radio-tagged prairie chickens. Upland grass and grass-forbs (bluegrass, quackgrass and Solidago spp.) dominated day use (Table 77, Appendix). Timothy, butter and eggs and clover were the only other species that exceeded 2%.

At night, use of grass-forbs increased slightly and use of upland grass declined. The shift to taller cover at night during the summer indicated that security, as well as protection from the elements was an important aspect of night roosting habitat. The use of taller species was shown by the approximate doubling the use of quackgrass and

Table 60. Habitat type use by day and night (%) for radio-tagged prairie chickens during summer, in central Wisconsin 1972-76 and Crex Meadows Wildlife Area, 1976-78. Number of locations are in parentheses.

Habitat Type	Central Wisconsin			Crex Meadows		
	Daylight	Night	Total	Total	Daylight	Night
Agriculture	4.0 (70)	3.5 (31)	3.8 (101)	18.5 (200)	24.9 (185)	4.5 (15)
Edge	8.3 (146)	10.5 (92)	9.1 (238)	36.0 (389)	33.9 (252)	40.7 (137)
Upland Grass	51.3 (899)	39.2 (344)	47.3(1243)	8.6 (93)	9.4 (70)	6.8 (23)
Grass Forbs	32.2 (563)	41.4 (363)	35.2 (926)	5.0 (54)	5.9 (44)	3.0 (10)
Grass Shrub	0.5 (9)	0.1 (1)	0.4 (10)	14.5 (157)	10.8 (80)	22.8 (77)
Shrub	2.9 (50)	0.8 (7)	2.2 (57)	0.6 (6)	0.4 (3)	0.9 (3)
Wetland	0.1 (2)	0.2 (2)	0.2 (4)	16.4 (177)	14.3 (106)	21.1 (71)
Trees	0.2 (3)	-	0.1 (3)	-	-	-
Forbs	0.5 (9)	4.2 (37)	1.8 (46)	0.1 (1)	0.1 (1)	-
Other	-	-	-	0.3 (3)	0.3 (2)	0.3 (1)
Total	66.6(1751)	33.4 (877)	100.0(2628)	100.0(1080)	68.8 (743)	31.2 (337)

increased in Solidago spp. and Spirea and a halving of the use of bluegrass (Table 77, Appendix).

The highest use of upland grass for night roosting occurred in the summer. This increased use was due to regrowth which improved cover. When bluegrass was associated with goldenrod, it created a mixture of tall secure cover and short cover which permitted ease of movement. Goldenrod was common, but where it was dominant it formed cover too dense for prairie chickens to use.

Some individuals used agriculture during summer, but only when it was in close proximity to undisturbed cover. Most agriculture in central Wisconsin was on private land and much of the grass around it was heavily grazed or mowed.

Baker (1953), Lehmann (1941) and Robel et al. (1970) have reported the use of brush by prairie chickens for shade during the midday heat. Yeatter (1943) reported that prairie chickens in Illinois loafed in the shade of tall grass or forbs during the midday. In this study birds in both areas made no movements to shrubs or trees for shade during hot weather. Instead of woody cover the radio-tagged prairie chickens in both areas used taller clumps of grass and grass-forbs for shade. Radio-tagged prairie chickens made no movement to water although free water was readily available to all birds in nearby drainage ditches in both areas.

The general pattern of summer habitat use for 20 of 30 radio-tagged cocks and and non-brooding hens in central Wisconsin was to feed in the morning and evening in heavily grazed fields, day roost in grass or grass-forb patches and fly or walk to nearby undisturbed grass or grass-forb habitat for night roosting. Robel et al. (1970) also found a high percentage of day locations in heavily grazed fields during the summer.

Three radio-tagged birds fed in agriculture (alfalfa, old corn field, mowed oats with clover) and night roosted in adjacent undisturbed grass and grass-forb habitat all summer. Four other radio-tagged birds used undisturbed grasslands during the summer. Based on observations and sign, these 4 birds fed in the short bluegrass patches between the taller goldenrod patches, night roosted in nearby grass or grass-forb cover and walked to and from their feeding and night roosting areas. Prairie chickens were attracted to strawberries as most of the radioed birds that used the undisturbed grasslands localized their movements during early summer in areas with ripe berries.

The agricultural edge, upland grass and agriculture made up 79.5% of the habitat used by the radio-tagged prairie chickens at Crex (Table 60). All agricultural species at Crex were used during the day with rye, corn and buckwheat used the most (Table 77, Appendix). The main non-agricultural species used during the day were reed

grass Carex spp., big bluestem, hazel and sweetfern. Agriculture and edge made up 58.8% of the use during the day and were used for feeding and day roosting (Table 60).

At night, use of agriculture declined to 4.5% and the edge, grass-shrub, or wetland and grass-shrub and wetland made up 84.6% of habitat used for night roosting at Crex. The agricultural edge consisted primarily of undisturbed grass, wetland and grass-shrub. At times individuals used the undisturbed borders around potholes in the agricultural fields for day and night roosting. The use of undisturbed grassland and edges of agricultural fields for loafing and day roosting was noted by Hamerstrom et al. (1957) and Jones (1963).

The general summer pattern for 8 of 12 radioed prairie chickens at Crex was to feed in agriculture, primarily rye, and day roost in the undisturbed borders or small pothole edges within the agricultural fields. At night the birds left the agricultural fields and walked or flew to undisturbed grass and grass-shrub habitat adjacent to the fields. The other 3 birds spent the summer in grass-shrub habitat, feeding in open areas and roosting in the shrub or wetland cover in a manner similar to the way birds used grass-forbs habitat in central Wisconsin. The wetland species, Carex spp., Calamagrostis spp. and Scirpus sp. were used the most at night at Crex (Table 77, Appendix).

The grass-shrub habitat at Crex was structurally

comparable to the grass-forbs habitat type in central Wisconsin. The grass-shrub type at Crex consisted of taller hazel brush and sweetfern mixed with shorter open patches of big and little bluestem. Both types were a mixture of tall and short cover.

Habitat-- Fall. In central Wisconsin the use of agriculture increased from the annual summer low of 3.8 to a high of 24.3% in the fall (Table 60 and 61). The use of agriculture in fall (39.1%) ranked second only to its use in winter (52.3%). The main agricultural species used were corn, mowed oats and buckwheat. Bluegrass and quackgrass were the most used grass species during the day and Solidago spp. the main forb. (Table 77, Appendix). Mohler (1952) noted that feeding in agriculture began within a few days of the first general frost. Use of agriculture and upland grass decreased from day to night while grass-forbs, which provided more cover security and protection from the cold increased.

Frost and changing temperatures during fall caused the quality of upland grass to deteriorate as night cover. Changing weather conditions also caused cover to open up and allow access to some cover that was too dense to use in summer. Thus, use of quackgrass and Solidago spp. increased from day to night and the short form bluegrass declined. Spirea spp. and Salix spp. were the other species that showed increased use from day to night (Table 77,

Appendix). Hamerstrom et al. (1957) also found that bluegrass afforded less cover after fall frosts and the stouter grasses and sedges were used more for roosting.

Although most of the prairie chickens at Crex were already using agriculture during summer, use of agriculture increased during the day in fall. Diurnal use of agriculture in the fall (36.2%) was higher than summer, (24.9%) but comparable to use in spring (36.6%) and winter (34.3%)(Table 61). The birds continued to use the edge of agricultural fields for day roosting. Corn, buckwheat and rye were main agricultural species used in the fall. Sedges, wetland grasses and big bluestem dominated the non-agricultural habitat species used during the day (Table 77, Appendix). Prairie chickens moved from agriculture areas they used for feeding to more secure wetland grass and edge between wetland and grass-shrub habitats for night roosting (Table 61). Buckwheat was the only agricultural species used for night roosting during the fall. As in the other seasons at Crex, wetland grasses and sedges were dominant vegetational components associated with night locations.

Habitat-- Weekly. Year-long daylight and night habitat trends are summarized by weekly periods in Figures 41 and 42 respectively for central Wisconsin and 43 and 44 respectively for Crex Meadows. In central Wisconsin, the number of radio locations collected per week during the day

Table 61. Habitat type use by day and night (%) for radio-tagged prairie chickens during fall, in central Wisconsin 1972-76 and Crex Meadows Wildlife Area, 1976-78. Number of locations are in parentheses.

Habitat Type	Central Wisconsin			Crex Meadows		
	Daylight	Night	Total	Total	Daylight	Night
Agriculture	39.1 (349)	5.2 (36)	24.3 (385)	23.7 (201)	36.2 (200)	0.3 (1)
Edge	4.8 (43)	7.2 (50)	5.9 (93)	33.2 (281)	28.6 (158)	41.7 (123)
Upland Grass	27.9 (249)	16.7 (116)	23.0 (365)	4.3 (36)	4.3 (24)	4.1 (12)
Grass Forbs	22.4 (200)	60.5 (419)	39.0 (619)	2.1 (18)	2.4 (13)	1.7 (5)
Grass Shrub	0.3 (3)	0.4 (3)	0.4 (6)	10.2 (86)	10.0 (55)	10.5 (31)
Shrub	3.2 (29)	2.9 (20)	3.1 (49)	2.2 (19)	2.0 (11)	2.7 (8)
Wetland	-	-	-	23.6 (200)	15.4 (85)	39.0 (115)
Trees	1.7 (15)	-	0.9 (15)	0.6 (5)	0.9 (5)	-
Forbs	0.4 (4)	6.8 (47)	3.2 (51)	-	-	-
Other	0.1 (1)	0.3 (2)	0.2 (3)	0.1 (1)	0.2 (1)	-
Total	56.3 (893)	43.7 (693)	100.0(1586)	100.0 (847)	65.2 (552)	34.8 (295)

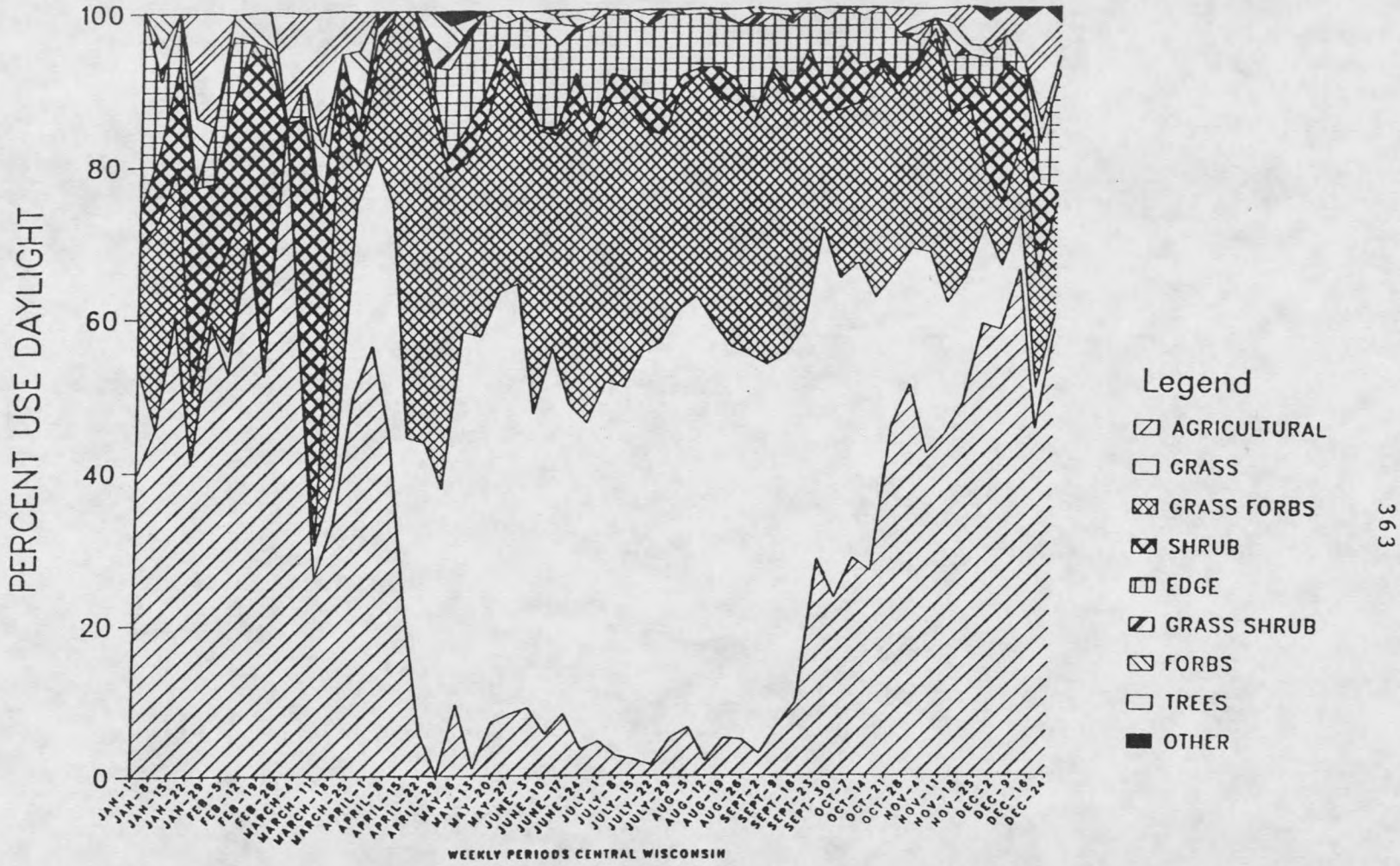


Figure 41. Weekly habitat use during the day by radio-tagged prairie chickens, central Wisconsin, 1972-76.

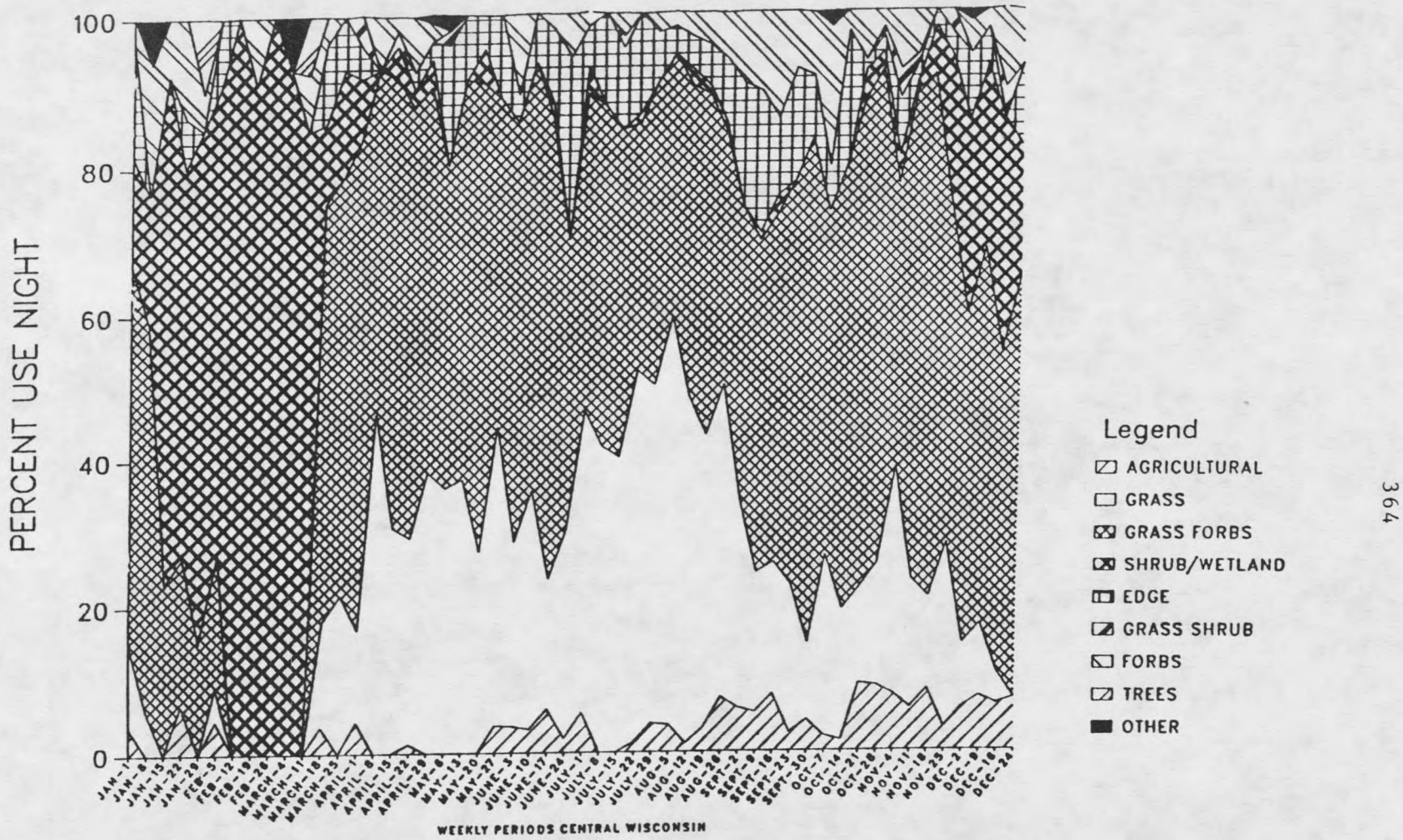


Figure 42. Weekly habitat use at night by radio-tagged prairie chickens, central Wisconsin, 1972-76.

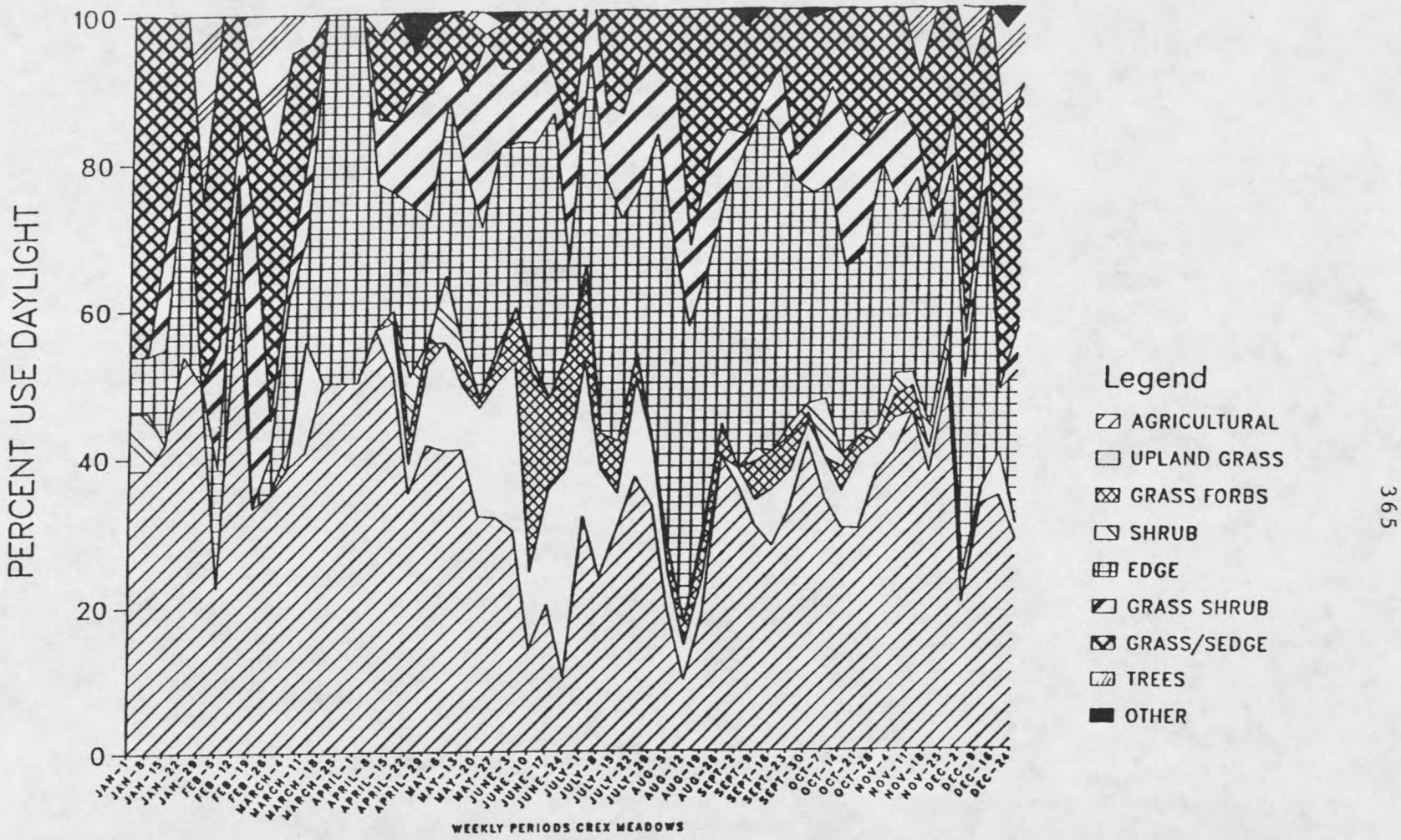


Figure 43. Weekly habitat use during the day by radio-tagged prairie chickens, Crex Meadows Wildlife Area, Wisconsin, 1976-78.

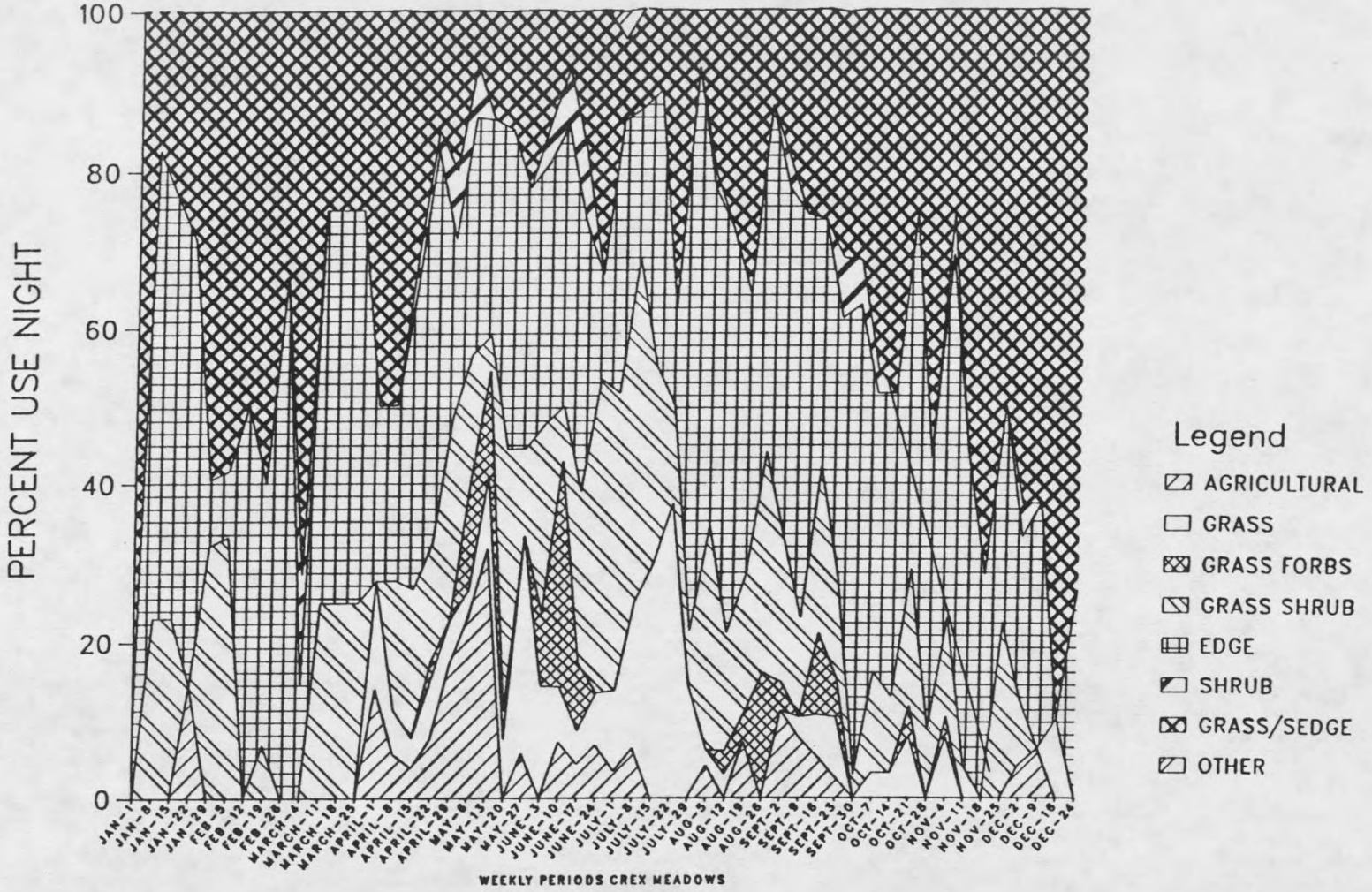


Figure 44. Weekly habitat use at night by radio-tagged prairie chickens, Crex Meadows Wildlife Area, 1976-78.

and night averaged 56.3±18.6 per week (Range 13-122) and 19.2±12.3 (Range 7-62) respectively. At Crex the number of locations collected during the day and night per week averaged 46.3±21.6 (Range 13-93) and night 21.2±11.3 (Range 7-51) respectively. The smallest number of weekly locations occurred during winter and the largest during summer in both areas.

Daylight use of grass and grass-forbs types in central Wisconsin increased with spring snowmelt and dominated use through the spring, summer and early fall. Major use of grassland habitats and edges at Crex was also highest during this same period but not nearly as pronounced as in central Wisconsin. Habitat use trends at night were influenced by snow and cold temperatures. Grass and grass-forbs dominated night roosting habitat during the snow free months in central Wisconsin while the wetland/shrub type dominated the winter months. At Crex grass-sedge, grass-shrub and the edge between these types dominated night roosting habitat during the snowfree months. Use of the grass-sedge type increased during the winter months.

Use of Cover by Height

The structural form of vegetation as determined by height seemed to have the greatest influence on the habitats used by prairie chickens. Cover has to provide security and protection from the elements, yet permit mobility and access to food during all seasons. Plant

specie(s), cover type, time since last disturbance, and land use practices all influence the height of cover in a grassland community.

Height-- Annual. On an annual basis prairie chickens made the greatest overall use of vegetation in the Class III (26-100 cm) height range. The percentages were similar in central Wisconsin and at Crex (44.6% versus 47.6%)(Fig. 45). The combined use of Class III and Class IV vegetation made up 62.9% and 71.9% of the cover used by adult prairie chickens in central Wisconsin and Crex respectively. Jones (1963) reported 42% of resting prairie chickens were found in the midgrass life-form (25-80 cm) and 51% in the midforb life-form (25-80 cm).

Use of vegetation in the shorter height classes and the edge between Class II (0-8 cm or II (9-25 cm) and taller vegetation were used regularly by prairie chickens during the day in central Wisconsin (53.3%) and Crex (36%). Minimal use of Classes I and II for night roosting was evident in both areas, since prairie chickens actively selected taller, more secure vegetation for night roosting. In central Wisconsin 89% and at Crex 91.2% of the year-round night roosting by radio-tagged prairie chickens occurred in Classes III and IV with Class III dominating in both areas (Fig. 45). Schwartz (1945) and Drobney and Sparrowe (1977) found that prairie chickens in Missouri used grass cover in the 15-90 cm range for night roosting.

Robel et al. (1970) indicated that visual obstruction was not a "significant factor in habitat usage in prairie chickens". However, their density data were collected from vegetation transects and not from the specific areas used by radio-tagged prairie chickens.

Height-- Winter. Vegetation that projected above the snow was critical in providing prairie chickens with screening cover and protection from the snow and wind during winter. Vegetative cover in the Class III or greater categories made up 75.2% of the winter habitat used by radio-tagged prairie chickens in central Wisconsin. These same height classes dominated day use at 64%, while Classes I and II received 26.1% of diurnal use (Table 62). Taller cover created by the grass-forbs and shrub/wetland habitats was used during the day for loafing and day roosting. Some of the use of Class IV+ cover occurred in standing corn which was usually used for feeding, and occasionally for loafing and day roosting.

Cover in the Class III and above height ranges were used 75.2% of the time during the winter for night roosting in central Wisconsin. Cover in the Class IV+ category made up 50.7% of the night use (Table 62). The high use of Class IV+ vegetation was the result of birds using the shrub/wetland habitat for night roosting. Class III and IV+ vegetation consisted of species which were strong

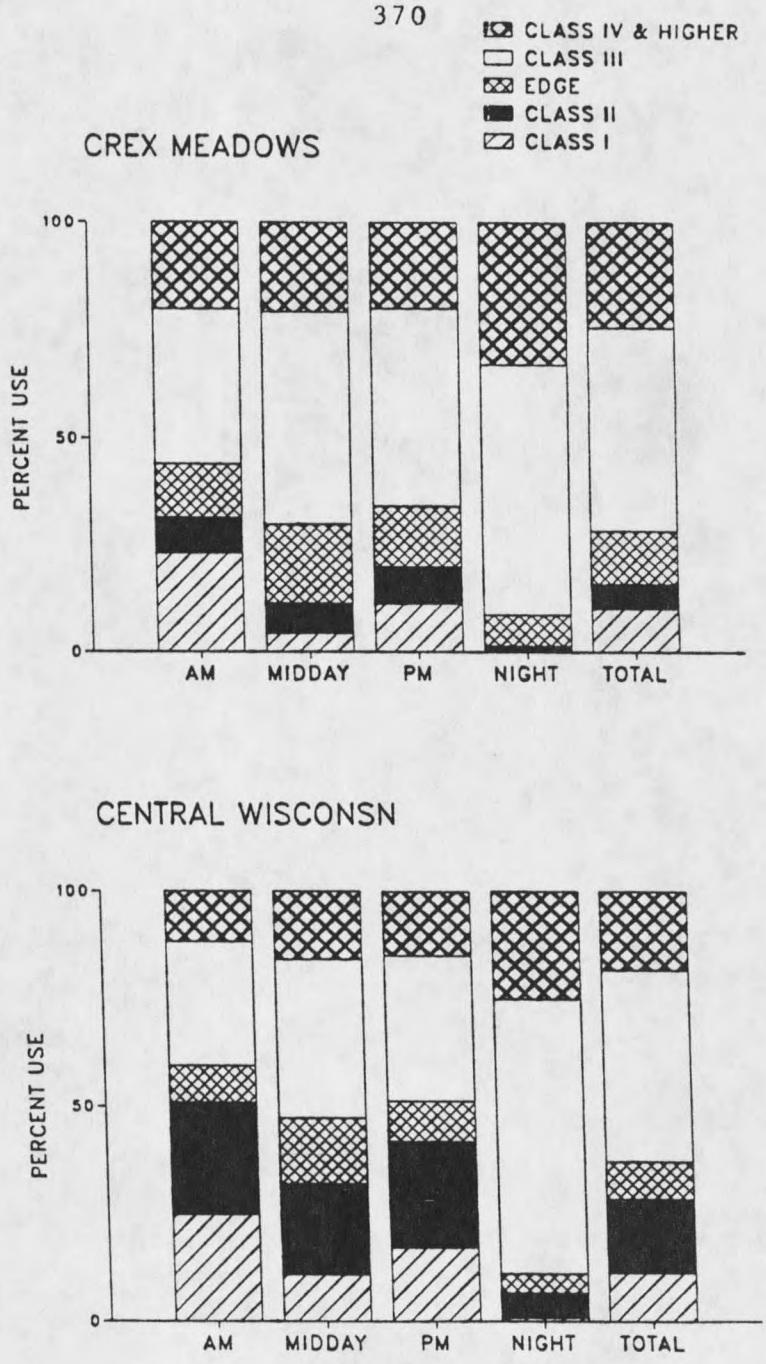


Figure 45. Annual weighted use of vegetation by height classes (I=0-8 cm, II=9-25 cm, III=26-50 cm, IV+=50+ cm) by radio-tagged prairie chickens by time of day, central Wisconsin, 1972-76, and Crex Meadows Wildlife Area, Wisconsin, 1976-78.

Table 62. Use of vegetation height classes (%) by day and night for radio-tagged prairie chickens during winter and spring in central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78. Number of locations are in parentheses.

	Central Wisconsin			Crex Meadows		
Height Class	Daylight	Night	Total	Total	Daylight	Night
WINTER						
Class I	19.0 (96)	0.7 (2)	12.1 (98)	16.9 (104)	24.3 (104)	-
Class II	7.1 (36)	0.7 (2)	4.7 (38)	1.5 (9)	2.1 (9)	-
Edge	9.1 (46)	6.3 (19)	8.0 (65)	7.0 (43)	9.1 (39)	2.1 (4)
Class III	22.8 (115)	27.3 (83)	24.5 (198)	51.8 (319)	43.7 (187)	70.2 (132)
Class IV	12.3 (62)	33.6 (102)	20.3 (164)	19.0 (117)	16.6 (71)	24.5 (46)
Class V & VI	29.7 (150)	31.6 (96)	30.4 (246)	3.9 (24)	4.2 (18)	3.2 (6)
Total	62.4 (505)	37.6 (304)	100.0 (809)	100.0 (616)	69.5 (428)	30.5 (188)
SPRING						
Class I	15.8 (168)	0.9 (5)	10.7 (173)	12.0 (110)	16.3 (108)	0.8 (2)
Class II	27.9 (297)	5.6 (31)	20.2 (328)	11.0 (101)	14.2 (94)	2.7 (7)
Edge	7.2 (77)	2.0 (11)	5.4 (88)	14.1 (130)	15.0 (99)	12.0 (31)
Class III	43.0 (457)	82.8 (462)	56.7 (919)	50.2 (462)	43.7 (289)	66.8 (173)
Class IV	4.9 (52)	7.5 (42)	5.8 (94)	11.4 (105)	9.8 (65)	15.4 (40)
Class V & VI	1.1 (12)	1.3 (7)	1.2 (19)	1.3 (12)	0.9 (6)	2.3 (6)
Total	65.6(1063)	34.4 (558)	100.0(1621)	100.0 (920)	71.8 (661)	28.2 (259)

and tall enough to provide cover above the snow. Classes I and II cover were used by prairie chickens when loafing in snow depressions or when the snow was deep enough to permit snow burrowing.

At Crex, Classes III and above combined to equal 74.7% of the cover used by radioed prairie chickens during the winter, a use that was comparable to that observed in central Wisconsin (75.2%). The use of Class III vegetation at Crex was greater than in central Wisconsin (51.8% versus 24.5%) and reflected the large amount of wetland grass/sedge cover available at Crex. This was in contrast to the taller wetland/shrub habitat used in central Wisconsin.

Classes III and above dominated day use (68.5%) at Crex while Class I made up 19.0% (Table 62). The high use of Class I cover was due to morning and evening feeding on corn platforms. Some Class IV+ use was due to use of standing corn (18.2%) for day roosting and feeding. However, by early winter deer eliminated most of the food in the standing corn strips at Crex, forcing the birds to the corn platforms for winter food. At Crex, 97.9% of the cover used by radio-tagged prairie chickens for night roosting was in the Class III (70.2%) and IV+ (27.7%) height classes (Table 62).

Height-- Spring. During the spring, Classes II and III vegetation made up 76.9% of the cover used by prairie

chickens in central Wisconsin. The use of Class IV+ vegetation dropped from 50.7% during winter to 7.0% in the spring. The increased use of Classes I and II during the spring related to this cover becoming available following snow melt. Classes I and II were used for feeding during the day at about the same rate as Class III was used for day roosting and loafing (43.7% versus 43.0% respectively). However, the use of Classes I and II declined from 43.7% during the day to 6.5% at night while use of Class III increased from 43.0%-82.8%. Class IV+ vegetation was used some during the day and at night, but during the spring when snow was not present, much of this taller cover was too rank for the birds to use for feeding or roosting. During winter, snow altered the structure and permitted access to much of the taller vegetation.

At Crex, Class III vegetation dominated cover used during the spring. Class I and II and the edge were used most during the day and were used for feeding. Use of Classes I and II declined from 30.5% during the day to 3.5% at night. Classes III and above made up 84.5% of use by radio-tagged birds for night roosting (Table 62).

Height-- Summer. The use of cover Classes I and II by prairie chickens peaked at 38.0% in central Wisconsin during the summer (Table 63). However, Class III vegetation still dominated the cover used by prairie chickens and made up 34.2% of the cover used during the day. Jones (1963)

Table 63. Use of vegetation height classes (%) by day and night for radio-tagged prairie chickens during summer and fall in central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78. Number of locations are in parentheses.

	Central Wisconsin			Crex Meadows		
Height Class	Daylight	Night	Total	Total	Daylight	Night
SUMMER						
Class I	24.8 (433)	1.4 (12)	17.0 (445)	6.2 (67)	8.7 (65)	0.6 (2)
Class II	25.2 (440)	12.7(111)	21.0 (551)	7.4 (80)	9.9 (74)	1.8 (6)
Edge	13.8 (242)	6.4 (56)	11.4 (298)	15.5 (168)	17.8 (133)	10.4 (35)
Class III	34.2 (599)	72.2 (632)	46.9(1231)	44.8 (487)	41.9 (314)	51.3 (173)
Class IV	1.3 (23)	7.0 (61)	3.2 (84)	25.9 (281)	21.5 (161)	35.6 (120)
Class V & VI	0.7 (12)	0.3 (3)	0.6 (15)	0.3 (3)	0.3 (2)	0.3 (1)
Total	66.7(1749)	33.3 (875)	100.0(2624)	100.0(1086)	69.0 (749)	31.0 (337)
FALL						
Class I	10.0 (90)	0.3 (2)	5.8 (92)	5.3 (42)	8.1 (42)	-
Class II	36.0 (325)	4.6 (32)	22.4 (357)	3.6 (29)	5.6 (29)	-
Edge	14.6 (132)	3.5 (24)	9.8 (156)	13.2 (105)	17.2 (89)	5.7 (16)
Class III	31.7 (287)	73.8 (509)	49.9 (796)	42.6 (340)	40.0 (207)	47.3 (133)
Class IV	2.2 (20)	16.1 (111)	8.2 (131)	30.1 (240)	22.2 (115)	44.5 (125)
Class V & VI	5.6 (50)	1.7 (12)	3.9 (62)	5.3 (42)	6.8 (35)	2.5 (7)
Total	56.7 (904)	43.3 (690)	100.0(1594)	100.0 (798)	64.8 (517)	35.2 (281)

found prairie chickens during summer in the shortgrass life-form with cover less than 25 cm being the most important. Even during summer when temperatures were warm, radio-tagged prairie chickens shifted from shorter more open cover to taller Class III and Class IV+ vegetation which made up 79.5% of the night roosting cover (Table 63).

At Crex, cover Class III made up 41.9% and Class IV+ 21.8% of the summer habitat used during the day by radio-tagged prairie chickens. The higher use of Class IV+ vegetation at Crex than in central Wisconsin reflected the use of the undisturbed grass-shrub and wetland habitats that reached maximum height during the summer. The low use of height Classes I and II at Crex was due to the birds using the agricultural edge for feeding and day roosting. Classes III and above dominated the cover used for night roosting (87.2%) at Crex during the summer (Table 63).

The agricultural fields at Crex provided a very diverse habitat both in type and height due to the alternating, 10 m wide rows of rye, corn, and buckwheat. The birds typically fed in these strips usually in the 0-3 cm high rye strips. These strips were similar in form to the heavily grazed fields used by the prairie chickens for feeding in central Wisconsin. Classes III and above dominated the cover used for night roosting (87.2%) at Crex (Table 63).

Height-- Fall. In central Wisconsin Class III vegetation was used 31.7% of the time by radio-tagged prairie chickens in fall, while Classes I and II were used during the day (46.0%) as birds fed in buckwheat, oats, and cut corn. The use and availability of cover by height during the fall was similar to that observed in spring (Tables 62 and 63). Classes III and above made up 91.6% of the cover used for night roosting with Class III dominating at 73.8%.

At Crex, classes III and greater made up 78% of the habitat used by radio-tagged birds in the fall. Lower height classes were also used during the day at Crex for feeding, but at a lesser rate than in central Wisconsin. The low use of short cover at Crex was due to the regular use of the agricultural strips which consist of varying height classes in close proximity. Class III and IV+ vegetation were used equally and made up 94.3% of the cover used for night roosting (Table 63).

Height-- Weekly. Use of vegetation by height classes also varied within the seasons and was related to the development of vegetation and weather conditions. Classes I and II, the edge between I, II and taller vegetation dominated cover use by prairie chickens in central Wisconsin during the day for much of the growing season when vegetation was green (Fig. 46). Drobney and Sparrowe (1977) in Missouri observed that cover in 10-20 cm range

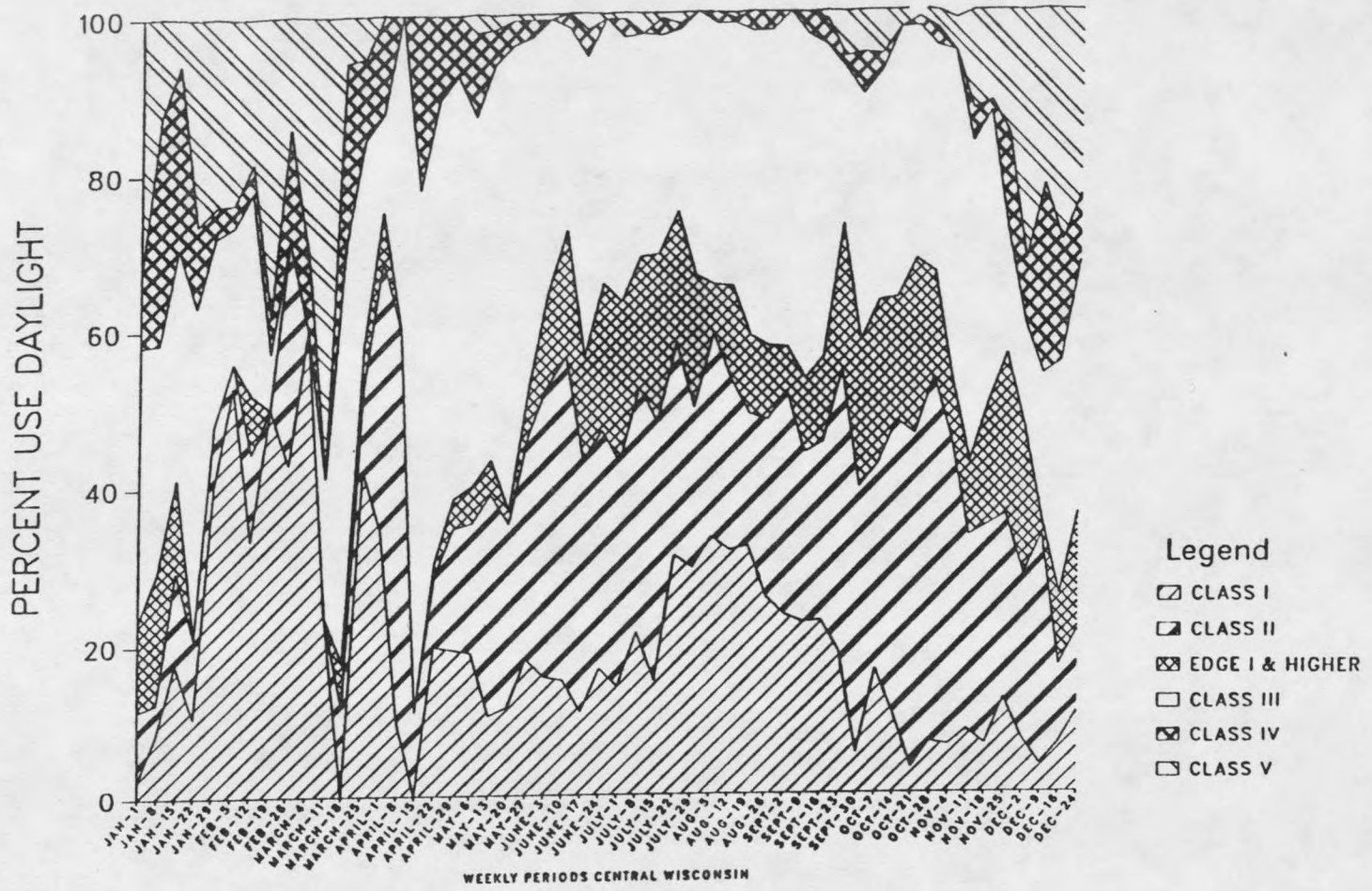


Figure 46. Weekly use of vegetation by height classes (I=0-8 cm, II=9-25 cm, III=26-50 cm, IV=51-100 cm and V=101-200 cm) by radio-tagged prairie chickens during the day, central Wisconsin, 1972-76.

was used more than either shorter or taller cover from February to May and cover less than 10 cm was preferred for feeding.

The use of shorter vegetation reflected the heavy use of disturbed cover in the grazed fields and bluegrass habitat type. Use of Class I vegetation in winter resulted from use of corn bait piles. Class III vegetation was used throughout the year for day roosting. Jones (1963) suggested that prairie chickens used tall cover (20-70 cm) during spring, summer, and fall for concealment. The use of Class IV+ cover during the day was associated with those times when snow reduced the availability of shorter types.

The use of Class III vegetation dominated the cover used for night roosting throughout the non-snow seasons (Fig. 47). Use of class IV+ cover increased with cooler temperatures in early fall and increased even more with the arrival of a permanent snow cover.

At Crex, Class III vegetation dominated diurnal cover used throughout much of the year (Fig. 48). The increased use of Class I and II vegetation and edge was associated with green-up and was used through the non-snow seasons. Use of edge during non-snow seasons resulted from the use of agricultural strips and their edges. The use of Class IV+ vegetation at Crex increased through the growing season as wetland and grass-shrub habitats reached maximum height. The year-round use of Class IV+ vegetation was higher at



Figure 47. Weekly use of vegetation by height classes (I=0-8 cm, II=9-25 cm, III=26-50 cm, IV=51-100 cm and V=101-200 cm) by radio-tagged prairie chickens at night, central Wisconsin, 1972-76.

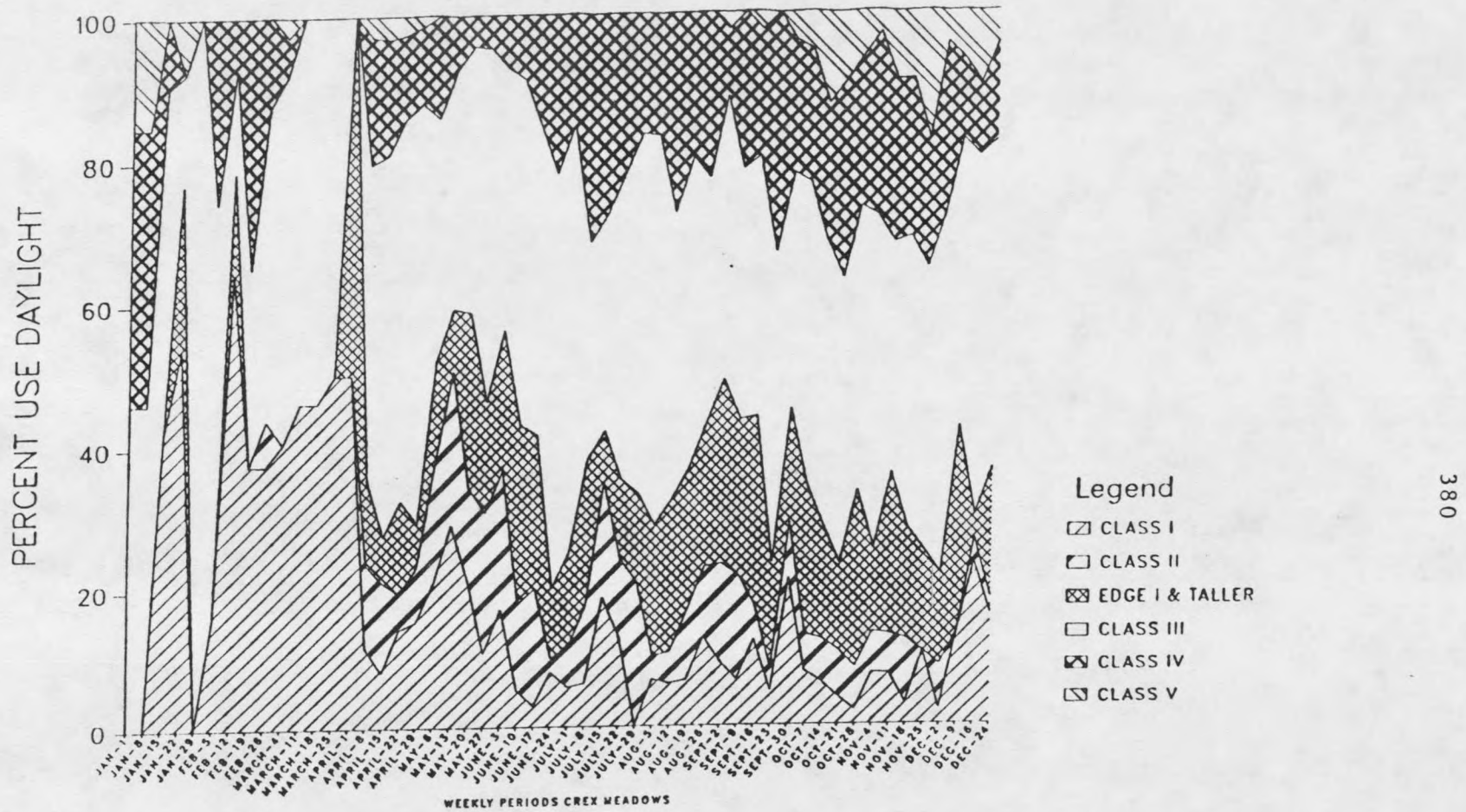


Figure 48. Weekly use of vegetation by height classes (I=0-8 cm, II=9-25 cm, III=26-50 cm, IV=51-100 cm and V=101-200 cm) by radio-tagged prairie chickens during the day, Crex Meadows Wildlife Area, Wisconsin, 1976-78.

Crex than in central Wisconsin where only a few species were in this taller height category.

Class III and IV+ vegetation dominated the year-round night roosting cover used by the prairie chickens at Crex (Fig. 49). Use of Class IV+ vegetation was highest during the growing season, and was a function of the growth of new vegetation. Much of the grass and sedge cover in the Class IV+ vegetation category was reduced to Class III or II category by weathering in the fall and snow cover in winter.

Class III vegetation made up approximately 50% of the cover used by radio-tagged prairie chickens during the day in all seasons except winter in central Wisconsin. The general pattern of prairie chicken cover use by height during the day in all seasons was to feed in shorter Classes I and II and day roost in taller Class III and IV+ vegetation. At night, class III and VI+ height classes made up up over 80% of the cover used for night roosting in all seasons. A mix of short (0-25 cm) and tall (26-100 cm) grassland habitat best characterized the cover needs of adult prairie chickens in central Wisconsin and Crex Meadows.

Disturbance Patterns

The nature of habitat disturbances indicates the direction management should take in its efforts to create and maintain habitats required by prairie chickens. On an

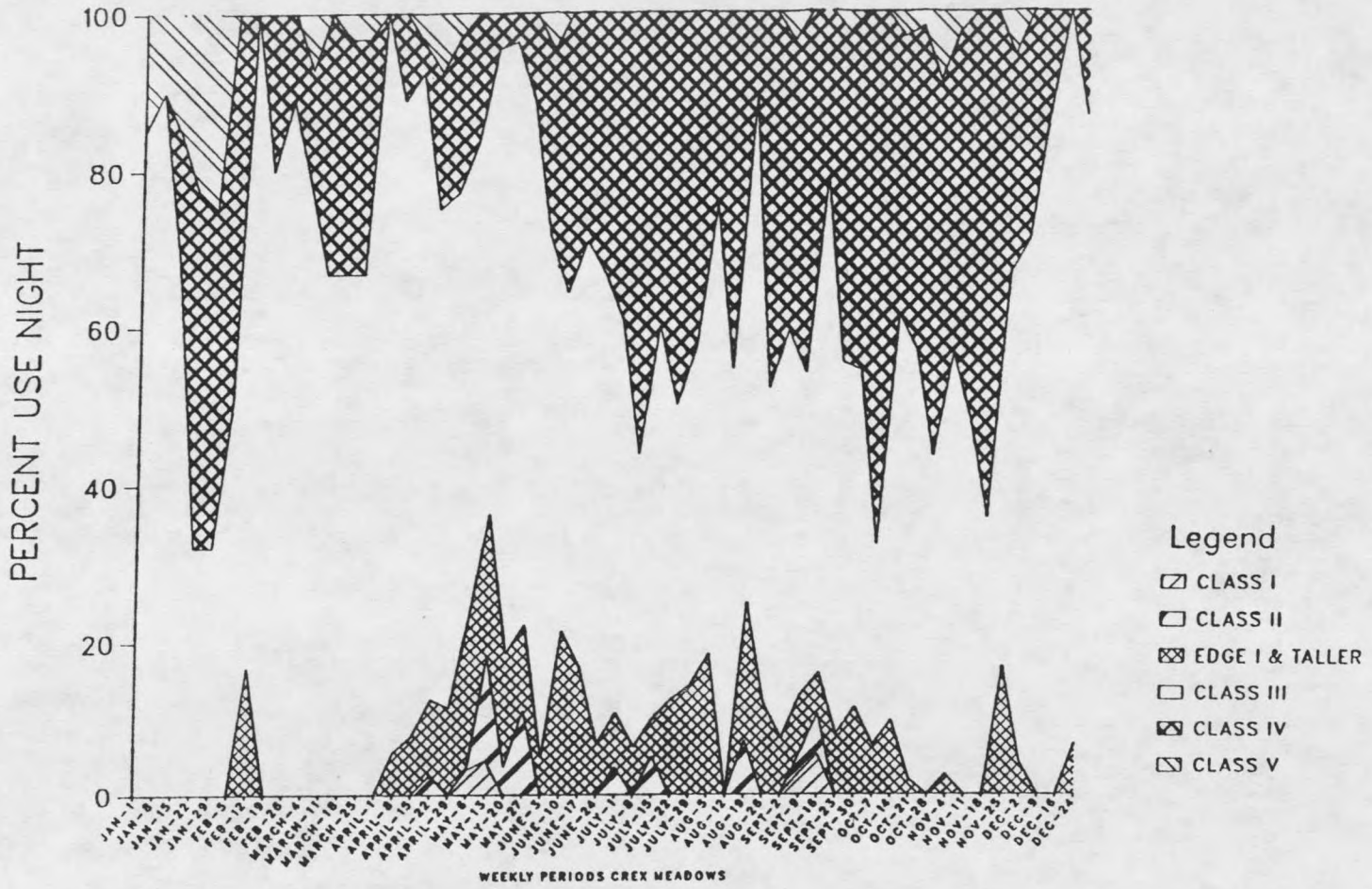


Figure 49. Weekly use of vegetation by height classes (I=0-8 cm, II=9-25 cm, III=26-50 cm, IV=51-100 cm and V=101-200 cm) by radio-tagged prairie chickens at night, Crex Meadows Wildlife Area, Wisconsin, 1976-78.

annual basis, radio-tagged prairie chickens used an almost equal amount of disturbed (within 12 months) and undisturbed vegetation (12+ months) (Fig. 50). In central Wisconsin, undisturbed cover was used slightly more than disturbed vegetation (40.2% versus 34.1%). The use of the edge between disturbed and undisturbed vegetation (25.7%) was important because usually it provided simultaneous access to two types of cover (tall and short) which meet different needs (feeding and roosting) of prairie chickens.

The diurnal use favored disturbed habitat during all seasons in central Wisconsin with increased use through the fall and into the winter (Table 64 and Fig. 51). This pattern reflects the heavy use of agricultural and grazed fields for feeding.

Disturbed cover also dominated diurnal use through the year at Crex (Table 64). The use of the edge was not as obvious at Crex as in central Wisconsin particularly during the summer (Figures 51 and 52). The lower use of edge was due to the high use of agricultural fields at Crex which were all disturbed at the same time and the management practice of burning one-third of the area every spring in a mosaic pattern.

The most obvious pattern of habitat use relative to the last disturbance was the year-round use of undisturbed cover (49.0-78.6%) for night roosting in both areas (Table 64 and Figs. 53 and 54). The undisturbed areas were also

Table 64. Seasonal use of disturbance types (%) by day and night for radio-tagged prairie chickens in central Wisconsin 1972-76 and Crex Meadows Wisconsin, 1976-78. Number of locations are in parentheses.

	Central Wisconsin			Crex Meadows		
	Daylight	Night	Total	Total	Daylight	Night
Habitat Type						
WINTER						
Disturbed[a]	58.0 (239)	17.7 (52)	41.2 (291)	36.7 (173)	42.1 (125)	27.4 (48)
Undisturbed[b]	31.3 (129)	49.0(144)	38.7 (273)	58.5 (276)	51.5 (153)	70.3 (123)
Edge	10.7 (44)	33.3 (98)	20.1 (142)	4.9 (23)	6.4 (19)	2.3 (4)
Total	58.4 (412)	41.6 (294)	100.0 (706)	100.0 (472)	62.9 (297)	37.1 (175)
SPRING						
Disturbed	44.0 (416)	17.9 (99)	34.4 (515)	44.7 (398)	51.6 (328)	27.6 (70)
Undisturbed	25.3 (239)	60.4 (334)	38.2 (573)	47.6 (424)	39.8 (253)	67.3 (171)
Edge	30.8 (291)	21.7 (120)	27.4 (411)	7.6 (68)	8.6 (55)	5.1 (13)
Total	63.1 (946)	36.9 (553)	100.0(1499)	100.0 (890)	71.5 (636)	28.5 (254)
SUMMER						
Disturbed	26.8 (356)	17.7 (142)	23.4 (498)	36.9 (396)	44.4 (328)	20.2 (68)
Undisturbed	21.3 (283)	65.1 (523)	37.9 (806)	56.3 (611)	47.8 (353)	75.0 (258)
Edge	51.8 (687)	17.2 (138)	38.8 (825)	6.8 (73)	7.7 (57)	4.8 (16)
Total	62.3(1326)	37.7 (803)	100.0(2129)	100.0(1080)	68.7 (738)	31.3 (342)
FALL						
Disturbed	53.5 (435)	15.6 (104)	36.4 (539)	39.4 (330)	51.0 (277)	18.0 (53)
Undistubed	24.0 (195)	71.8 (478)	45.5 (673)	55.0 (460)	42.2 (229)	78.6 (231)
Edge	22.5 (183)	12.6 (84)	18.1 (267)	5.6 (47)	6.8 (37)	3.4 (10)
Total	55.0 (813)	45.0 (666)	100.0(1479)	100.0 (837)	64.9 (543)	35.1 (294)

[a] Not disturbed within 12 months.
[b] Disturbed within 12 months.

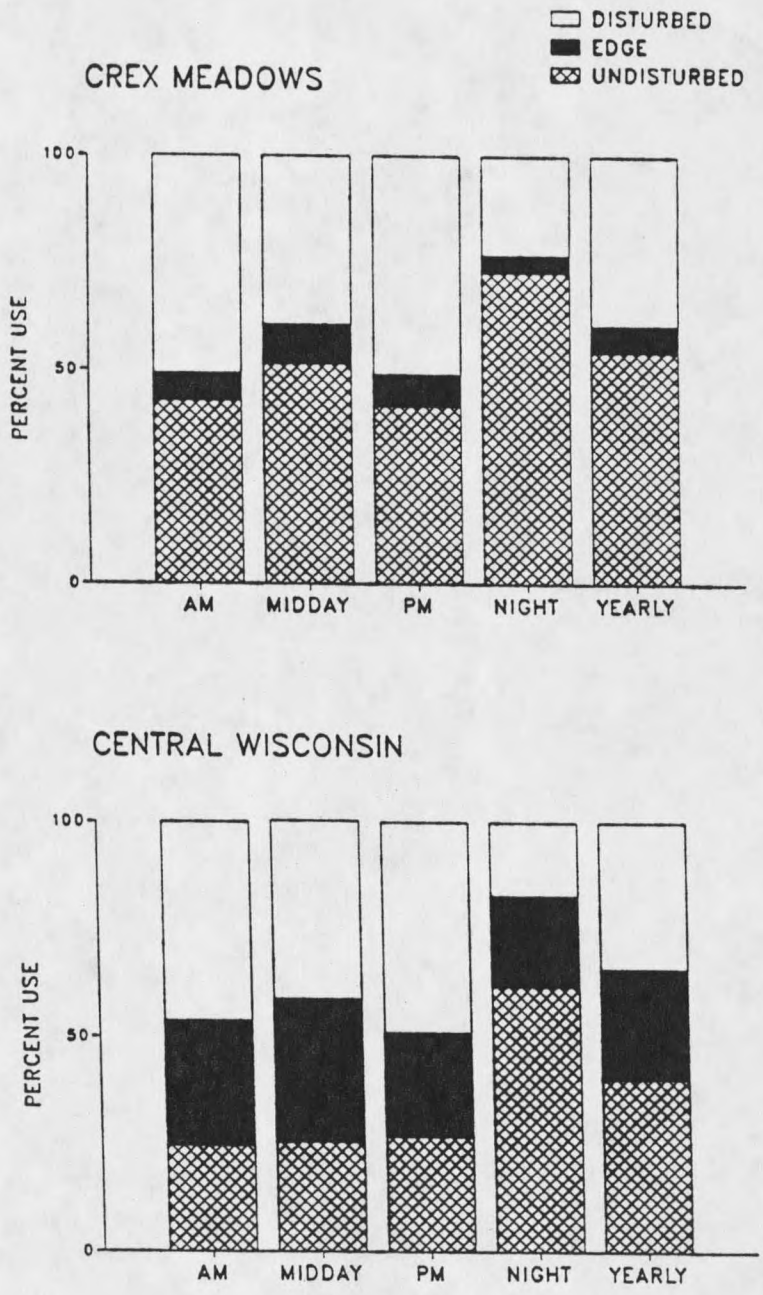


Figure 50. Annual weighted use of disturbance types for radio-tagged prairie chickens by time of day central Wisconsin, 1972-76, and Crex Meadows Wildlife Area, Wisconsin, 1976-78.

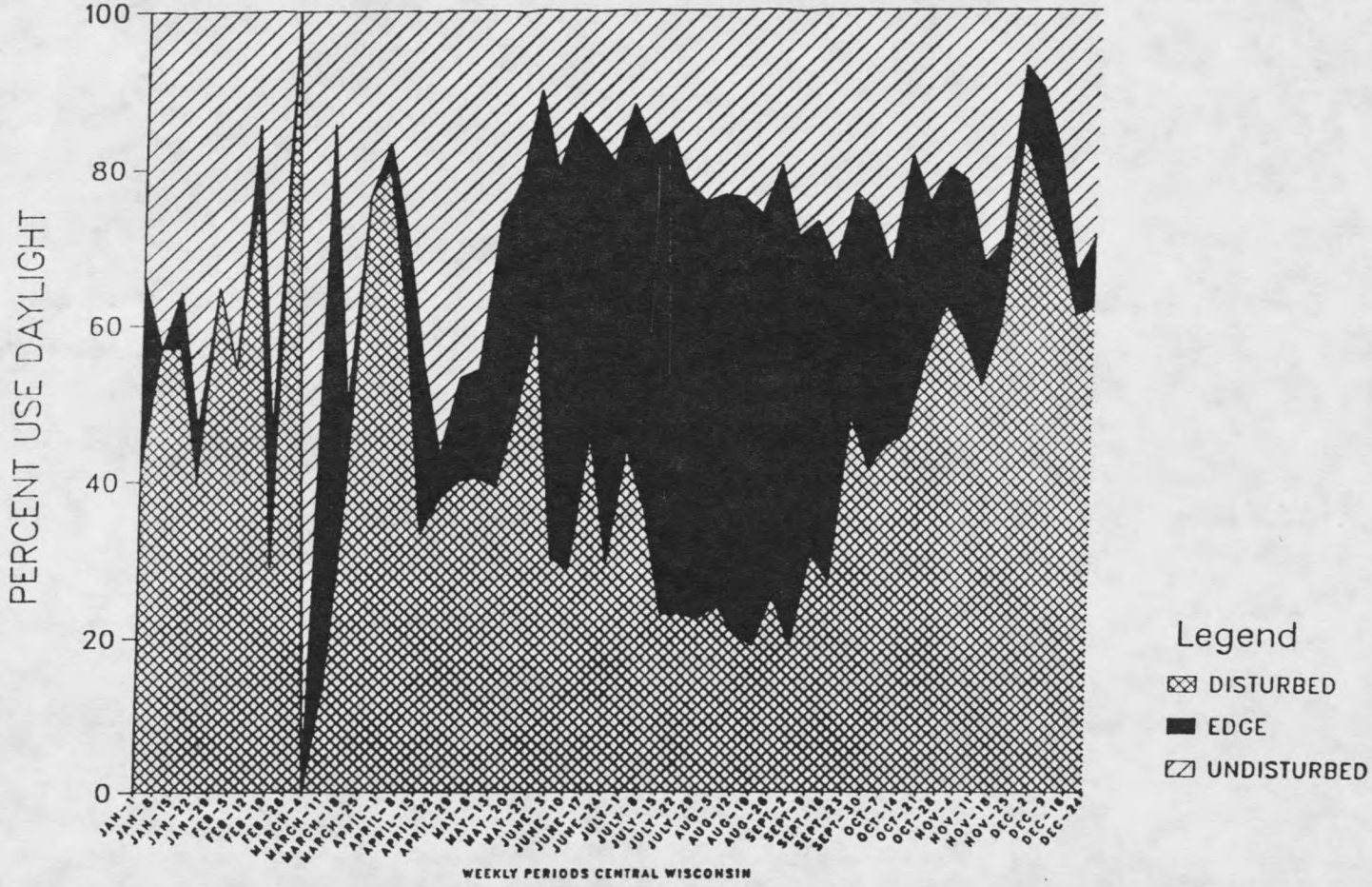


Figure 51. Weekly use of disturbance types during the day by radio-tagged prairie chickens in central Wisconsin, 1972-76.

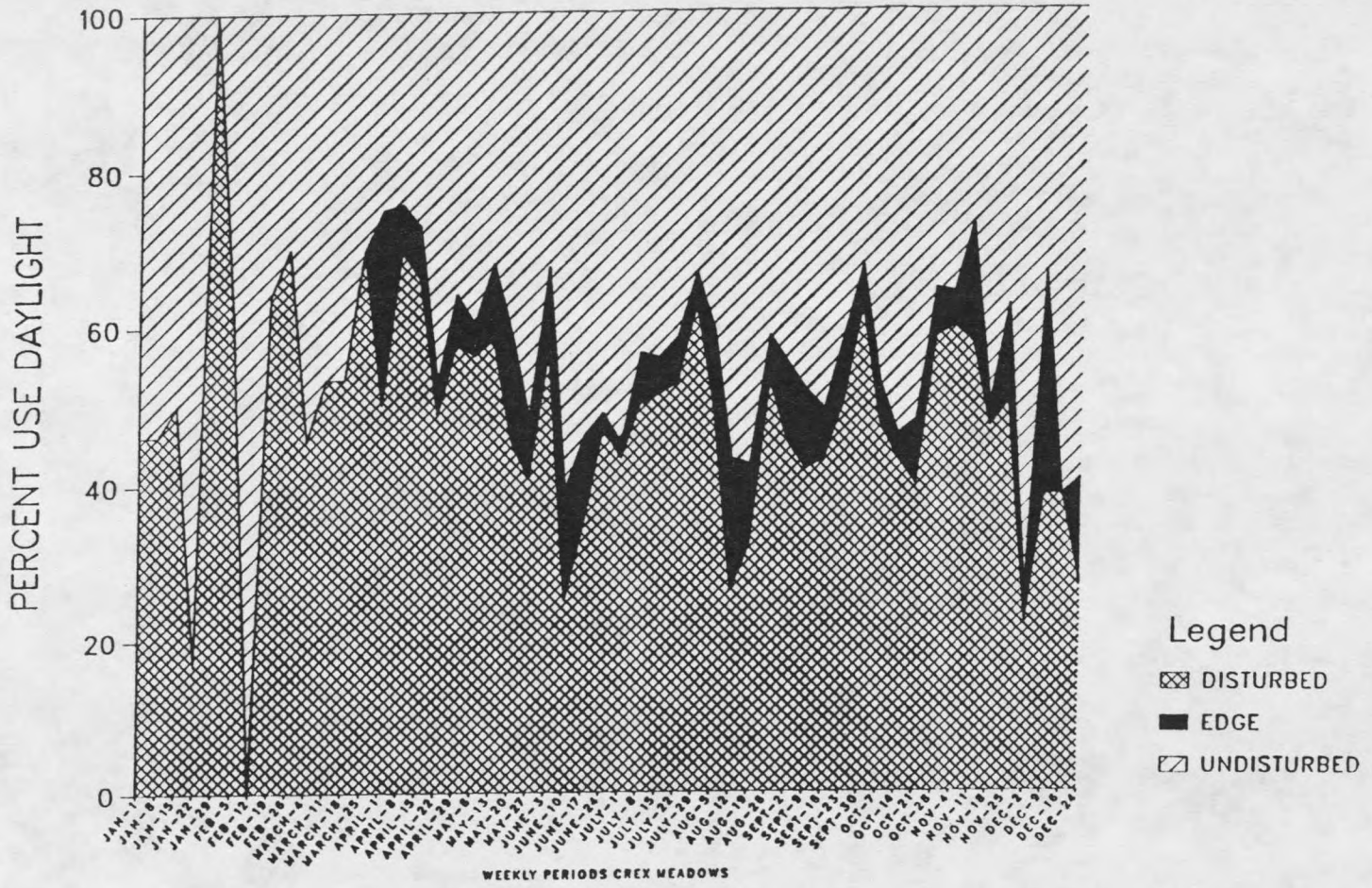


Figure 52. Weekly use of disturbance types during the day by radio-tagged prairie chickens, Crex Meadows Wildlife Area, Wisconsin, 1976-78.

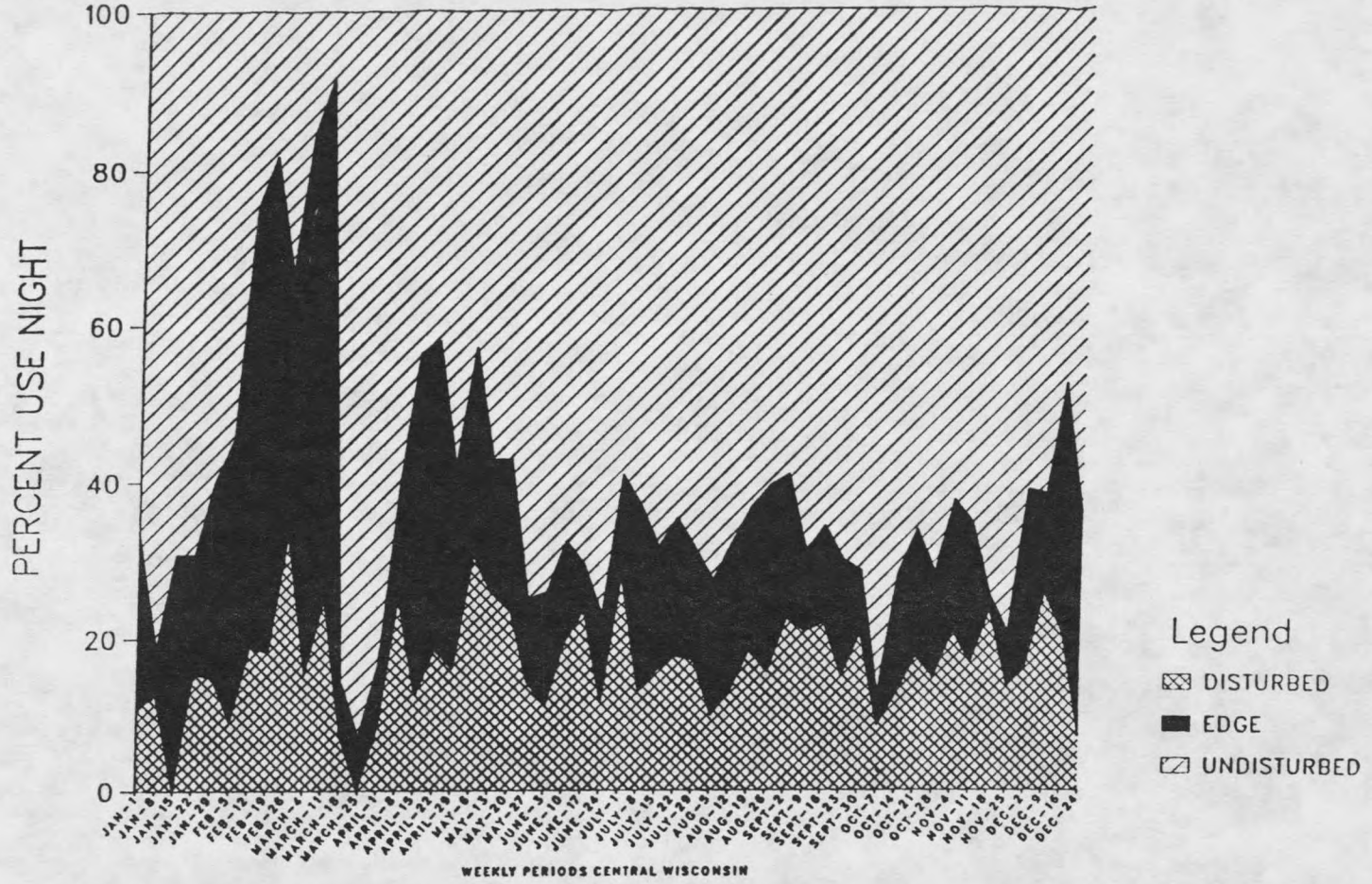


Figure 53. Weekly use of disturbance types at night by radio-tagged prairie chickens in central Wisconsin, 1972-76.

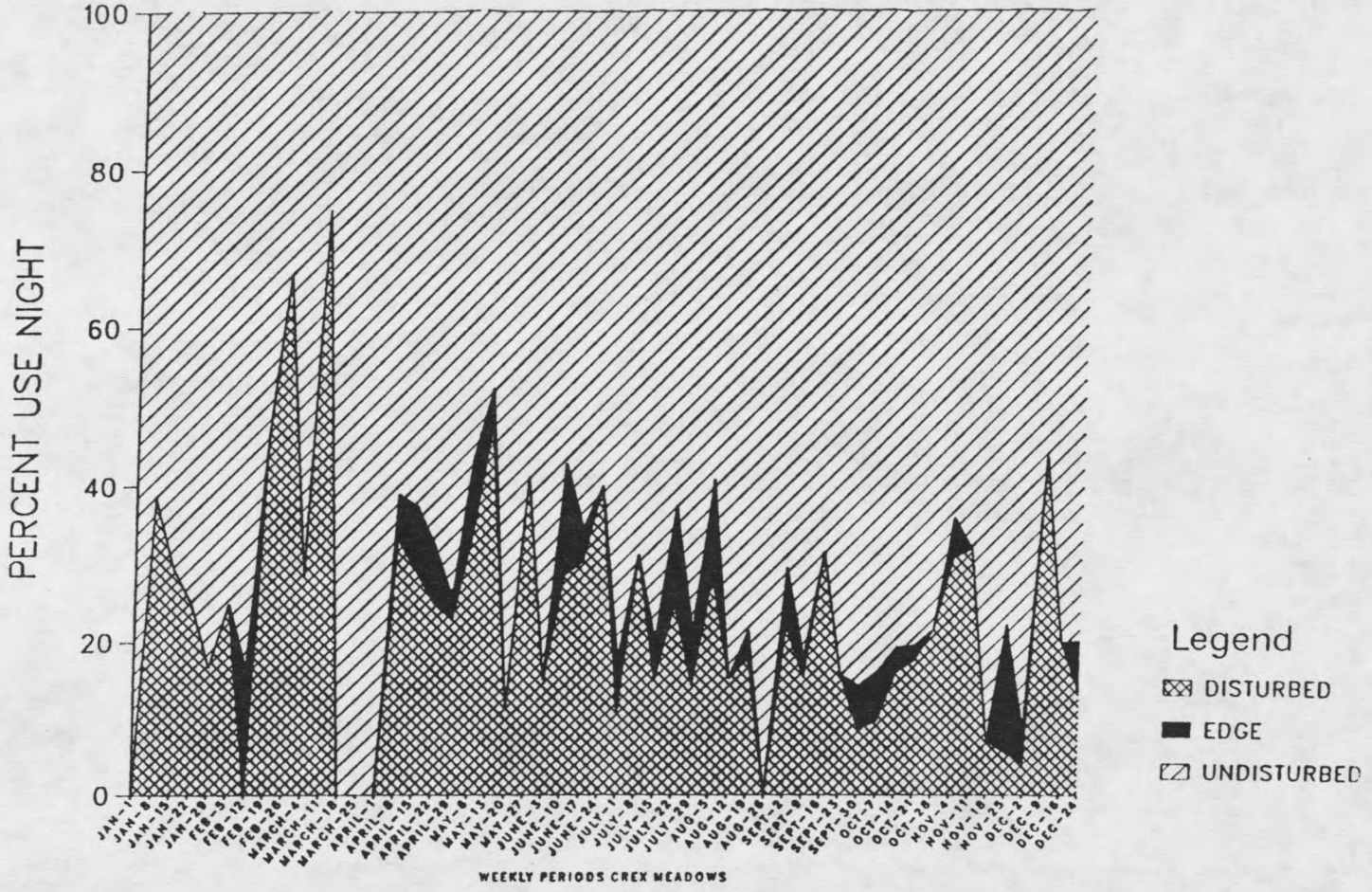


Figure 54. Weekly use of disturbance types at night by radio-tagged prairie chickens, Crex Meadows Wildlife Area, Wisconsin, 1976-78.

used during the daytime in all seasons (21.3-58%) for day roosting. Use of edge at Crex was lowest at night and was related to the high use of large undisturbed wetland areas where the edge was not obvious because of the burning pattern.

Undisturbed grassland is a key component of prairie chicken habitat and provides secure cover used for nesting and night roosting whereas disturbed cover appeared to increase the amount and availability of food. However, if the grass and grass-forb habitats go undisturbed too long they may become rank. In the midwest, succession in undisturbed grasslands tends to move from grass-forbs, to shrubs and eventually trees. Because of these changes, habitats managed for prairie chickens must be disturbed on a regular basis. However, a rotation should be used that leaves at least two-thirds of the grassland cover undisturbed in any one year to provide nesting cover in the spring.

Use of disturbed habitat relative to the time of last disturbance in months showed that the highest use of recently disturbed habitat (0-6 months) occurred in the summer. At Crex, the high amount of night roosting which occurred in cover undisturbed for 36 months (40.6-56.3%) reflected the 3 year burning rotation.

The year-round use of cover undisturbed for 36 months or longer in both areas suggested that the accumulation of

residual vegetation may be important in creating night roosting cover. Because of the burning pattern at Crex, cover disturbed within 6, 12, and 24 months was readily available. In central Wisconsin, large portions of grassland reserves consisted of grass undisturbed for 3-5 years. Figures 55 and 56 present weekly habitat use by radio-tagged prairie chickens by the number of months since the last disturbance for day and night respectively in central Wisconsin. Figures 57 and 58 present weekly habitat use by radio-tagged prairie chickens by the number of months since the last disturbance and by day and night respectively at Crex Meadows.

Both the age and type of disturbance were important in determining the cover components and condition. Cover burned in the spring, if allowed to regrow, provided good cover by early summer and fall and residual vegetation the following spring. However, mowing in late summer and/or grazing through the fall will permit little regrowth, provide no winter cover and no residual cover the following spring. Grazing of most grasses after growth was complete created a mix of height Classes III, I and II. This type of grass cover was used by prairie chickens during all the snow free seasons for all activities. The timing of grazing can be critical in determining what cover remains the following spring. Overstocking or continuous grazing will result in large areas of Class I and II vegetation

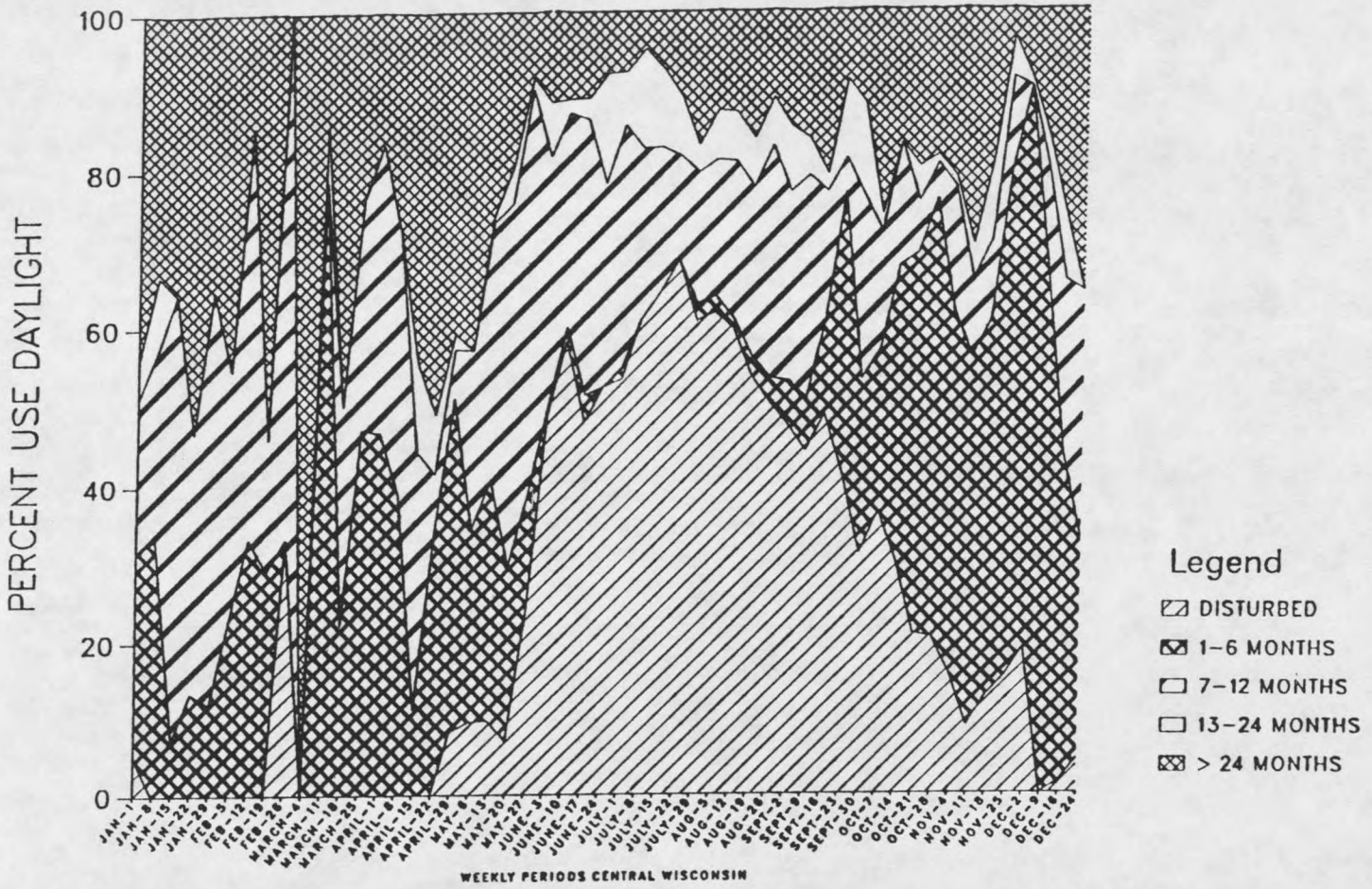


Figure 55. Weekly use of cover by months since last disturbance for radio-tagged prairie chickens during the day, central Wisconsin, 1976-78.

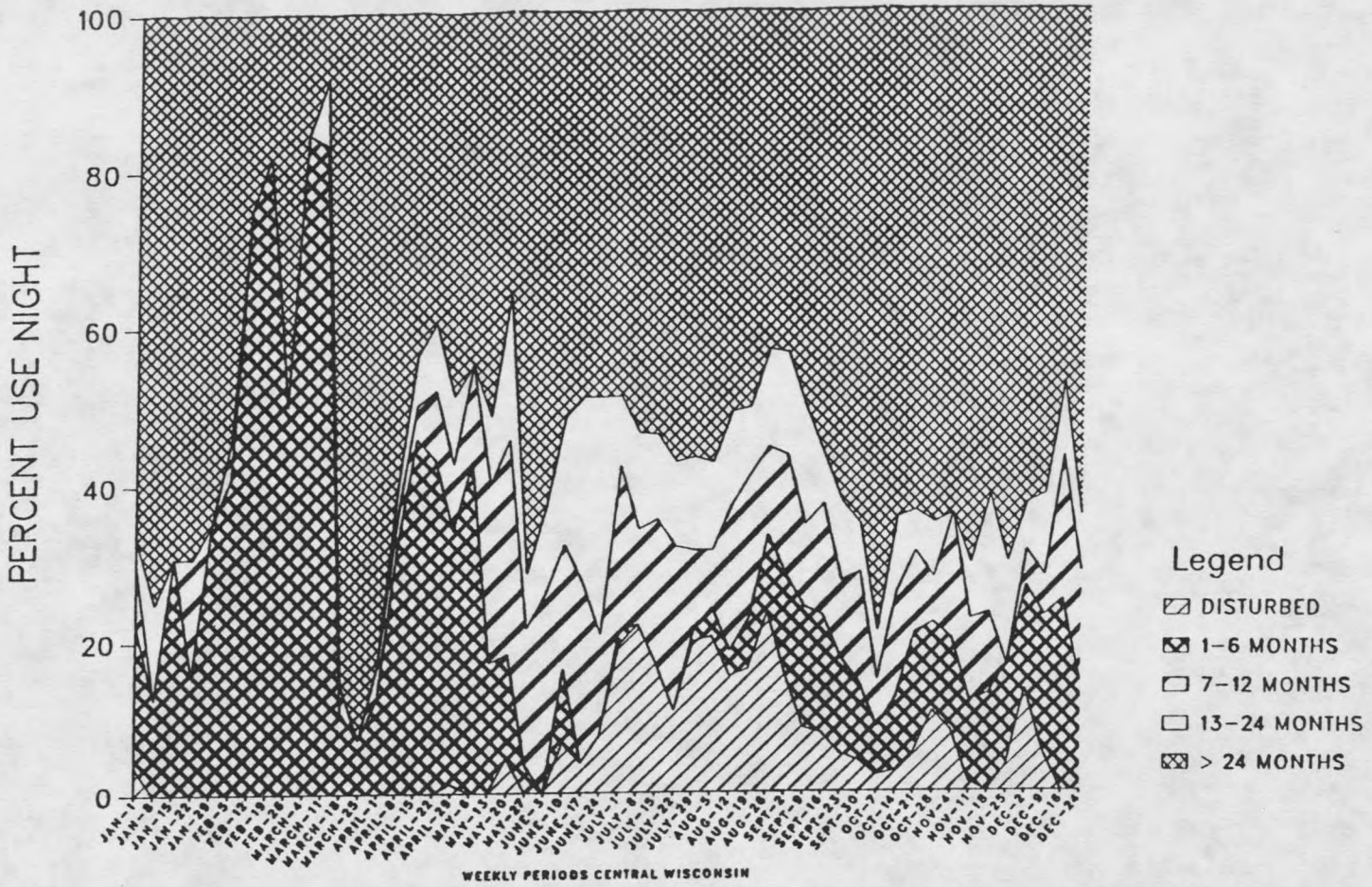


Figure 56. Weekly use of cover by months since last disturbance for radio-tagged prairie chickens at night, central Wisconsin, 1976-78.

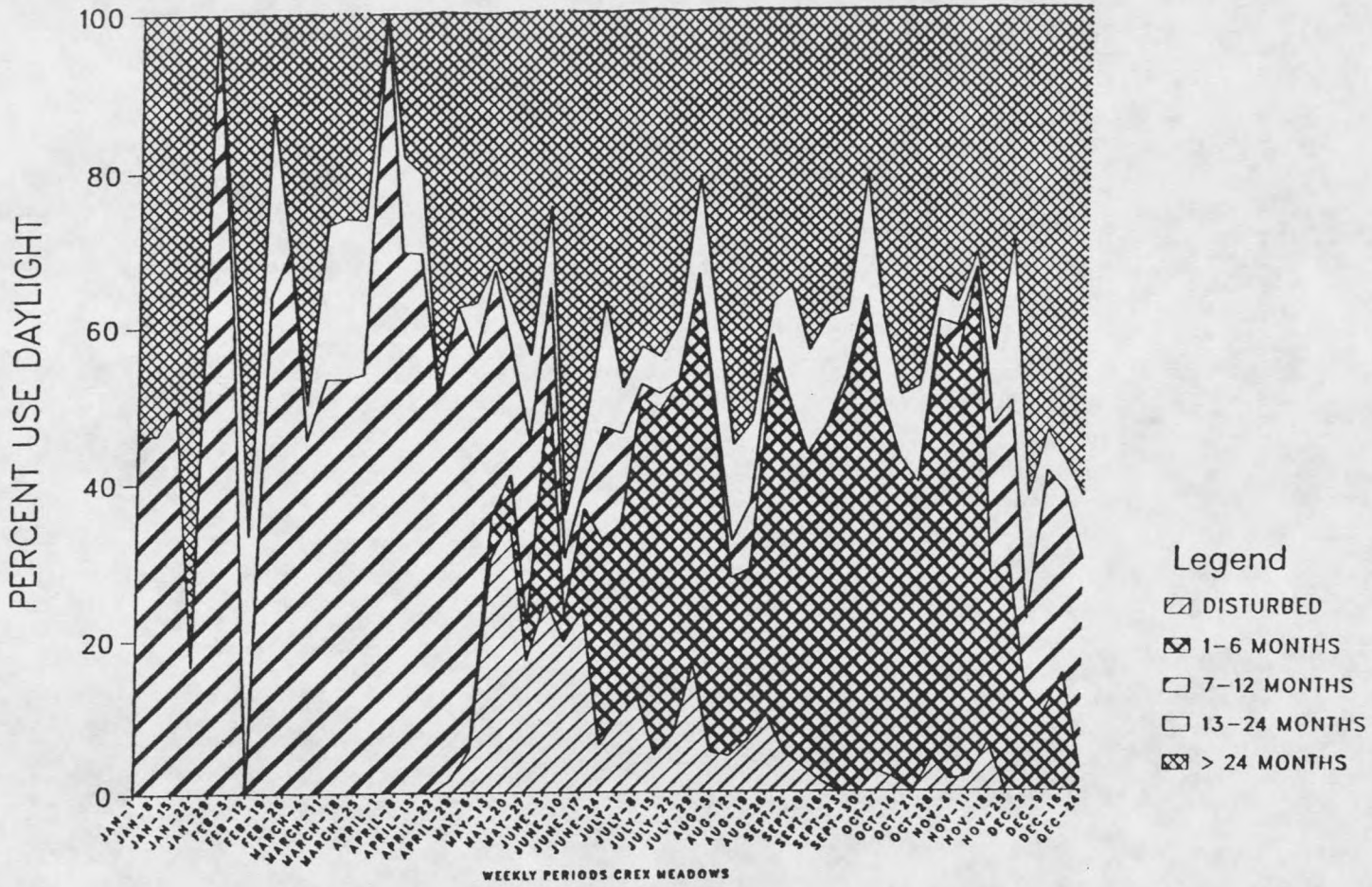


Figure 57. Weekly use of cover by months since last disturbance for for radio-tagged prairie chickens during the day, Crex Meadows Wildlife Area, Wisconsin, 1976-78.

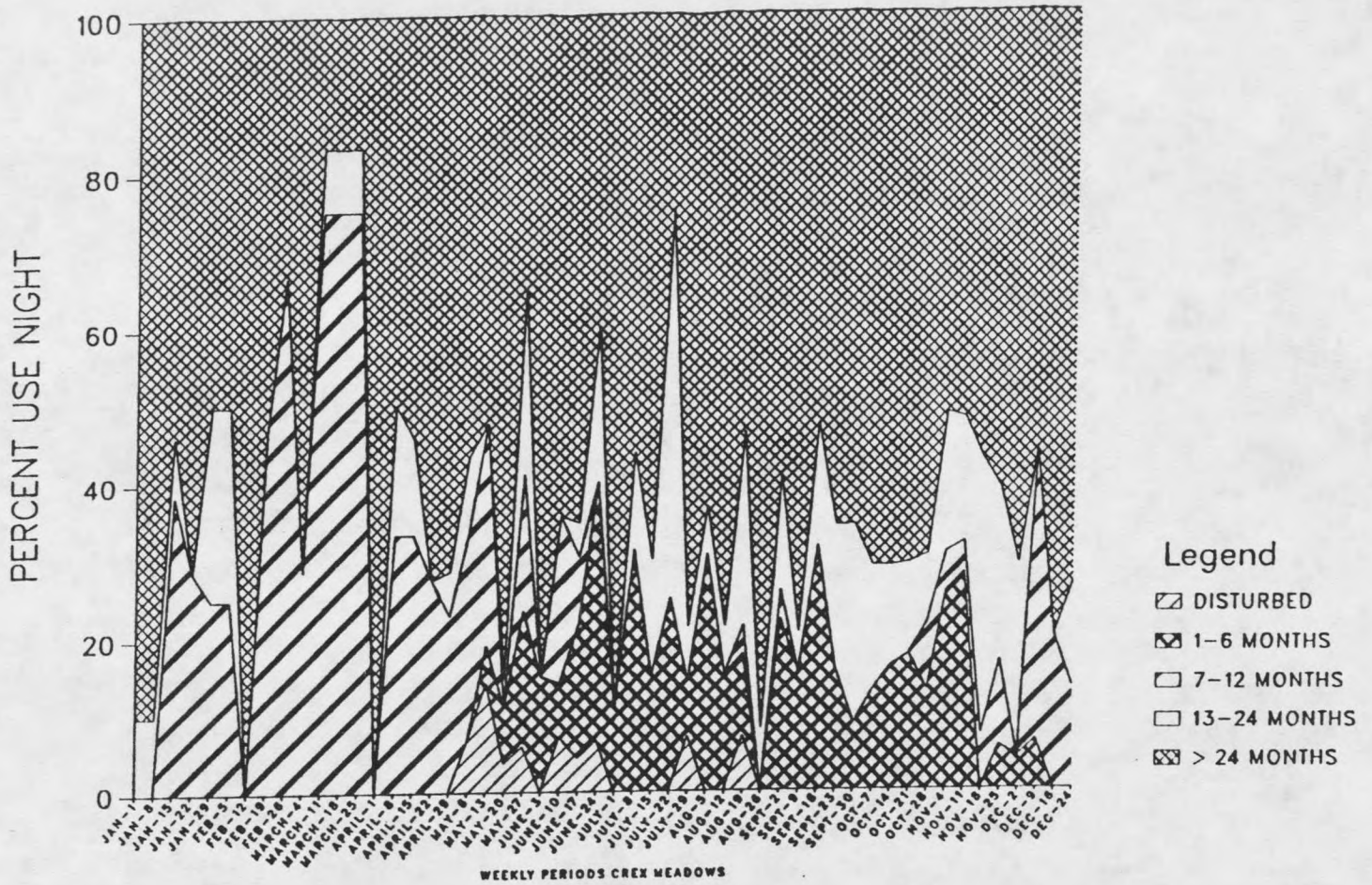


Figure 58. Weekly use of cover by months since last disturbance for radio-tagged prairie chickens at night, Crex Meadows Wildlife Area, Wisconsin. 1976-78.

that will provide little, if any cover for prairie chickens.

Of the many ways in which habitat can be altered, grazing, mowing, plowing, planting, clearing, chemical spraying and burning all were used at Crex, and all except burning were used in central Wisconsin. Burning every 3 years appeared to be the best overall management tool for producing and maintaining the quality and structure of grasslands used by prairie chickens for all activities.

The role of controlled burning for prairie chickens has been discussed in detail by Kirsch and Kruse (1973), Westemeier (1972) and Kirsch (1974). The effects of burning, rotary mowing, and herbicides on plant species composition and density for the grassland habitat in central Wisconsin have been evaluated by Halversen (1981).

Figures 59 and 60 present day and night habitat use respectively for radio-tagged prairie chickens by type of last disturbance in central Wisconsin. The agricultural disturbance types dominated day use during fall and winter while grazed areas dominated the habitat used during the warm weather periods. Areas of moderate grazing received heavy use during summer and reflected the mixed structure of tall and short cover. The use of heavily grazed cover peaked during mid-summer. Disturbed areas used at night were primarily areas of moderate or light grazing.

Habitat that was burned or disturbed by agricultural

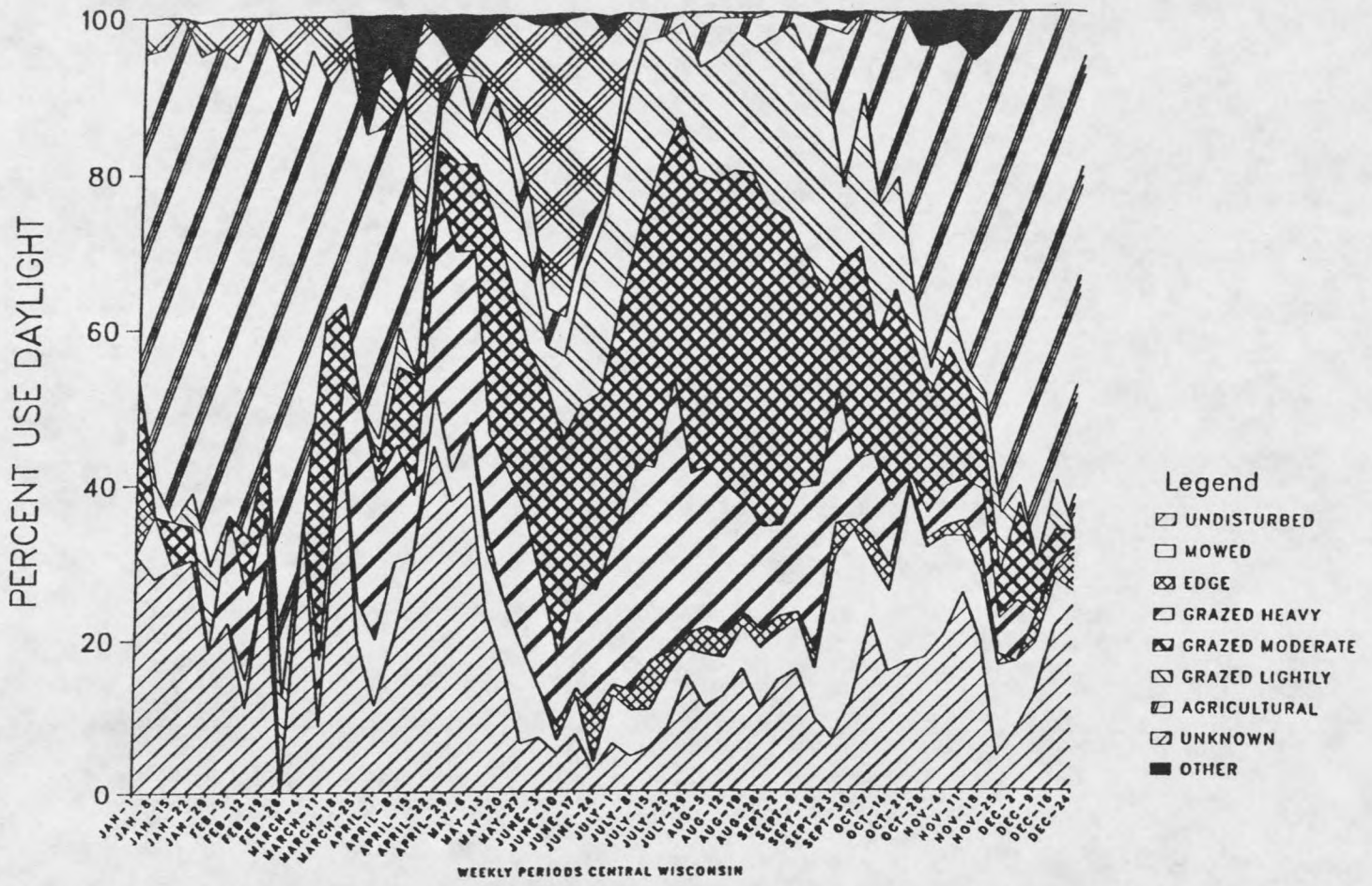


Figure 59. Weekly use of cover by type of last disturbance for radio-tagged prairie chickens during the day, central Wisconsin, 1972-76.

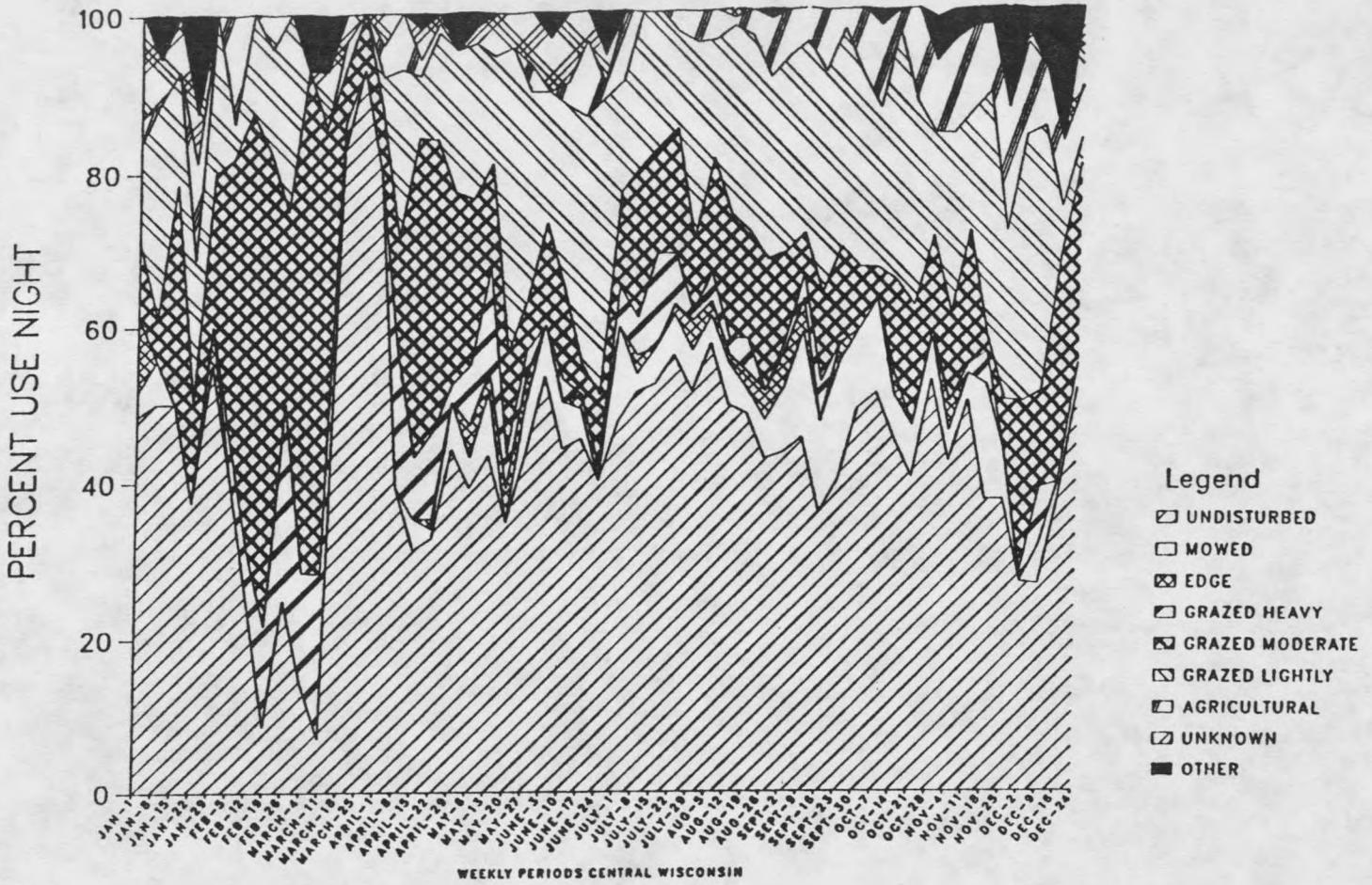


Figure 60. Weekly use of cover by type of last disturbance for radio-tagged prairie chickens at night, central Wisconsin, 1976-78.

means dominated cover used at Crex during the day (Fig. 61). Habitat types disturbed by fire dominated cover used at night during all seasons (78-88%), except during the spring (59%) when one-third of the area was burned (Fig. 62).

Light to moderate or even heavy grazing can be beneficial as long as it leaves 50% or more of the grass cover in the Class III category. Baker (1953) believed that prairie chickens benefited from moderate grazing that created paths and small areas of reduced cover which facilitated movement and provided sunning areas in which to get away from wet vegetation. With grazing, it is important to prevent changes in species composition towards shorter species. Heavy grazing or mowing that produces large areas of Class I and II vegetation will be detrimental to prairie chicken numbers. Such areas provide habitat only for booming grounds and feeding areas during the snow-free seasons and provide no cover for nesting or brood rearing. Short cover occurs naturally (with or without grazing) as a site specific phenomenon and is rarely a limiting factor in a grassland area.

Successful management of prairie chickens involves maintaining large areas of grassland habitat in the Class III and IV height classes. However, grassland vegetation must be periodically disturbed to prevent it from becoming brushland and/or too rank for prairie chickens to use.

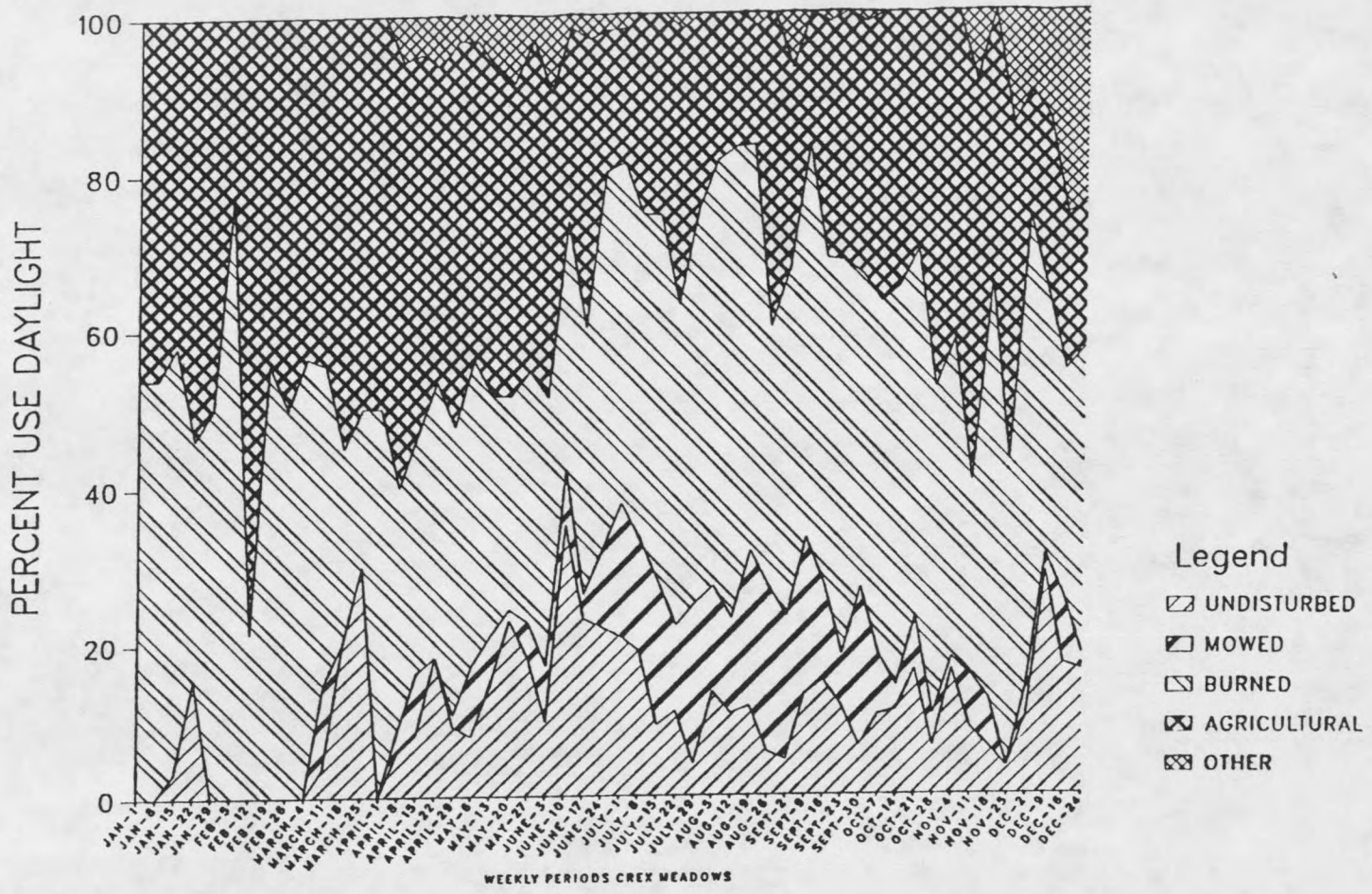


Figure 61. Weekly use of cover by type of last disturbance for radio-tagged prairie chickens during the day, Crex Meadows Wildlife Area, Wisconsin, 1976-78.

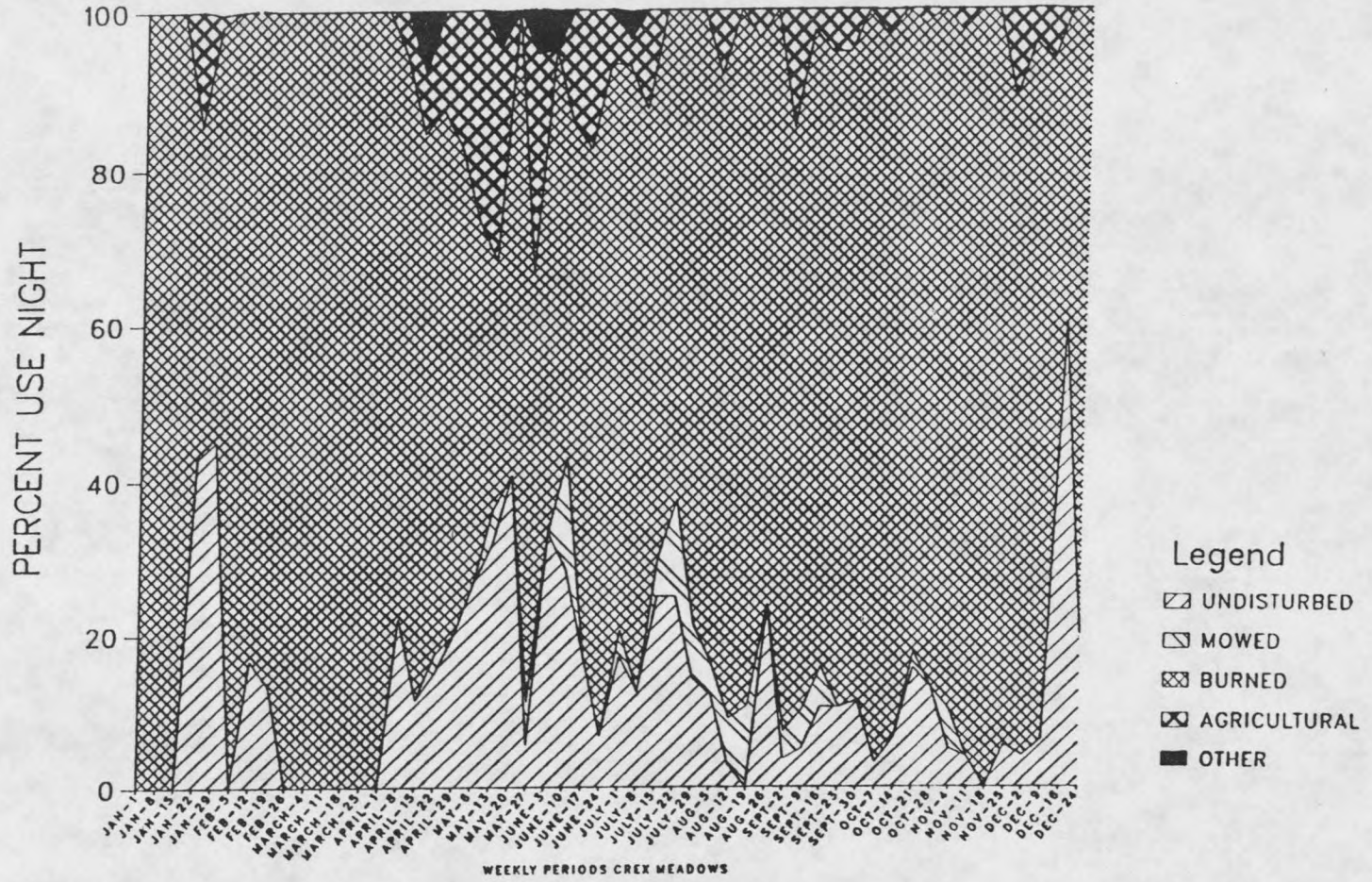


Figure 62. Weekly use of cover by type of last disturbance for radio-tagged prairie chickens at night, Crex Meadows Wildlife Area, Wisconsin, 1976-78.

Land Use Patterns

On an annual basis, prairie chicken habitat use based on land ownership in central Wisconsin was nearly an equal mix between private (54.0%) and managed public land (46.0%). Private land was used most during the day (65.0%) and public land at night (72.0%). Private land made up 76.5% of the central Wisconsin study area.

This pattern of use was not related to land ownership per se but to the activities that do and do not occur on the two types of land. The main activities on private land were the planting of crops and the grazing of cattle. Grazed lands were used by cocks and non-brooding hens for feeding in the summer and late spring. No grazing occurred on public land until 1 August, so grazed cover was not available on public land when birds left their booming grounds and nesting areas in late spring. Private agricultural fields were used by prairie chickens for feeding in fall, winter and late spring. However, small food patches of standing corn and buckwheat were planted on public land to supplement agricultural food on private land.

The use of private land was highest during the day in all seasons and ranged from 52.3% in winter to 65.0% in summer. The highest use of public land occurred at night and ranged from 67.0% during the winter to 79.4% during the summer, reflecting the greater incidence of height Classes

III and IV and undisturbed cover used by prairie chickens for night roosting. The highest use of private land occurred during winter when prairie chickens used the relatively undisturbed shrub/wetland habitat for night roosting and agriculture for feeding. Figure 63 and 64 present weekly habitat use by land ownership for prairie chickens during the day and night respectively in central Wisconsin, 1972-1976.

The combined use of private and public land by prairie chickens in central Wisconsin was implied when Hamerstrom et al. (1957) proposed ecological patterning. Under this management scheme, public land provided the taller undisturbed grassland cover critical for nesting, brood rearing and night roosting, while private agricultural land provided additional open space and food. This interspersion of private and public land permitted prairie chickens to move between the 2 types to meet their daily and seasonal needs. With approximately equal use of private and public land on a year-long basis, but only 25% of the area in public lands suggests that an increase in public ownership or cover in the height Classes III and IV would result in a larger prairie chicken population. However, incorporation of private land into the prairie chicken management plan in central Wisconsin is a necessary compromise due to the high cost of obtaining and managing grassland reserves. It is apparent that prairie

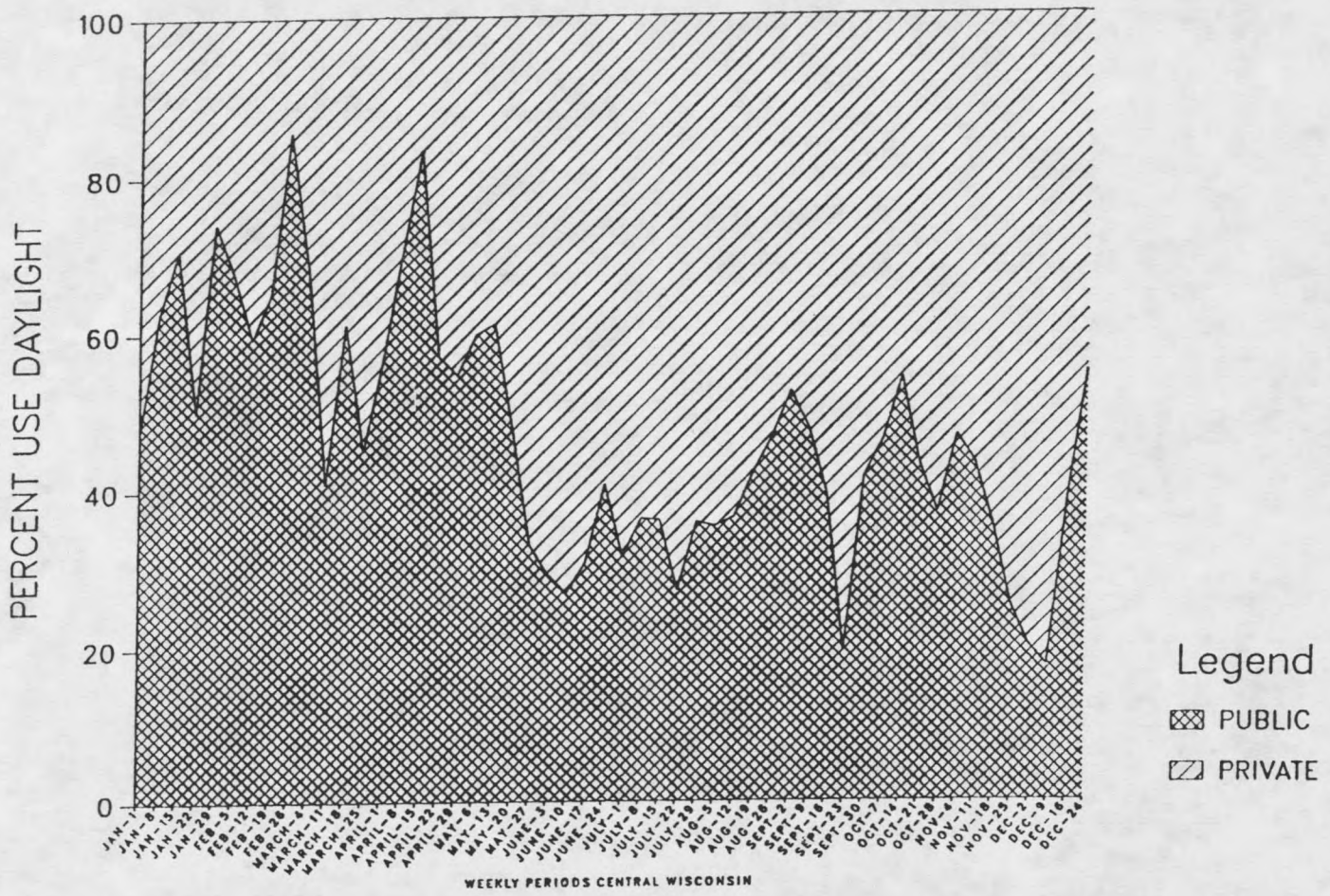


Figure 63. Weekly use of land types by land ownership during the day for radio-tagged prairie chickens, central Wisconsin 1976-78.

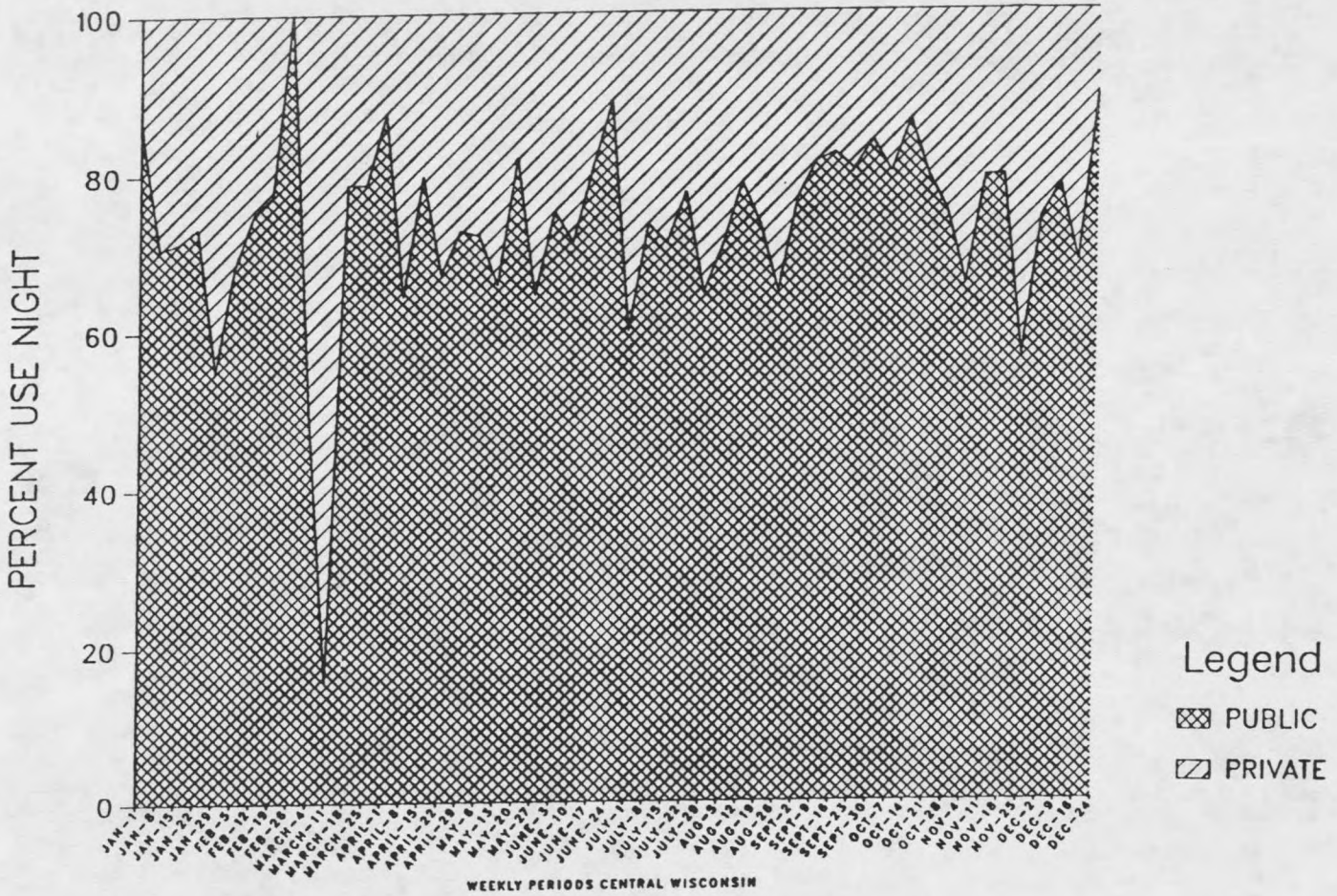


Figure 64. Weekly use of land types by land ownership at night for radio-tagged prairie chickens, central Wisconsin, 1972-76.

chickens make extensive use of private land throughout the year for feeding, but these private holdings are excessive to their needs. Small agricultural fields 4-6 ha in size, one for every 2 booming grounds, would easily meet the year-round needs for agriculture by prairie chickens.

At Crex, the nearest private agricultural land was 10 km away. However, the use of agricultural fields throughout the year was comparable to the use of private land in central Wisconsin. Management practices at Crex created and maintained a limited amount of prairie chicken habitat, but at a considerably higher cost. The management objectives at Crex were not single species oriented, but geared to maintain a brush prairie habitat that was beneficial to deer and breeding and migrating waterfowl. These objectives have created an open grass and grass-shrub habitat that will support sharptail grouse and a few prairie chickens.

Night and Day Roosting

A total of 1,553 prairie chicken and 718 prairie grouse night roosts were examined in central Wisconsin and Crex respectively. Night roosts were differentiated from day roosts by the greater accumulation of droppings. Most night roosts were located by walking in on radio-tagged individuals at night. The examined roosts confirms the use of cover by height classes as indicated by night locations of radio-tagged prairie chickens.

Height Class III dominated cover at roost sites in all seasons except during the winter in central Wisconsin (Table 65) where Class IV was used most in the winter (53.6%). Class III dominated cover used for night roosting at Crex during all seasons (74.3-92.0%). The high use of Class III at Crex, particularly in the winter was due to large areas of wetland grass and sedges. This type of habitat in central Wisconsin was usually associated with willows and was in the IV and sometimes V height classes. Class V cover was used during winter and most use occurred in standing corn or a few snow burrows in taller scattered willow, aspen or cherry clumps.

Table 66 compares seasonal species composition at examined night roosts in central Wisconsin 1972-76 and at Crex Meadows 1976-78. In central Wisconsin, Carex spp., Scirpus, Solidago spp., and the wetland grasses dominated cover at night roosts during the winter. Salix spp., Populus spp. and Cornus spp. were the main woody plants associated with winter night roosts. Bluegrass and quackgrass, 2 of the main species present at roost sites during the snow-free seasons, were of minor importance during the winter. Bluegrass made up ground cover with quackgrass, timothy and goldenrod providing cover above the bird. The presence of bluegrass seemed to reduce the density of the taller species and allowed the bird to move through the cover. The taller sedges and forbs were used

Table 65. Use of vegetation height classses (%) for prairie chicken day and night roosts by season in central Wisconsin 1972-76 and Crex Meadows Wildlife Area 1976-78. Number of roosts examined are in parentheses.

	Central Wisconsin				Crex Meadows			
Height	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
NIGHT ROOSTS								
Class I	1.7 (10)	8.3 (12)	1.6 (6)	-	2.9 (8)	-	-	-
Class II	6.4 (38)	2.1 (3)	1.1 (4)	6.8 (30)	12.9 (34)	5.0 (6)	4.0 (8)	-
Class III	23.4(138)	84.7(122)	93.1(351)	66.1(292)	74.3(201)	92.0(116)	85.0(179)	84.0 (94)
Class IV	53.6(317)	4.9 (7)	4.2 (16)	26.9(119)	10.0 (27)	3.0 (4)	11.0 (23)	16.0 (18)
Class V	14.9 (88)	-	-	-	-	-	-	-
DAY ROOSTS								
Class I	7.9 (32)	5.4 (8)	4.0 (15)	2.7 (6)	-	2.5 (3)	9.8 (40)	2.7 (6)
Class II	14.9 (61)	37.0 (54)	22.6 (84)	12.4 (28)	0.3 (1)	5.0 (6)	11.7 (48)	12.6 (28)
Class III	24.5 (99)	57.5 (84)	69.1(251)	64.6(146)	44.6(156)	79.3 (96)	61.5(252)	55.8(124)
Class IV	21.8 (88)	-	4.3 (16)	20.4 (46)	37.1(130)	13.2 (16)	17.1 (70)	28.8 (64)
Class V	10.6 (43)	-	-	6.2 (14)	18.0 (63)	-	-	-

Table 66. Plant species composition (≤0.5%) within 1 meter of night roosts of wild prairie chickens by season in central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78.

Species	Central Wisconsin				Crex Meadows			
	Winter n=542	Spring n=141	Summer n=369	Fall n=432	Winter n=263	Spring n=118	Summer n=205	Fall n=102
GRASSES/SEDGES								
Andropyron repens	1.4	11.3	26.7	12.1	-	0.4	2.3	0.5
Poa pratensis	9.6	32.3	37.0	45.6	-	-	-	-
Poa palustris	2.0	0.5	0.2	0.4	-	-	-	-
Phleum pratense	0.1	4.9	5.3	12.4	-	-	-	-
Phalaris arundinacea	0.1	0.5	2.6	-	-	0.2	0.3	0.3
Bromus inermis	0.4	0.1	3.0	0.1	-	-	-	-
Andropogon gerardi	-	-	-	-	-	-	0.3	0.1
Calamagrostis canadensis	9.3	2.5	0.7	1.2	26.0	29.6	25.7	26.7
Carex rostrata	29.8	7.4	1.9	3.7	40.5	38.6	27.0	36.6
Carex stricta	2.0	-	-	-	27.8	17.9	4.4	18.2
Carex spp.	2.0	1.0	0.3	0.1	3.0	2.6	2.8	3.1
Muhlenbergia spp.	5.6	1.2	1.7	1.5	0.1	0.8	7.4	1.9
Scirpus cyperinus	2.0	-	-	-	1.1	2.0	2.9	1.9
Unknown grass	1.5	0.1	-	0.2	-	-	-	0.1
FORBS								
Solidago canadensis	1.1	6.5	4.6	0.2	-	-	-	-
Linaria vulgaris	-	3.5	5.0	6.3	-	-	-	-
Vebascum thapsus	0.5	0.1	-	0.1	-	-	-	-
Asclepis syriaca	-	0.9	0.9	0.9	-	-	-	0.1

Table 66. Continued.

Species	Central Wisconsin				Crex Meadows			
	Winter n=542	Spring n=141	Summer n=369	Fall n=432	Winter n=263	Spring n=118	Summer n=205	Fall n=102
Taraxacum officinale	–	–	0.1	0.7	–	–	–	–
Lycopus americanus	–	0.6	0.4	1.3	–	–	–	–
Fragaria spp.	–	15.4	2.5	0.1	0.1	0.5	1.3	1.2
Thalicturn sp.	–	–	–	–	–	–	–	1.3
Onoclea sensibilus	–	–	–	–	0.1	0.4	0.6	0.4
Pteridium aquilinum	–	–	–	–	0.4	0.1	1.0	1.6
Solidago spp.	14.1	4.5	2.4	5.3	–	–	–	–
Solidago graminifolia	–	1.8	1.3	4.5	–	–	–	–
Urtica dioica	–	–	1.1	–	–	–	–	–
Brassica sp.	–	–	–	0.3	–	–	–	–
Achillia millefolium	–	0.5	0.2	0.6	–	–	–	–
SHRUBS								
Salix spp.	5.4	1.0	0.3	0.5	0.8	2.3	3.5	1.8
Rubus spp.	1.2	0.3	0.1	0.2	0.4	0.4	4.0	0.5
Comptonia peregrina	–	–	–	–	0.3	0.8	7.2	1.3
Quercus spp.	–	–	–	–	–	0.5	–	–
Corylus americana	–	–	–	–	–	–	0.5	–
Spirea sp.	2.6	0.2	0.1	0.1	1.3	4.7	6.8	3.8
Populus spp.	7.4	2.0	0.5	1.0	–	–	–	–
Cornus stolonifera	6.7	1.8	0.5	0.9	–	–	–	–
Vaccinium spp.	–	–	–	–	0.5	0.3	3.3	0.8

more during the spring and fall when temperatures were colder than summer (Table 66). Shrubs were important only during the winter.

At Crex, the sedges and reed grass dominated the cover at night roosts with sedges occurring more during the winter. Shrubs were used very little for night roosting at Crex and were used most during the summer when the birds roosted in the upland in sweetfern and Spirea (Table 66). Based on data from both areas, taller species were selected for night roosting by prairie chickens and wetland species played a major role in providing cover for roosting during the winter.

A total of 1,148 prairie chicken day roosts and 1,103 prairie grouse roosts were examined in central Wisconsin and Crex respectively. Class III dominated (57.5-69.1%) the cover used for day roosting in all seasons in central Wisconsin except during the winter (Table 65). Class IV cover was used most for day roosting during the winter (53.6%) in central Wisconsin. At Crex, Classes III and IV cover dominated the day roosting cover used by prairie chickens during the winter. Class IV vegetation was also used during the fall and reflected the colder temperatures during this period. This pattern was most evident in central Wisconsin (Table 65).

Day roosts were found in Class I and II at a much higher rate than night roosts in all seasons in central

Wisconsin and at Crex. The higher use of the lower height classes was the result of the birds selecting day roosts in or near the disturbed cover where they fed. The security needs of prairie chickens during the day are not as critical as at night. Day roosts are temporary and the birds typically used several during the day. This was in contrast to night when a bird remained in 1 spot for 8-12 hours. Schwartz (1945) noted that day roosts were occasionally in shorter and less dense cover than night roosts.

The role of disturbance in creating shorter cover can be seen in the day roosts at Crex. The prairie chickens at Crex did not use the shorter cover for day roosting at as high a rate as the birds in central Wisconsin. At Crex, they fed in the small agricultural fields which were surrounded by taller undisturbed cover into which they could easily walk for day roosting after feeding.

Species composition of day roosts for prairie chickens in central Wisconsin and Crex Meadows are presented in Table 67. In central Wisconsin, bluegrass and quackgrass dominated the species at day roosts. Solidago spp. was used at a much higher rate in day than night roosts and reflects its association with bluegrass and disturbed areas. The butter and eggs also showed up at day and night roosts and was associated with bluegrass areas. Sedges were used, but at a much lower rate during the day than at night.

Table 67. Plant species composition (≤0.5%) within 1 meter of the day roosts of wild prairie chickens by seasons in central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78.

Species	Central Wisconsin				Crex Meadows			
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
GRASSES/SEDGES								
Andropyron repens	13.9	10.1	37.2	19.1	-	2.3	3.3	1.2
Poa pratensis	29.6	59.1	40.4	52.4	-	-	-	-
Poa palustris	1.5	0.4	7.8	2.1	-	-	-	-
Phleum pratense	1.8	1.7	2.5	2.0	-	0.4	0.6	0.2
Phalaris arundinacea	1.0	-	-	-	-	0.6	0.9	0.3
Bromus inermis	-	1.3	0.2	1.1	-	-	-	-
Andropogon gerardi	-	0.5	0.2	-	0.3	11.7	2.4	4.5
Calamagrostis canadensis	3.5	-	0.6	0.1	4.6	3.6	13.0	8.0
Carex rostrata	5.2	-	-	-	27.9	16.8	5.6	13.9
Carex stricta	2.0	-	-	-	46.1	27.2	45.1	39.8
Carex spp.	-	0.1	1.6	0.5	0.1	4.4	1.3	2.1
Cyperus sp.	-	-	-	-	-	1.4	2.1	0.7
Iris vesicolor	-	-	-	-	0.2	0.4	0.2	0.2
Muhlenbergia spp.	-	-	-	-	3.4	9.9	5.3	5.5
Scirpus cyperinuss	2.5	-	-	-	11.4	5.1	10.6	14.9
FORBS								
Solidago canadensis	18.0	19.8	4.1	17.3	0.1	0.6	0.9	0.3
Linaria vulgaris	3.6	3.2	1.7	3.0	-	-	-	-
Galium boreale	-	-	-	-	0.1	2.0	0.3	0.7

Table 67. Continued.

Species	Central Wisconsin				Crex Meadows			
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Streptopus sp.	–	–	–	–	–	0.9	0.2	0.3
Asclepis syriaca	–	0.5	0.2	0.9	0.1	0.9	0.2	0.3
Taraxacum officinale	–	–	0.1	0.7	–	–	–	–
Lycopus americanus	–	0.6	0.4	1.3	–	–	–	–
Fragaria spp.	–	1.7	0.7	–	–	0.2	0.1	0.1
Thalicturn sp.	–	–	–	–	–	–	–	1.3
Onoclea sensibilis	–	–	–	–	0.2	0.5	0.2	0.2
Pteridium aquilinum	–	–	–	–	0.5	2.3	0.7	1.0
Soliodago spp.	–	–	0.5	0.3	–	0.1	–	–
Solidago graminifolia	3.6	3.1	0.5	2.7	–	–	–	–
Urtica dioica	–	–	0.5	–	–	–	–	–
SHRUBS								
Salix spp.	4.0	0.1	1.3	0.4	1.4	0.4	1.0	1.4
Rubus spp.	–	–	–	–	0.1	0.6	0.1	0.2
Comptonia peregrina	–	–	–	–	0.1	0.7	0.1	0.2
Quercus spp.	–	–	–	–	0.1	0.5	0.1	0.2
Corylus americana	–	–	–	–	0.7	1.4	–	0.2
Spirea sp.	1.0	0.1	2.2	0.6	1.7	2.9	4.1	2.3
Populus spp.	0.2	2.0	0.5	1.0	0.1	0.3	–	0.1
Cornus stolonifera	0.7	1.8	0.5	0.9	–	–	–	–
Vaccinium spp.	–	–	–	–	0.3	0.7	–	0.1
Other	–	–	–	0.5	–	–	–	–

At Crex, sedges and wetland grasses dominated the cover found at day roosts. The only upland grass used for day roosting at Crex was big bluestem (0.3-11.7%). The use of sedges at Crex reflected the availability of these species in undisturbed areas in close proximity to the agricultural fields where birds fed. Shrubs made up a small percentage of the species found at day roosts in central Wisconsin and at Crex.

Habitat-- Transplants, Pen-reared versus Residents

Habitat types used by the radio-tagged transplanted prairie chickens during orientation and released pen-reared birds were compared with wild residents for the period 15 April to 1 June (Tables 68-70).

Pen-reared Birds

The most obvious difference in habitat use between wild and pen-reared prairie chickens was the high use by the latter of the pen during the day in both the spring (34.8%) and the fall (25.1%). Most of the released birds fed or loafed and the cocks displayed in the pen area which increased the amount of short, open cover used by pen-reared birds when compared to wild residents at Crex (35.2% versus 19.7%). The high use of open cover also made the pen-reared birds more observable than wild prairie chickens.

Table 68. Comparisons of habitat use (%) between wild residents, transplanted and pen-reared radio-tagged prairie chickens during spring[a] in central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, 1975-1978. Number of locations are in parentheses.

Habitat Type	Day	Night	Total
AGRICULTURE			
Central Wisconsin	6.2 (49)	0.7 (3)	4.3 (52)
Crex Meadows	36.5 (216)	11.5 (26)	29.6 (242)
Transplants	19.0 (64)	6.6 (12)	14.7 (76)
Pen-reared	13.6 (58)	1.8 (4)	9.6 (62)
GRASS/SEDGE			
Central Wisconsin	49.4 (389)	32.8(133)	43.9 (522)
Crex Meadows	18.6 (110)	25.2 (57)	20.4 (167)
Transplants	51.0 (172)	45.4 (84)	49.4 (256)
Pen-reared	14.7 (63)	16.0 (35)	15.2 (98)
GRASS FORBS			
Central Wisconsin	31.0 (244)	55.1(223)	39.2 (467)
Crex Meadows	4.9 (29)	6.2 (14)	5.3 (43)
Transplants	1.5 (5)	1.7 (3)	1.5 (8)
Pen-reared	1.4 (6)	2.7 (6)	1.9 (12)
GRASS SHRUB			
Central Wisconsin	1.0 (8)	0.5 (2)	0.8 (10)
Crex Meadows	13.2 (78)	18.6 (42)	14.7 (120)
Transplants	13.6 (46)	26.5 (48)	18.1 (94)
Pen-reared	15.2 (65)	41.1 (90)	24.0 (155)
SHRUB			
Central Wisconsin	2.0 (16)	2.0 (16)	2.0 (24)
Crex Meadows	2.9 (17)	4.0 (9)	3.2 (26)
Transplants	4.5 (15)	6.6 (12)	5.2 (27)
Pen-reared	4.2 (18)	4.1 (9)	4.2 (27)
EDGE			
Central Wisconsin	8.5 (67)	5.4 (22)	7.5 (89)
Crex Meadows	22.5 (133)	34.5 (78)	25.8 (211)
Transplants	8.6 (29)	12.2 (22)	9.8 (51)
Pen-reared	16.1 (69)	24.7 (54)	19.1 (123)
OTHER[b]			
Central Wisconsin	1.7 (13)	3.5 (14)	0.3 (27)
Crex Meadows	1.5 (9)	-	1.0 (9)
Transplants	1.8 (6)	-	1.2 (6)
Pen-reared	34.8 (147)	9.6 (21)	26.0 (168)

[a] Common period for pen-reared and residents 15 April-30 May and transplants during orientation periods.

[b] Other habitat types include trees, release pen, and forbs except for pen-reared birds where other category equals the release pen.

Table 69. Comparisons of habitat disturbance type use (%) between wild resident, transplanted and pen-reared radio-tagged prairie chickens during spring[a] in central Wisconsin, 1972-76 and Crex Meadows Meadows Wildlife Area, Wisconsin, 1976-78. Number of locations are in parentheses.

Disturbance Habitat Type	Day	Night	Total
DISTURBED			
Central Wisconsin	41.4 (296)	18.8 (72)	33.3 (368)
Crex Meadows	51.1 (291)	27.6 (61)	44.6 (352)
Transplants	25.8 (95)	14.3 (27)	21.8 (122)
Pen-reared	27.1 (74)	3.0 (6)	17.0 (80)
UNDISTURBED			
Central Wisconsin	26.4 (189)	53.3(204)	36.3 (393)
Crex Meadows	40.6 (231)	67.9(150)	48.2 (381)
Transplants	59.6 (201)	74.1(140)	61.2 (341)
Pen-reared	66.3 (181)	93.4(185)	77.7 (366)
EDGE			
Central Wisconsin	32.2 (230)	27.9(107)	30.4 (337)
Crex Meadows	8.3 (47)	4.5 (10)	7.2 (57)
Transplants	19.8 (73)	19.0 (36)	16.9 (109)
Pen-reared	6.6 (18)	3.5 (7)	5.3 (25)
TOTAL			
Central Wisconsin	64.2 (726)	34.5(383)	100.0(1098)
Crex Meadows	72.0 (569)	28.0(221)	100.0 (790)
Transplants	65.1 (337)	34.9(181)	100.0 (518)
Pen-reared	58.0 (273)	42.0(198)	100.0 (471)

[a] Common time period equals 15 April-30 May for resident and pen-reared birds and orientation periods for transplants.

Table 70. Comparisons of vegetative height class use (%) between resident, transplanted and pen-reared radio-tagged prairie chickens during spring[a] in central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78. Number of locations are in parentheses.

Height Class[b]	Day	Night	Total[a]
CLASS I			
Central Wisconsin	15.9 (124)	1.0 (4)	10.8 (128)
Crex Meadows	19.7 (117)	0.9 (2)	14.5 (119)
Transplants	6.5 (22)	0	4.2 (22)
Pen-reared	30.4 (129)	1.8 (4)	20.7 (133)
CLASS II			
Central Wisconsin	28.2 (220)	5.7 (23)	20.5 (243)
Crex Meadows	15.5 (92)	3.5 (8)	12.2 (100)
Transplants	18.2 (62)	12.2 (22)	16.1 (84)
Pen-reared	8.7 (37)	3.2 (7)	6.8 (44)
CLASS III			
Central Wisconsin	50.2 (392)	87.3(352)	62.8 (744)
Crex Meadows	54.0 (320)	76.5(173)	60.2 (493)
Transplants	57.2 (195)	1.5 (108)	58.0 (303)
Pen-reared	49.4 (211)	85.8(187)	61.9 (398)
CLASS IV			
Central Wisconsin	5.2 (43)	6.0 (26)	5.8 (69)
Crex Meadows	10.8 (64)	19.0 (43)	13.1 (107)
Transplants	18.2 (62)	28.2 (51)	21.6 (113)
Pen-reared	11.2 (48)	9.2 (20)	10.6 (68)
TOTAL			
Central Wisconsin	66.1 (783)	33.9(401)	100.0(1184)
Crex Meadows	72.4 (461)	27.6(818)	100.0 (819)
Transplants	63.3 (341)	34.7(181)	100.0 (522)
Pen-reared	66.2 (426)	33.8(217)	100.0 (643)

[a] Common period equals 15 April-30 May for resident and pen-reared; orientation period for transplants.

[b] See text for explaination.

All major habitat types available to the wild prairie chickens at Crex were available within 200 m of the release pen. However, the strong attraction to the pen limited mobility. Radioed pen-reared birds used the pen area and made no effort to expand their movements beyond this familiar area.

Pen-reared radioed birds released away from the pen area also restricted movements and habitat use to a small area. Excluding pen locations, habitat use by pen-reared prairie chickens was a mix of the habitat types surrounding the pen; grass-shrub (20.3%), grass (19.7%) agriculture (18.5%) and edge (21.6%).

Habitat types used by resident prairie chickens at Crex during the day were agriculture (36.5%), grass (18.6) and grass-shrub (13.2%). The main difference between habitat used by wild and pen-reared prairie chickens was the higher use of grass-shrub habitat by pen-reared birds (20.3% versus 13.2%) and higher use of agriculture by wild birds (36.5% versus 13.6%). The lower use of agriculture by pen-reared birds reflected their use of the pen for feeding. In central Wisconsin, grass (49.4%) and grass-forbs (31.0%) were the main habitat type used by radioed prairie chickens during the day.

Pen-reared birds used the grass-shrub habitat (41.1%) followed by edge (24.7%) and grass (16.0%) for night roosting. Just the opposite was observed in wild birds

where grass (25.2%) was used more than the grass-shrub habitat (18.6%). In central Wisconsin, grass-forbs (55.1%) and grass (32.8%) were used for night roosting. Pen-reared and wild residents all exhibited the general pattern of shifting from disturbed habitat types during the day to undisturbed cover at night (Table 69). However, pen-reared birds used the undisturbed cover more during the day (66.3%) than their respective wild counterparts (26.4% and 40.6%). This difference was due to a large amount of undisturbed habitat around the pen.

Pen-reared and wild birds also showed a similar pattern of habitat use by height class with Class III vegetation dominating use in pen-reared and wild birds at Crex and central Wisconsin (61.9%, 60.2% and 62.8% respectively). Pen-reared birds, like their wild counterparts, shifted from the lower height classes during the day to taller cover for night roosting (Table 70). Use of vegetation by height classes would seem to be instinctive and related to greater protection and security afforded by taller vegetation.

A total of 62 night and 48 day roosts of pen-reared birds were examined at Crex during April and May 1975-1976. The use of cover for night roosting by pen-reared prairie chickens was comparable to wild birds (Class IV 9.7%, Class III 77.4% and Class II 12.9%).

During the October release in 1974, only 207 locations

were obtained from radio-tagged pen-reared birds, 25.1% of which occurred at the pen. The main habitats used during the day were agriculture (18.5%) grass-shrub (17.0%) and grass (11.6%), the 3 main habitat types within 200 m of the pen. During the fall, class III vegetation dominated (47.4%) the habitat use of pen-reared birds during the day and like wild birds the pen-reared prairie chickens shifted to Class III (64%) and IV (33%) cover for night roosting. These patterns were similar to those observed in wild birds in October and pen-reared birds released during the spring.

Transplanted Birds-- Orientation

The habitat data from the radio-tagged transplants during orientation in 1976 and 1977 were pooled for analysis and provided 518 locations. Although transplanted prairie chickens wandered through unfamiliar habitat, incapable of supporting prairie chickens, they still exhibited patterns of habitat use similar to those of resident prairie chickens: grass dominated (49.4%), followed by agriculture (14.7%) and grass shrub (18.1%)(Table 68).

Transplanted birds actively sought out undisturbed grass habitat in an agricultural community that contained few blocks of undisturbed grass larger than 10 ha. Most of the grass in this area consisted of undisturbed lowlands or grass-forb borders along agricultural fields. Agricultural areas used during the day consisted primarily of picked or

cut corn and were used for feeding. Woodland areas were not used even though several birds moved north of Crex into wooded habitat. When these birds were located they were in small wetland openings (10-80 ha, N=6) surrounded by mature forest.

Transplants used undisturbed cover during the day more than wild residents (59.6% versus 26.4-40.6%). It appeared that transplanted birds were attracted to these small undisturbed patches of grass and lowland areas as they wandered through the agricultural community. At night, 74.1% of the transplanted bird locations were in undisturbed cover. However, transplants used Class III and IV cover at a higher rate during the day and did not exhibit as great a shift to taller cover from day to night as residents (Table 70). Transplants, except when feeding apparently spent more time in more secure cover during the day.

Limited mobility, lack of flying and the attraction to the release pen was responsible for differences in habitat use between pen-reared and wild prairie chickens. However, day and night use of cover by height was comparable in both wild and pen-reared birds. Use of cover by height class was also comparable between transplanted prairie chickens and wild birds. The consistent use of Class III cover and shift to taller cover at night in wild, transplanted and pen-reared prairie chickens suggested that use of cover by

height was instinctive and a critical component of habitat.

Grass areas used by the transplanted birds during orientation were too small and too few in number to support a prairie chicken population, but did meet the structrual cover needs of adult prairie chickens. This points out a major paradox of habitat information based solely on data from adult sized birds. In order for an area to support a population it must not only meet the daily and yearly needs of adults, but provide enough habitat for adults to successfully nest and raise young. The habitat types used by adults may or may not be related to the quality of the habitat. Habitat types used by individuals in a declining population may be similar to those in an increasing population, and differences in numbers related to poor survival or production. Only through density measurements and the longterm maintenance of a population at relatively stable numbers can one evaluate the quality of the habitat. This aspect of habitat use was emphasized by the similar manner in which the transplanted, pen-reared, and wild resident prairie chickens used habitat. Habitat available at Crex was excellent for adult prairie chickens, but contained insufficient upland grass for nesting and brood rearing to maintain the reestablished population.

Nesting

Wild Birds

A total of 29 nests were located in central Wisconsin in 1972 and 1974. Nesting success was 52% with the fates of 2 nests undetermined. At Crex, 8 nests from 6 radioed resident hens were located in 1976-78 and nesting success was 50%. A nest was considered successful if 1 egg hatched. Nesting success of approximately 50% for prairie chickens has also been reported by Gross (1930), Hamerstrom and Hamerstrom (1939), Yeatter (1943), Baker (1953) and Sisson (1976). Robel et al. (1970) reported nesting success of 26% for prairie chickens in Kansas. Hatchability of individual eggs was 91.3% for residents in central Wisconsin and 97.3% for transplants that hatched nests. Ammann (1957) reported a hatchability rate of 90.9%.

Pen-reared

None of the released radio-tagged pen-reared hens were known to have nested in 1975. Nest clockers near the pen and a single hen observed with a brood of 5 chicks on 27 June indicated that at least 1 of the 15 pen-reared hens nested. This hen was observed 3 times during July and was without chicks.

Three of the 10 radio-tagged pen-reared hens released in 1976 nested, 3 exhibited egg-laying behavior and 1 hen

renested after she abandoned her first nest. Six nests of non-radioed birds were located and 3 other hens were observed with incubation patches indicating that at least 15 of the 77 hens released initiated nests. In wild prairie chickens, all of the hens alive in late April initiated nests or exhibited egg-laying behavior.

Of the 10 nests of pen-reared hens under observation none were successful. Four nests were destroyed, 3 abandoned before the hens were killed and the eggs disappeared from the 3 remaining nests. Abandonment of nests was unusual in wild prairie chickens and occurred in only 2 of 42 nests under observation. One hen abandoned her nest during egg-laying and the other hen was stepped on during a nest search.

The 1 brood observed in 1975 indicated that pen-reared prairie chicken hens will nest and hatch chicks, although the high abandonment suggests some physical or behavioral problems with incubation.

Clutch size

Mean clutch size for prairie chickens in central Wisconsin was 11.3±1.9 (N=29, Range 8-16) similar to that reported by Hamerstrom and Hamerstrom (1939), Baker (1953) and Ammann (1957). Clutch sizes were slightly larger for adults than immatures (11.6±2.5, n=15 versus 11.0±1.6, n=9, P=0.445). Newell (1987) also found clutch sizes of initial nests of adult prairie chickens were larger than clutches

of immatures (14.3±1.3, n=22 versus 13.6±1.5, n=19, P=0.122). The large clutch sizes in adults was believed to be the result of their size and maturity (See Section on Condition). The mean clutch size of renests was smaller than initial nests (9.0±0.8, n=8 versus 11.9±2.4, n=20, P=0.001). Newell (1987) also found renests to be smaller than initial nests (11.4±1.9, n=17 versus 13.9±1.4, n=41, P=0.128). Others, although uncertain of the nest sequence, have reported that clutch size of later nests were smaller than early nests (Baker 1952, Arthrud 1977, and Svedarsky 1979). The mean clutch size for the initial nests of pen-reared prairie chickens was 11.1±2.3, (n=9) and was comparable to the clutch size of wild immature hens (11.0±1.6, n=9, P=0.916).

Mean clutch size of transplanted prairie chickens was 10.0±3.1 (n=10, Range 4-12), which included the clutches of 3 transplanted hens that wandered away from Crex for 4 weeks. These 3 hens laid small clutches (4, 6, and 4 eggs) which may have resulted from excessive weight loss due to large movements made by these individuals before nesting. The exclusion of these 3 hens increased the mean clutch size to 11.3±1.8 (n=7, Range 8-12) which was comparable to that of residents.

Toepfer (1976) found that 3 hens transplanted in central Wisconsin also laid normal clutches. Prairie chicken hens transplanted during the peak of the breeding

season are capable of producing normal clutches and hatching broods provided they begin nestingwithin 16 days.

Nesting Cover

One of the most obvious components of prairie chicken nesting habitat was the presence of residual grass around the nest bowl. Leopold (1933) indicated that because all gallinaceous birds start nesting before green growth is available, they are dependent upon residual vegetation to provide nesting cover.

All three types of prairie chickens located their nests in vegetation from the previous seasons growth (Residents 74%, Transplants 100%, Pen-reared 90.0%, Total 82.2%, n=45). Most nests were located in Class III residual vegetation (Residents III 63%, II 25.9%, I 11.1%, Transplants III 75%, II 12.5%, I 12.5%, Pen-reared III 90%, I 10%, Total III 68.9%, II 20.0%, I 11.1%). The height of residual grass was important as nesting success was higher for nests in taller classes (Class III 63.6% 14/22, II 44.9% 4/9 and I 0% 0/4). Newell (1987), based on 50 prairie chickens nests, also found that cover was taller at successful nests than unsuccessful and that cover was higher at the nest site than 5 and 10 m away and vegetation was taller at successful nests. Not all nests in Class III vegetation provide excellent or even good cover and factors other than just height at the nest seem to be involved in

determining nesting success.

Schwartz (1945) and Baker (1953) also believed that residual cover was important for prairie chicken nesting and Jones (1963) and Drobney and Sparrowe (1977) found vegetation at prairie chicken nests in Missouri averaged 45 cm in height. Buhnerkempe et al. (1984) indicated that prairie chickens preferred residual vegetation in the 25-40 cm height range and Svedarsky (1979) found that prairie chickens in Minnesota selected residual grass in the 10-30 cm range. The latter 2 also indicated that cover can be too tall or dense and vegetation above 1 meter may not be suitable for nesting. In this study, no nests were found in cover above 1 meter (Class IV), but nests of radio-tagged hens located in cover less than 9 cm were all unsuccessful.

Rands and Paulhayward (1987) suggested that hand-reared gray partridge (Perdix perdix) seemed to place their nests in poor cover. This was not the case in pen-reared prairie chickens as 50% were in excellent or good cover. Poor concealment did not appear to be responsible for the poor nesting success.

In central Wisconsin, 20 of 27 nests were in grass that had not been disturbed within the past 12 months (Mean 35.0±23.2, Range 3-60 months). Successful nests were located in cover that had been undisturbed for a longer period (Successful 36.4±23.8, Unsuccessful 34.2±22.5

months)(Growth, Successful, 13.2±10.1, Unsuccessful 10.8±8.7 months).

At Crex, 8 of 10 nests were in undisturbed cover (Mean 36.9±21.2 Range 9-60 months, Successful 44.0±18.3, Unsuccessful 34.0±22.7). Eight of 10 pen-reared birds also nested in undisturbed cover (Mean 25.5±12.8, Range 10-48). Overall, nesting habitat selected by prairie chicken hens consisted of cover that had 2 seasons growth and had developed residual cover in the 25-50 cm height range. In wild birds, 28 of 39 nests were found in cover undisturbed within the last 12 months. (Mean 36.4±22.6, Successful 38.8±23.0, Unsuccessful 35.5±22.8). The sample sizes are small, but the higher success of nests located in taller residual cover suggests that the quality of grass as nesting cover improved as more residual accumulated.

In central Wisconsin, 23 of 29 nests of radio-tagged hens were located on the managed grassland reserves (79.3%). Nesting success was lower for nests on private land than public land (50% versus 64%). Newell (1987) also found that nesting success for radioed prairie chickens was lower on private land. Most land use activities on private land are not conducive to the accumulation of residual cover for prairie chicken nesting. Westemeier (1973) found that undisturbed grasslands in Illinois were most heavily used for nesting in the 2nd and 4th year following burning or mowing.

These undisturbed grasslands were actively selected by prairie chicken hens because all the radio-tagged hens that nested had disturbed and undisturbed cover available within their prenesting and egg-laying ranges. The habitat immediately surrounding the nest was also important to the hen because it was used for feeding during incubation. All incubating radio-tagged hens fed within 400 m of their nests (Mean central Wisconsin 183±169 m, n=69 and Crex 185±169, n=38). The habitats used for feeding varied but most used grass (51.8%) or grass-forbs (18.5%) areas in the II (25.9%) and III (66.7%) height classes which had been disturbed within the past 24 months (73.9%). Agriculture was used occasionally (14.8%), but was only available within 400 m of the nests at Crex and 4 nests in central Wisconsin.

Species Composition

Plant species present at Crex were different from those in central Wisconsin. Hence, species composition at nests were different and supported the contention that structure and form, not species determined the cover selected by a hen for nesting.

Grass species made up 86.8% and 82%, forbs 10.8 and 15.5% and shrubs 2.4% and 2.2% of the cover within 1 meter and 30 meters respectively of the prairie chicken nests in central Wisconsin. Grass species also dominated at and within the vicinity of nests of wild residents (65-63%) and

pen-reared birds (72.5-57.3%) at Crex. Shrubs and forbs were much more prevalent at nests at Crex reflecting the large amount of grass-shrub habitat in the area. However, grass still dominated the cover at the nest (Table 71).

In central Wisconsin, quackgrass, bluegrass and timothy made up 73.7 and 62.6% of the species within 1 and 30 m of the nest respectively. Quackgrass, timothy, big bluestem and Carex made up 55.4 and 32.6% of species within 1 and 30 m of the nest at Crex (Table 71). Quackgrass and timothy were not common species at Crex where the grasslands were dominated by big and little bluestem, reed grass and June grass.

None of the forbs exceeded 5% at the nest or 8% within 30 m of the nest in central Wisconsin. Although a variety of species may not have been present at different nest sites, selection by prairie chickens hens seemed to be directed toward taller residual cover. Shrubs and forbs played a minor role in providing nesting cover in central Wisconsin.

There was a general trend for a greater incidence of taller grass species at the nest than the area surrounding it. This pattern influenced success in central Wisconsin as the incidence of quackgrass was higher at successful nests (51.2%) than unsuccessful nests (18.9%) while its incidence within 30 m of the nest was similar for both (Table 71).

Table 71. Plant species composition (≤0.5%) within 1 meter and 30 meters of the nest of wild, transplanted and pen-reared prairie chickens in central Wisconsin 1972-1974, and Crex Meadows Wildlife Area, Wisconsin, 1976-1978.

	Central Wisconsin		Crex Meadows			
	Residents N=28		Wild Birds N=10		Pen-reared N=10	
	Within 1 m	Within 30 m	Within 1 m	Within 30 m	Within 1 m	Within 30 m
GRASSES/SEDGES						
Andropyron repens	41.5	30.5	17.2	7.6	13.3	2.4
Poa pratensis	22.7	23.6	2.2	3.5	12.5	2.1
Phleum pratense	9.5	9.0	10.0	4.8	–	–
Phalaris arundinacea	9.1	5.0	–	8.3	–	–
Bromus inermis	2.7	8.0	–	–	0.8	2.3
Andropogon gerardi	–	3.4	10.3	9.3	12.5	17.8
Poa palustris	–	–	0.9	2.2	2.5	5.3
Calamagrostis canadensis	–	–	4.1	7.5	17.5	12.5
Agrostis spp.	–	–	–	3.4	5.5	5.9
Carex rostrata	–	–	2.5	4.4	–	–
Carex stricta	–	–	14.1	5.5	–	–
Carex spp.	–	–	1.3	1.0	–	2.6
Muhlenbergia spp.	–	–	–	0.6	5.0	1.0
Scirpus canadensis	–	–	–	1.8	–	1.8
Unknown grass	0.8	–	–	0.2	0.8	–
Other	0.5	2.5	1.5	3.3	2.1	3.6
Total Grass	86.8	82.0	65.4	63.5	72.5	57.3

Table 71. Continued.

	Central Wisconsin		Crex Meadows			
	Residents N=28		Wild Birds N=10		Pen-reared N=10	
	Within 1 m	Within 30 m	Within 1 m	Within 30 m	Within 1 m	Within 30 m
FORBS						
Solidago canadensis	4.2	7.6	5.3	2.5	1.7	2.9
Linaria vulgaris	2.0	3.2	–	–	–	–
Sonchus arvense	1.1	–	–	–	–	–
Achillia millefolium	1.0	–	1.6	–	–	–
Rumex crispus	0.8	–	–	–	–	–
Trifolium repens	–	–	0.6	1.3	–	–
Asclepis syriaca	–	0.8	–	–	5.0	–
Oxalis stricta	–	–	–	–	–	0.5
Taraxacum officinale	–	–	–	–	2.5	–
Pteridium aquilinum	–	–	1.3	1.6	–	0.5
Erigeron spp.	–	0.4	–	–	0.8	–
Fragaria spp.	–	0.5	4.7	3.8	2.5	3.5
Sporobolus spp.	–	0.8	–	–	–	–
Soliodago spp.	–	–	–	1.4	–	0.8
Verena hastata	–	–	1.3	–	–	–
Thaspi arvense	–	–	0.9	0.7	–	–
Medicago sativa	–	–	6.3	3.0	–	–
Mentha spp.	–	–	0.9	–	–	–
Potentilla spp.	–	–	0.9	–	–	–

Table 71. Continued.

	Central Wisconsin		Crex Meadows			
	Residents N=28		Wild Birds N=10		Pen-reared N=10	
	Within 1 m	Within 30 m	Within 1 m	Within 30 m	Within 1 m	Within 30 m
FORBS						
Galium boreale	-	-	-	-	-	0.5
Iris spp.	-	-	-	0.5	-	-
Aster simplex	-	-	-	-	-	0.5
Unidentified forb	1.2	0.7	0.9	0.7	2.5	0.5
Other	-	1.1	2.4	2.6	1.8	1.0
Total Forbs	10.8	15.8	27.1	18.1	16.8	15.0
SHRUBS						
Salix spp.	1.4	0.9	-	1.4	3.3	2.9
Rubus spp.	1.1	0.8	5.3	4.2	3.3	2.6
Comptonia peregrina	-	-	1.6	3.9	-	12.4
Quercus spp.	-	-	-	1.1	-	1.3
Corylus americana	-	-	1.3	6.4	-	5.9
Rosa spp.	-	-	-	-	3.3	1.6
Spirea spp.	-	-	0.6	0.9	0.8	0.5
Other	-	0.5	-	0.5	-	0.5
Total Shrubs	2.4	2.2	8.8	18.4	10.7	27.7

The information on nesting cover collected here and in other prairie chicken nesting studies indicated that hens seek out undisturbed residual grass cover in the 15-50 cm height range. Taller species at the nest suggested that the site was a taller patch of grass within shorter less dense grass cover. This aspect needs to be explored with larger sample sizes.

Nest cover was structurally similar to that found at night roosts during the spring. Night roosts and nests are the only places where individual prairie chickens spend more than a few hours in one spot. However, in central Wisconsin, night roosts were associated with shorter species, such as bluegrass and nests with taller cover species such as quackgrass (Table 71). The use of taller species at nests reflected the need for better concealment during the day than at night.

Hens with Broods

Hens with broods have different needs than broodless adults, a difference apparent in their movement patterns and habitat use. After the chicks hatched, hens moved away from the more dense undisturbed residual cover to less dense cover, through which the hen and chicks could easily move to find food.

In central Wisconsin 663 brood locations (482 day and 181 night) were collected from 8 hens, 3 of which were

followed from hatching to the abandonment of the brood. At Crex, 476 locations (326 day and 150 night) were obtained from 3 radio-tagged hens followed from hatching to abandonment.

In central Wisconsin, grass was the key component of brood rearing habitat as over 95% of brood locations were in grass, grass-forbs or the edge between them (Fig. 65). This was similar to habitat types used by adults, except adults made greater use of the grass-forbs habitat. The lower use of grass-forbs habitat by broods was believed due to the thicker nature of the forb component making it more difficult for a hen with young chicks to move through and find food.

Grass, grass-forbs and edge between the 2 types made up 94.5% of the habitat used by hens with broods during the day. At night, use of grass declined (66-48.4%) and use of grass-forbs and the edge between grass forbs and grass increased from 18.6 to 25.3% and from 9.9 to 21.4% respectively (Fig. 65). Increase in use of grass-forbs and edge provided more secure cover for hens with broods at night for roosting.

During the day broodless adults made greater use of grass-forb habitat than hens with broods (32% versus 18.6%) because it provided greater security and could be used by adults because of their larger size and greater mobility. Adults like hens with broods also moved to more secure cover at night because the use of the grass-forbs habitat

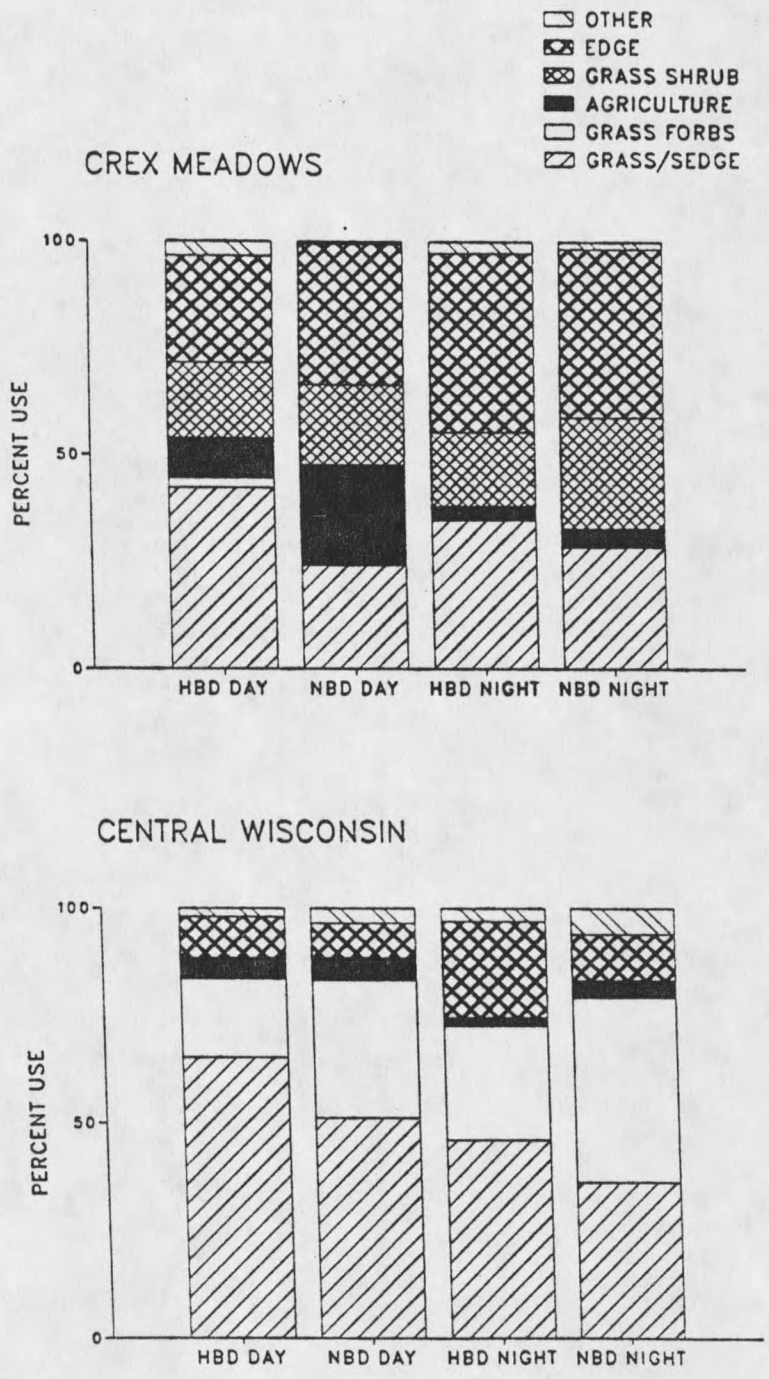


Figure 65. Habitat use for radio-tagged prairie chicken hens with broods (HBD) and broodless adults (NBD) by day and night in central Wisconsin, 1972 and 1974 and Crex Meadows Wildlife Area, 1976 and 1977.

also increased (32-43%) while the use of grass declined (50.8-37.6%)(Fig. 65).

Habitats used by hens with broods at Crex were also dominated by grass and were structurally similar to those used in central Wisconsin (Fig. 65). Upland and wetland grass (39.3%), grass-shrub (17.6%) and edge (30.3%) between upland and lowland grass made up 87.2% of cover used by hens with broods. The grass-shrub type was over 60% grass and structurally similar to grass-forbs habitat used in central Wisconsin.

The non-grass habitat types were relatively unimportant to prairie chicken hens with broods (Fig. 65). Agriculture was used by 2 hens with a brood for a 2 week period (buckwheat and standing oats), but overall received only 7.6% of the use by hens with broods. At Crex, broodless adults during the day made greater use of agriculture and the agricultural edge than broods (57.6 versus 9.5%) and less use of grass cover (25.4 versus 39.3%). At night, adults moved away from agriculture and like hens with broods moved to the more secure cover types of grass-shrub (22.2%), grass (28.4%) and edge between grass and grass-shrub (39.6%).

Ninety-five percent of all the day use by hens with broods in central Wisconsin was in Class II to Class IV with Class III making up 64.9%. Class I vegetation was used very little by hens with broods (1.9%).

The greatest difference in habitat use between adult prairie chickens and hens with broods was the higher use by broodless adults of Classes I and II vegetation during the day (51.1% versus 18.1%)(Fig. 66). This difference in use of shorter cover was believed to reflect the differences between food and cover needs of adults and chicks. Adults seemed to feed more on vegetation in the heavily grazed fields whereas chicks fed on insects which apparently are more diverse in taller vegetation than in the heavily grazed fields. The taller vegetation provided more food and better cover for chicks which are potential prey for a wider variety of predators than adults. Mussehel (1963) working with blue grouse also found that brood hens used taller cover than broodless adults and that hens with broods preferred cover high enough (25-30 cm) to conceal all but the head and neck of the hen.

The use of taller cover by broods during both day and night confirms the idea that it provided hens with broods both food and screening cover. The consistent use of the taller grasses is probably the main reason why prairie chickens broods are rarely seen. Adults were easily observed when feeding in the heavily grazed fields.

Both hens with broods and adults in central Wisconsin used the edge between shorter and taller height classes, but this type made up a relatively small percentage of the total use (Fig. 66). At night the use of taller cover by

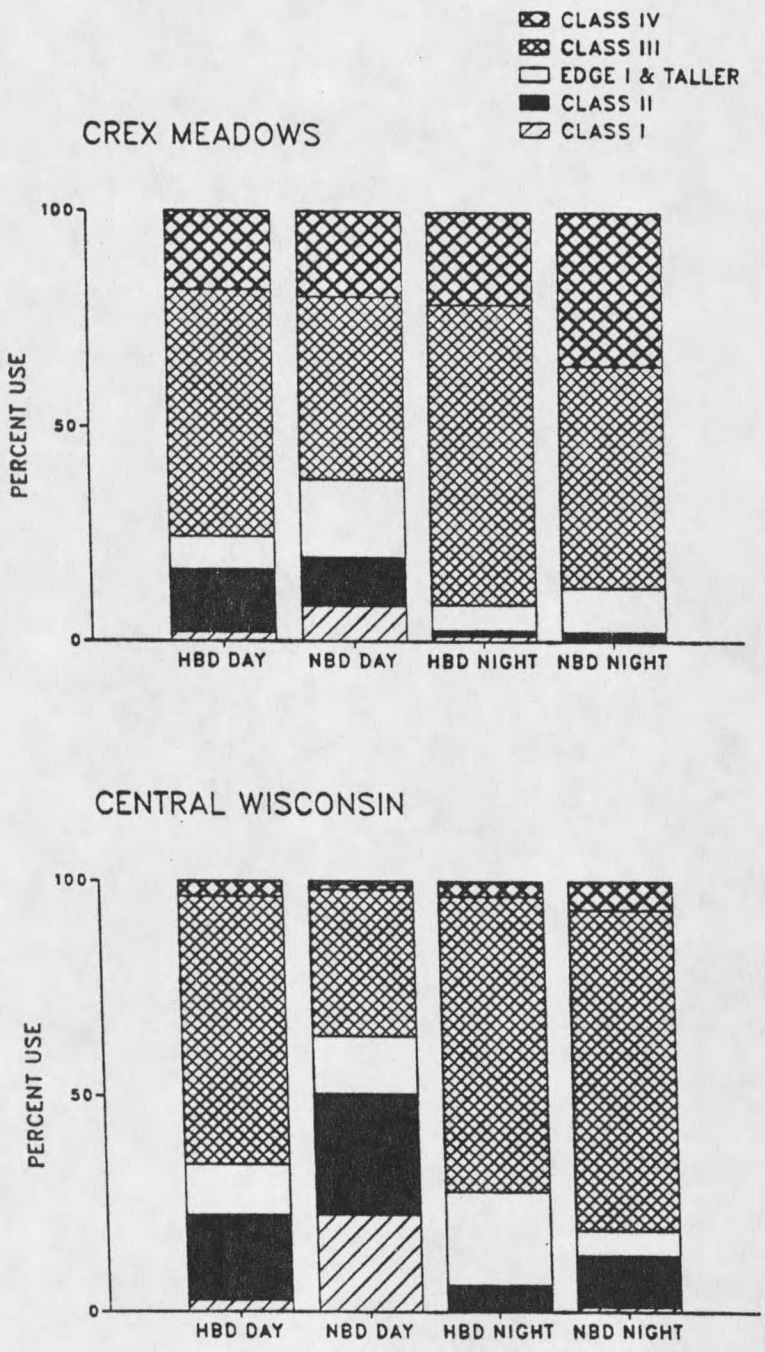


Figure 66. Use of vegetation by height classes (I=0-8 cm, II+9-25 cm, III=25-50 cm, IV=50-100 cm) for radio-tagged prairie chicken hens with broods (HBD) and broodless adults (NBD) by day and night in central Wisconsin 1972 and 1974 and Crex Meadows Wildlife Area, Wisconsin, 1976-77.

hens with broods increased only 11.0% and reflected the already high use of Class III vegetation during the day. This was in contrast to adults without broods where the use of the taller Class III and IV vegetation increased 52.8% from day to night (29.1% to 81.9%).

Grass in the 9-100 cm range made up 78% of the cover used by hens with broods at Crex, with 70% in the Class III category. Like broodless adults in central Wisconsin, the bulk of cover used by adults at Crex was also in the Class III (46.1%) and IV (24.6%) range. The difference in the use of cover height classes between adults and hens with broods was the greater use of Class I, II cover and edge during the day by adults (37.7 versus 24.5%). This difference was related to the use of agricultural fields and edges by broodless adults for feeding and loafing. At night hens with broods at Crex remained in Class III and IV vegetation (91.4%) while adults shifted from shorter vegetation (19.5%) during the day to taller more secure Class III and IV vegetation for night roosting (87.5%).

Comparisons between the plant species associated with the radio locations in central Wisconsin showed that the taller species (quackgrass, timothy, and brome) were associated more with the locations of hens with broods (48.9%) than adults (25.3%). The main difference was that adults were associated more with the shorter bluegrass than

were hens with broods (45.8% versus 26.9%). At night, hens with broods continued to be associated with the taller grass species while the association with bluegrass by adults declined (45.8-23.4%) as they shifted to taller cover for night roosting. Solidago was associated with locations of both hens with broods and adults, which reflected the use of the grass-forbs habitat. The association with shrub species was minor and was higher for adults than hens with broods (Table 72). None of the major plant species associated with the locations of hens with broods in central Wisconsin were abundant at Crex. However, the locations of hens with broods were associated more with the taller grass/sedge species (53.1%) such as big bluestem, little bluestem, reed grass and sedge. Adults without broods used these same species, but at a lower rate (30.5%) and were associated more with the agricultural species. Shrubs were used at a higher rate at Crex than in central Wisconsin and reflected the brush-prairie habitat at Crex (Table 72).

Like their counterparts in central Wisconsin, adults without broods at Crex increased their use of the tall species from day to night, while hens with broods remained associated with the tall species they used during the day. The data from radio-tagged hens with broodless adults from both areas indicated that the needs

Table 72. Frequency of species associated by day and night locations for radio-tagged prairie chickens with and without broods in central Wisconsin, 1972 and 1974 and at Crex Meadows Wildlife Area, Wisconsin, 1976 and 1977.

	Central Wisconsin						Crex Meadows					
	Hens w/Broods			Without Broods			Hens w/Broods			Without Broods		
Habitat Type	Day	Night	Total	Total	Day	Night	Day	Night	Total	Total	Day	Night
AGRICULTURAL												
Stand Corn	–	–	–	1.0	1.0	1.0	1.8	–	1.2	5.8	7.7	2.0
Picked corn	–	–	–	–	–	–	–	–	–	–	–	–
Cut corn	–	–	–	0.1	–	–	–	–	–	0.1	–	–
Total corn	–	–	–	1.1	1.0	1.0	1.8	–	1.2	5.9	7.9	2.0
Buckwheat	–	–	–	0.4	0.3	0.3	3.3	3.0	3.2	4.8	6.7	0.7
Alfalfa	–	–	–	1.7	0.9	1.4	–	0.6	0.2	2.3	2.8	1.3
Mowed Oats	–	–	–	0.8	0.4	0.6	1.6	–	1.0	4.0	4.9	2.0
Rye	–	–	–	–	–	–	2.5	3.0	2.7	5.8	–	8.2
Mint	–	–	–	0.1	0.1	0.1	–	–	–	–	–	–
Oats	3.7	1.7	3.1	–	–	–	–	–	–	–	–	–

Table 72. Continued.

Habitat Type	Central Wisconsin						Crex Meadows					
	Hens w/Broods			Without Broods			Hens w/Broods			Without Broods		
	Day	Night	Total	Total	Day	Night	Day	Night	Total	Total	Day	Night
GRASSES/SEDGES												
Andropyron repens	32.1	34.6	32.8	17.1	31.2	22.0	1.4	0.9	1.2	1.3	1.1	0.5
Poa pratensis	28.9	21.9	26.9	45.8	23.4	38.1	0.3	–	0.2	–	–	–
Phleum pratense	10.9	7.3	9.9	7.5	8.2	7.7	0.9	0.6	0.8	0.6	0.8	0.2
Panicum sp.	–	–	–	0.3	0.1	0.2	3.0	3.0	3.0	3.9	3.9	3.9
Glyceria spp.	–	–	–	–	–	–	0.5	0.6	0.5	–	–	–
Koleria cristata	–	–	–	–	–	–	0.3	0.2	0.3	–	–	–
Bromus inermis	5.7	7.5	6.2	0.7	2.5	1.3	–	–	–	0.3	0.4	0.2
Andropogon gerardi	0.5	1.0	0.6	–	–	–	13.9	10.6	12.7	9.9	8.8	12.1
Andropogon scoparius	–	–	–	–	–	–	9.3	2.4	6.9	1.4	1.4	1.6
Phalaris arundinacea	0.7	1.1	0.8	0.2	–	0.1	–	–	–	2.2	1.6	3.3
Calamagrostis canadensis	–	0.6	0.2	–	0.2	0.1	8.2	11.8	9.5	11.7	12.2	10.8
Mulenbergia spp.	0.2	–	0.1	–	–	–	3.2	3.9	3.5	2.9	2.3	4.2
Carex spp.	0.2	0.8	0.4	0.7	0.6	0.7	1.9	4.1	2.7	4.6	4.7	4.4
Carex stricta	–	–	–	–	–	–	22.8	26.4	24.1	7.5	6.4	9.9
Scirpus cyperinus	0.9	1.1	1.0	0.2	0.2	0.2	2.8	3.5	3.0	8.5	7.6	10.4

Table 72. Continued.

Habitat Type	Central Wisconsin						Crex Meadows					
	Hens w/Broods			Without Broods			Hens w/Broods			Without Broods		
	Day	Night	Total	Total	Day	Night	Day	Night	Total	Total	Day	Night
FORBS												
Linaria vulgaris	0.2	0.3	0.2	3.2	3.8	2.2	–	–	–	–	–	–
Pteridium aquilinum	–	–	–	–	–	–	1.2	1.5	1.3	2.2	1.7	3.2
Helianthus spp.	0.2	0.6	0.3	–	–	–	–	–	–	–	–	–
Trifolium repens	3.4	–	2.4	2.1	1.1	1.8	–	–	–	1.5	1.8	1.0
Asclepis syriaca	1.1	0.4	0.9	–	–	–	–	–	–	–	–	–
Urtica dioica	0.5	2.2	1.0	0.6	0.5	0.6	–	–	–	0.6	–	–
Solidago spp.	9.7	16.1	11.5	13.0	19.0	15.1	0.7	0.9	0.8	2.1	2.5	1.3
Fragaria spp.	0.1	–	–	0.8	–	0.5	–	–	–	1.1	1.6	0.1
SHRUBS												
Alnus spp.	–	–	–	–	–	–	–	–	–	0.2	0.4	0.2
Populus spp.	0.3	–	0.2	0.6	0.2	0.5	–	–	–	–	–	–
Prunus spp.	0.2	–	0.3	–	–	–	–	–	–	–	–	–
Corylus americana	–	–	–	–	–	–	6.2	7.4	6.6	6.1	4.3	10.1
Quercus spp.	–	–	–	–	–	–	2.0	2.6	2.2	2.4	1.4	4.5
Comptonia peregrina	–	–	–	–	–	–	6.8	6.8	6.8	6.3	3.6	12.0
Spirea spp.	0.2	2.4	0.8	0.8	5.0	2.2	0.2	0.6	0.4	–	–	–
Salix spp.	0.4	0.6	0.5	1.1	2.5	1.6	4.8	4.5	4.7	0.4	0.5	0.2

of hens with broods were best met by the structure and form created by the taller grass and grass-like species.

The high use of vegetation in the taller height classes during both day and night indicated that brood rearing habitat was relatively undisturbed or had time to grow following a disturbance. During the day, hens with broods in central Wisconsin used undisturbed grass more than disturbed (29.2 versus 50.6%), while broodless adults used disturbed cover and edge (Fig 67). However, 74.8% of day and 59.8% of night locations of hens with broods were in cover that had been disturbed within the past 2 years; 45.2% of day use by broods at Crex occurred in cover burned in April, 2.5 months before it was used.

This disturbed regrowth seemed to be preferred by hens with broods as only 26.6% of the locations of adults were in this type of cover. In central Wisconsin, 42.1% of the locations of hens with broods were in cover that was disturbed and in the process of growth (Fig. 68). This type of cover provided new green vegetation of the proper height, and little accumulation of residual grasses which permitted ease of movement for broods and access to food on the ground. This green, recently disturbed (burned, mowed or grazed) habitat was thought to increase insect numbers. Chamrad and Dodd (1973) found that insects were more abundant in burned than unburned grassland plots and spring burning produced the greatest weight of total insects.

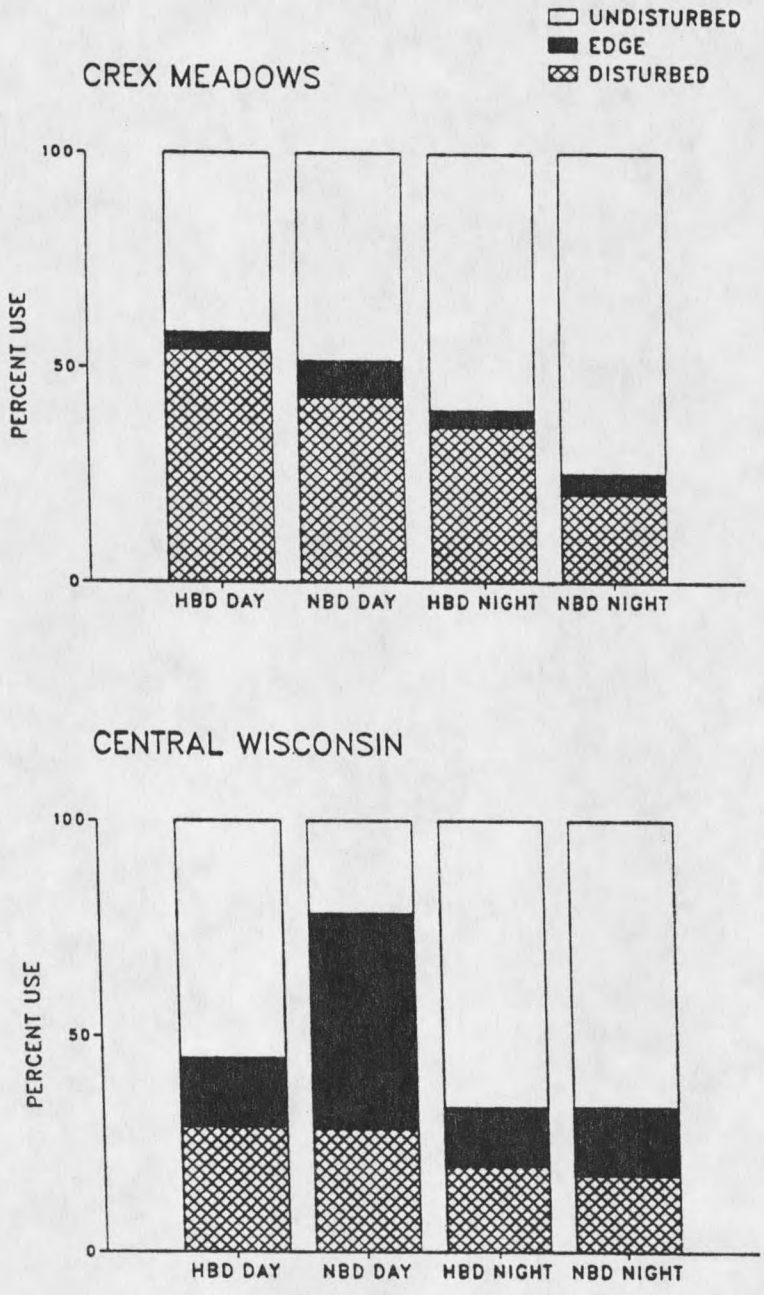


Figure 67. Use of cover by disturbance types for radio-tagged prairie chicken hens with broods (HBD) and broodless adults (NBD) by day and night in central Wisconsin 1972 and 1974 and Crex Meadows Wildlife Area, Wisconsin, 1976-77.

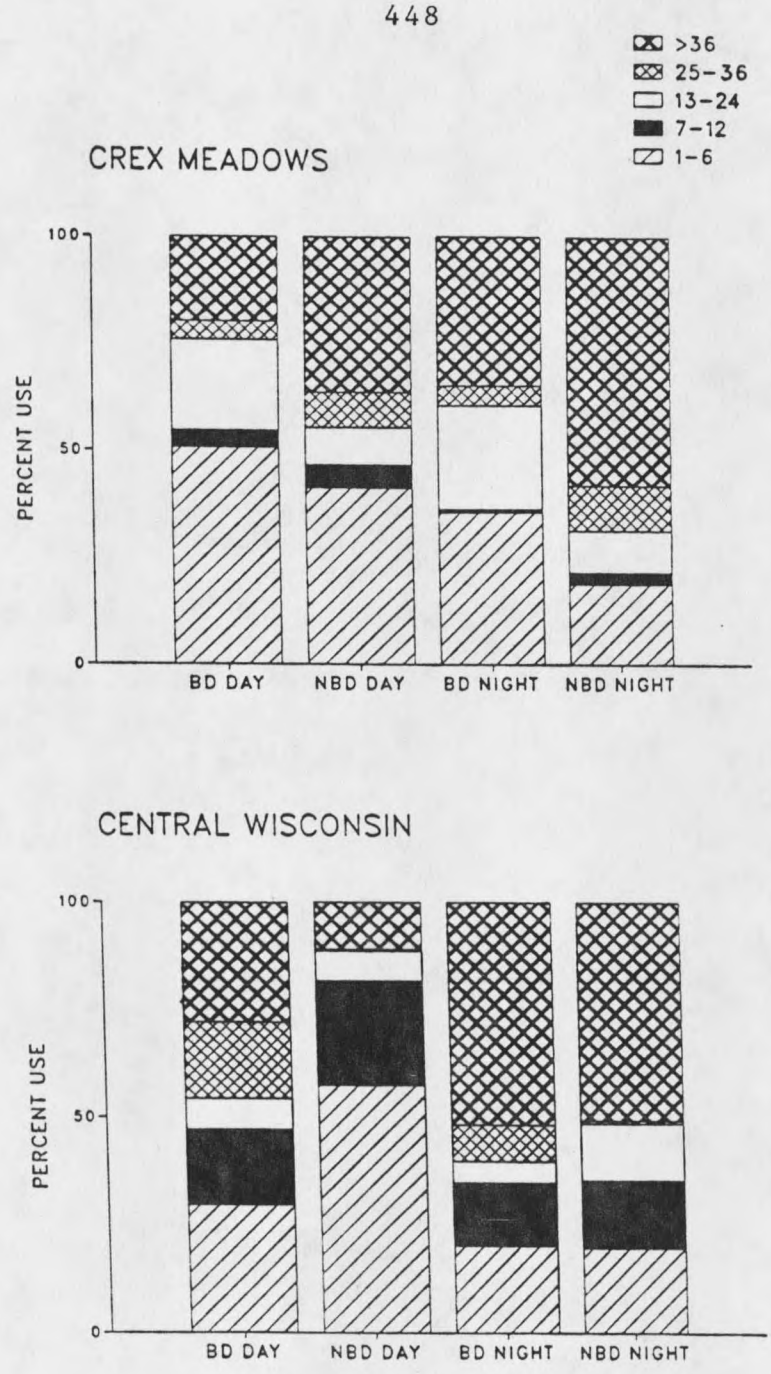


Figure 68. Use of cover by months since last disturbance for radio-tagged prairie chicken hens with broods (HBD) and broodless adults (NBD) by day and night in central Wisconsin, 1972 and 1974 and Crex Meadows Wildlife Area, Wisconsin, 1976-78.

They also reported that the burning of grasslands in spring increased the density of vegetation, but significantly decreased the amount of residual cover. Other investigators have characterized prairie chicken brood rearing habitat as recently disturbed and less dense than nesting cover (Yeatter 1943, Schwartz 1945, Hamerstrom et al. 1957, Jones 1963, and Svedarsky 1979).

The pattern for radio-tagged hens in both areas was to nest in undisturbed residual grass and move to grass areas that were disturbed within the past two years. This was most evident at Crex where the hens with broods moved to areas that were burned during the spring. The 2 months of regrowth that occurred in these areas provided excellent screening cover that was easy to move through and superficially produced good insect populations. The adults at Crex were not attracted to this type of habitat as their daylight activities were associated with agricultural fields. At night, hens with broods remained in this recently disturbed cover or shifted to more undisturbed cover. Adults shifted from the disturbed agricultural fields to undisturbed cover for night roosting (43.2 vs 74.7%).

Hens with broods in central Wisconsin made almost equal use of private and public managed land (51.2% versus 48.8%) in central Wisconsin during the summer. The equal use of both types by broods indicated that private land does provide brood rearing habitat. Private land, because

of the regular disturbances provides many of the areas with developing vegetation that appeared to be attractive to hens with broods. Adult prairie chickens during a comparable period used private land more than managed land (59.8% versus 40.2%) which reflected their use of the shorter, disturbed habitat types.

Based on locations of radio-tagged adults and hens with broods, brood rearing habitat consisted of grass or mixed grass habitat in the 25-100 cm range, that was undisturbed during the season of use, but disturbed within the past 6-24 months. This was in contrast to adults which also used grass and mixed grass habitat, but used a mixture of the shorter height classes (0-9 and 9-25 cm) for feeding and then moved to undisturbed taller cover (25-100 cm) at night.

Booming Ground Habitat

The booming grounds of prairie chickens were typically located in short vegetation from which the displaying cocks could easily see and be seen. In this study, booming grounds were located on roads, drainage ditch banks, wet sedge marshes and even airport runways. Single cocks occasionally displayed in trees, brush, on fenceposts, blinds and were even observed on the top of an abandoned automobile.

Booming ground cover types varied between the years, but the general pattern was one of short, disturbed cover.

Of the 106 booming grounds examined in central Wisconsin 86% were disturbed within the past year, 68% on private land and were typically in grazed (48%) mowed (33%) or plowed (10%) fields. Of 104 booming grounds classified, 94.1% were in Class I vegetation. Only a few booming grounds were located on natural undisturbed grass (7%) and these grounds were located in bluegrass, a species that remained in the 0-9 cm range even when it reached full height.

Other researchers have also reported the selection of short cover types for booming grounds. Schwartz (1945) noted that booming grounds were "more sparsely covered than the surrounding cover", and Jones (1963) reported that height of vegetation on booming grounds averaged 15 cm. Anderson (1969) found that cocks showed a preference for cover 6 inches (15 cm) or less for displaying and Horak (1985) indicated that the majority of 800 height measurements on booming grounds in Kansas were less than 5 cm, 90% less than 15 cm.

Booming grounds examined in western Minnesota (n=24) during the spring of 1977 were also located on cover that was disturbed during the summer or fall (79%), and 52% were located on fall plowed fields and 48% were located on mowed grass.

Booming ground cover was not critical to the prairie chicken population. However, booming grounds with the most

cocks were usually located on grass and were within the vicinity of large areas of undisturbed grassland. Booming grounds in plowed fields and large heavily grazed fields were smaller unless surrounded by large blocks of undisturbed grass in the Class III height class.

The locations of booming grounds appeared to be traditional. Some booming grounds in central Wisconsin have remained in the same 16 ha for over 40 years (F. N. Hamerstroms and R. K. Anderson unpubl. data). Schwartz (1945) also reported a booming ground that had remained in the same location for at least 40 years. Although locations of booming grounds in central Wisconsin were traditional and usually remained in the same spot for years, a few shifted locations from 1 spring to the next. The 4 (<1%) regular booming grounds that shifted locations in central Wisconsin from 1972-1976 (Mean 146±64 m), shifted when in the absence of mowing or grazing and the vegetation grew taller. In each case the display ground shifted to the nearest short cover. Anderson (1969) also observed that booming grounds shifted to locations with shorter cover when the previous location became rank with new vegetative growth. In managing for short cover by mowing or heavy grazing, the disturbance must occur before the birds return in the fall since the presence of Class III vegetation on the booming ground appeared to cause the cocks to shift locations. In one instance in central

Wisconsin, the display activities of cocks matted down taller vegetation on a booming ground.

The pen-reared and transplanted cocks at Crex also displayed in short cover and used roads, rye strips, mowed areas and the area at the pen for booming. In the spring of 1977, wild cocks did not display at the pen area, but shifted to a matted sedge marsh area situated over 1.0-1.5 m deep water. The birds used this area for 10 years and displayed at times in water and on the matted, floating sedge vegetation.

Space Factor

Hamerstrom et al. (1957) indicated that prairie chicken habitat has to have grass and open space. Grange (1948), Ammann (1957) and Hamerstrom et al. (1957) indicated that good prairie chicken habitat should contain no more than 25% of the area in woodland. The grass aspect of prairie chicken ecology has long been recognized by wildlife biologists, but the space factor has not been examined in detail. Prairie chickens may have a psychological aversion to being closed in by woodland. Hamerstrom et al. (1957) reported the abandonment of a booming ground due to the growth of a pine windrow. Anderson (1969) found that an artificial windrow of pines placed near a booming ground caused some cocks to abandon the ground and others to shift their territories away from the trees.

The habitat used by the prairie chickens in central Wisconsin consisted of open grasslands and agricultural fields with scattered trees and woodlots (1-40 ha). The radio-tagged prairie chickens in this habitat moved within the open grassland and agricultural areas between the woodlots. Prairie chickens did use trees, but they were used only occasionally in the fall and winter for loafing and budding. A few radioed individuals used windrow cover for day roosting during the fall and winter, but this was the only roosting cover available near their feeding area.

The mean distance from booming grounds to nearest tree(s) in central Wisconsin was 1059±347 m, (n=103) and ranged from 241-2714 m. Based on these distances, the mean size of the treeless area around each booming ground was 390±254 ha and ranged from 53-1051 ha. The mean distance to the nearest screening woodlot was 1413±420 m, (n=104) and ranged from 241-6432 m. This produced a mean open area with a few trees around each booming ground of approximately 682±387 ha with a range of 107-1855 ha.

Random points located within the distribution of booming grounds in central Wisconsin were measured in the same manner as booming grounds except random points that were in woodlots were excluded. The random points were closer to the nearest tree than booming grounds (649±260 m, Range 121-845 m, versus 1059±347 m, P=0.001). The random

points were also closer to the nearest screening woodlot than were the booming grounds (971±322 m versus 1413±420 m, P=0.001, Range 121-3801 m.

The same analysis on 24 booming grounds in western Minnesota in 1974 showed booming grounds were located in larger treeless areas than random points (406±371 m versus 217±150 m, P=0.025) and contained more open space than random points (2437±1374 versus 1406±1046, m, P=0.004) (Table 78, Appendix). The mean size of treeless areas in western Minnesota was larger (406±371 ha versus 390±254 ha, P=0.840) than areas in central Wisconsin, and the open area was almost 3 times larger than that seen in central Wisconsin (2437±1374 ha versus 682±387 ha, P=0.001). The larger open areas around booming grounds in western Minnesota resulted from the presence of larger agricultural fields (259+ ha) than in central Wisconsin. The main screening treelines in western Minnesota were windrows or trees surrounding homesteads in contrast to woodlots in central Wisconsin.

Several booming grounds had trees and woodlots much closer than others. These booming grounds were usually well established and it was believed that over the years trees have grown up in the open area surrounding them. This has occurred over 20-50 years and has allowed each generation of cocks to gradually adjust to these trees.

The mean size of open space increased with the number

of years a booming ground was active in central Wisconsin (1 years 897±115 ha, n=8 versus 5 years 1167±343, n=65, P=0.001). When new booming grounds developed, they were also located in open areas, but they were limited to the more closed in terrain by the presence of existing booming grounds.

The mean size of the treeless area and open space around booming grounds increased with the number of cocks present in all areas (Table 79, Appendix). Comparisons between the number of cocks with the amount of open space were positive, but not strong (r=0.155, n=104, P=0.058). This was not unexpected, as the number of birds in an area was not a simple function of open space, but related to distribution and the amount of various habitat components within this open area. The direct relationship between the number of cocks on a booming ground and open space was related more to the amount of grass habitat than space. More trees and woodlots (less space) means less grassland surrounding the booming grounds.

At Crex the main booming ground established by the transplanted prairie chickens and their young developed in a wetland area in the middle of the open treeless refuge. Others developed in open marshes and the agricultural fields. The mean size of the treeless areas were greater and the open area larger than around booming grounds in central Wisconsin (Table 78, Appendix). Random points were

surrounded by smaller treeless areas (542±207, versus 86±69 ha, P=0.001) and less open space (1222±297 ha versus 217±157 ha, P=0.001) than the booming grounds at Crex.

The comparisons between distances from booming grounds to trees and woodlots with random points showed that resident and transplanted prairie chickens selected open areas for displaying. The use of the areas within the vicinity of the booming grounds and the limited use of trees by prairie chickens indicated that open space was a critical aspect of prairie chicken habitat in the northern midwest. Based on the size of open areas surrounding booming grounds in central Wisconsin, the minimum open space for a booming ground of 10 cocks was approximately 600 ha and for 15 plus cocks 880 ha.

Sharptails occupied the more closed savanna habitat at Crex and have a closer association with trees and woodlots. The same analysis on sharptail dancing grounds at Crex showed that sharptail dancing grounds were closer to the nearest tree than prairie chickens in central Wisconsin and at Crex. Mixed display grounds were intermediate between prairie chicken booming grounds and sharptail dancing grounds. However, sharptail dancing grounds were located in larger treeless areas (152±189 ha versus 86±69 ha, P=0.001) and had more open space surrounding them (519±370 ha versus 217±157 ha, P=0.001) than random points (Table 78, Appendix). For sharptails, there was an inverse

relationship between the number of cocks, the size of the treeless areas and open space. This inverse relationship was related more to the amount of savanna brush habitat than to open space (Table 79, Appendix). However, one dancing ground which was located on the edge of a pine plantation was abandoned after 4 years when the trees grew too tall. Sharptails, like prairie chickens need open space but will apparently tolerate more trees and closed in terrain than prairie chickens.

Interactions Between Prairie Chickens Sharptails and Pheasants

The sympatry and incidence of hybridization between the prairie chicken and the sharptail has long intrigued grouse biologists (Brewster 1877, Gross 1930, Ammann 1957 and Johnsgard and Wood 1968). Prairie chickens and sharptails are closely related species that can share a common area, interbreed and produce fertile offspring (McEwen et al. 1969 and Sparling 1980). However, for a species to have evolved, they must have been separated over time either genetically, behaviorally or by a physical barrier (Mayr 1963).

Historically, the prairie chicken moved northward into the sharptail's range as advancing agriculture created small fields throughout the open grasslands (Judd 1905, Leopold 1931, Aldrich 1963, and Partch 1970). Cooke (1888),

Gross (1932), Leopold 1931, and Schorger (1944) all thought that prairie chickens were migratory in the northern portions of their range and that these migrations ceased when agriculture provided them with winter food above the snow (Hamerstrom et al. 1941, Hamerstrom and Hamerstrom 1973). Thus the lack of a winter food source during long periods of deep snow is believed to have originally prevented the prairie chicken from moving north into the sharptails' range. Factors that kept the sharptails from moving south into the original range of the prairie chicken are not known.

Observations on the interactions between prairie chickens and sharptails have been primarily concerned with behavior on mixed display grounds and hybridization (Ammann 1957, Johnsgard and Woods 1963, Sparling 1980, 1981a and 1981b). At Crex, mixed display grounds were observed every year from 1977-87 and hybrids from 1978-81 and 1985-87. When the first pen-reared prairie chickens were released in 1974, there were approximately 10-15 sharptails at Crex. In late April 1975, a single sharptail cock displayed for a week in the agricultural strips adjacent to the release pen. He dominated the displaying pen-reared prairie chicken cocks and after several encounters they avoided him. During the spring of 1976, no interactions were observed between sharptails or pen-reared and transplanted prairie chickens.

The sharp-tailed grouse hunting season was closed at Crex in 1976 to protect the released prairie chickens. During the period 1975-1987 sharptails observed on dancing grounds increased from 17 to 42-63 cocks. During this same period, only 1 display ground was present where the 2 species displayed together on a daily basis. However, the incidence of hybrids increased as sharptails increased and prairie chickens decreased. The largest display ground with both species present occurred in 1977 when 2 prairie chickens transplanted in 1976 and 6 sharptails displayed together. The 2 prairie chickens were relegated to one side of the display ground and interactions between the 2 species were dominated by sharptails. Similar observations of prairie chickens and sharptails on mixed display grounds have been reported by others (Grange 1948, Ammann 1957, Johnsgard and Wood 1968, Lumsden 1970, Sparling 1980 and Schmidt 1980).

Based on observations from Crex, the 2 species appeared capable of segregating themselves during the breeding season and, given the opportunity, selected their own kind for breeding. Sparling (1980) felt that hybridization occurred when 1 species became more abundant than the other and that vocalizations were important in mate selection. I agree, but feel that hybridization usually occurs when a hen of 1 species becomes isolated with the other. In a mixed population, prairie chicken

hens have an advantage because the booming of chickens is more audible than the cooing of sharptails. At Crex, prairie chickens could be heard booming on calm mornings from any of the sharptail dancing grounds. Hybridization did not appear to be a major factor in the decline of prairie chickens at Crex, but as the ratio of sharptails to prairie chickens increased so did the incidence of hybrids (Table 8).

Efforts were made to document the mixing and interactions between prairie chickens and sharptails on and away from the display grounds. Mixed prairie chicken and sharptail flocks were common at Crex and made up 35.3% of the 895 flocks of prairie grouse observed during the period 1976-78. A mixed flock was a group of 2 or more prairie grouse with at least 1 representative of each species. The incidence of these mixed flocks was lowest in the summer (9.8%), increased in the fall (38.2%) and winter (46.8%) and declined in the spring (22.8%) (Fig 69). The increase in the number of mixed flocks in fall and winter suggests that the 2 species were congregating in the agricultural fields to feed. Overall, 63% (120/190) of all mixed flocks were observed in the agricultural fields. This was in contrast to only prairie chicken or sharptail flocks where 45.4% (n=443 birds) and 31.1% (n=916 birds), respectively, were observed in the agricultural fields.

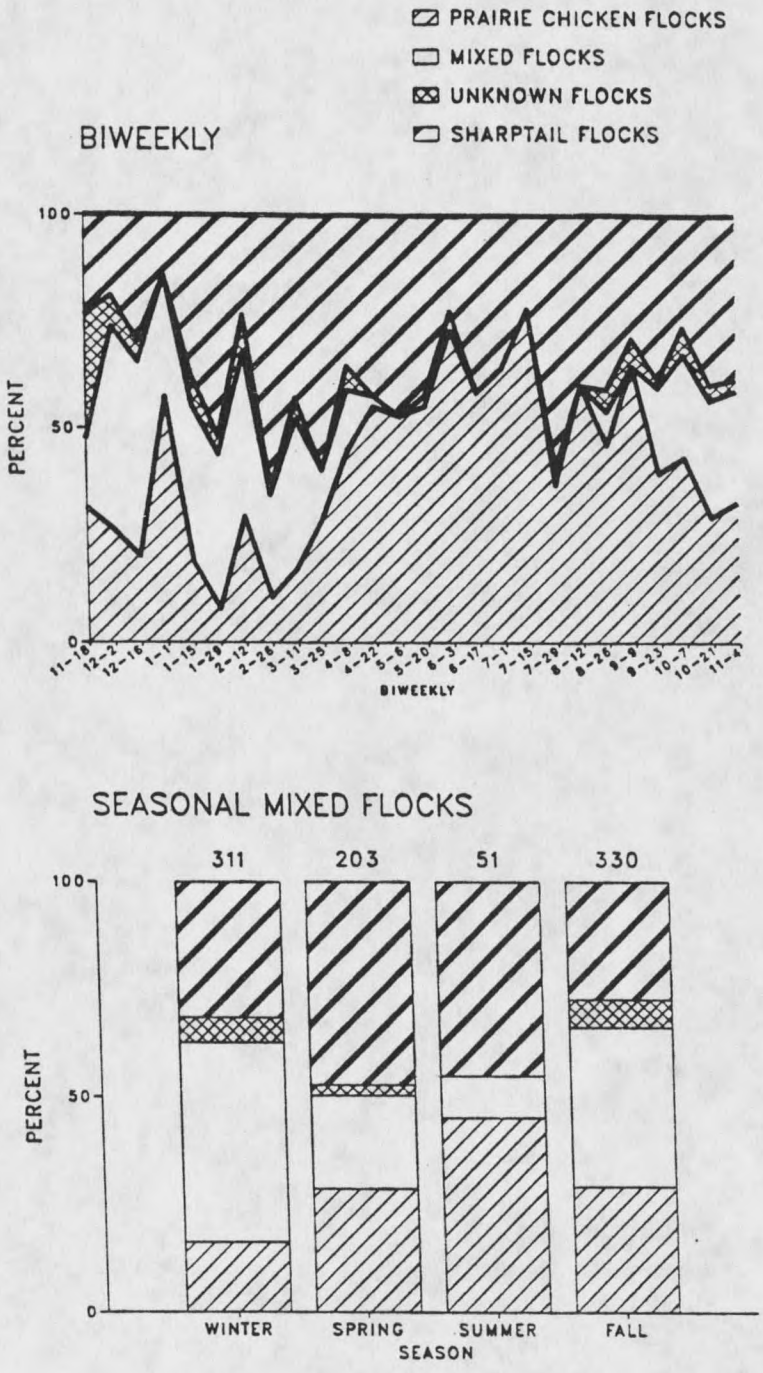


Figure 69. Seasonal distribution of mixed flocks of prairie chickens and sharptail grouse and biweekly changes in mixed flocks of prairie chickens and sharptail grouse, Crex Meadows Wildlife Area, Wisconsin, 1976-78.

The ratio of sharptails to prairie chickens in mixed flocks varied from 1.2:1.0 to 1.1:1.0 in the fall and winter, 1976-77, respectively and 1.5:1.0 in the fall and 1.2:1.0 in winter 1977-78. These ratios were similar to the ratio of sharptail cocks to prairie chicken cocks in the respective spring populations of 1977 and 1978 (CSq df=1, $0.92<P<.05$), which suggested that the 2 species mixed at random as they congregated in common feeding areas.

During 1977-1978 sharptails were also radio-tagged and followed at Crex (Gratson 1983, Toepfer unpubl. data). Based on the incidence of mixing of radio-tagged individuals, prairie chickens were observed in mixed flocks more than sharptails (58.5% versus 13.9%). Prairie chicken hens were more likely than cocks to be observed with sharptails (97.5% and 71.7%). Hens of both species were more likely to be observed in mixed flocks and sharptail cocks were only observed in mixed flocks during winter (Table 80, Appendix). Sample sizes are not large, but the low incidence of sharptail cocks in mixed flocks suggested that hens of both species may have avoided sharptail cocks. Prairie chicken cocks dominated prairie chicken hens and it seemed likely that sharptail cocks dominated hens. This implied that part of this sex segregation may have been to avoid competition from more dominant individuals. However, during winter the sexes may have been forced to feed in the same areas because of limited food.

Interactions observed between prairie chickens and sharptails in common feeding areas showed that in aggressive encounters, sharptails (unknown sex) dominated prairie chickens 55 out of 59 times (93.2%). Sharp (1957) also reported that sharptails dominated prairie chickens during interactions in winter feeding areas. If this dominance carried over into other seasons (nesting, brood rearing), then sharptails would have a decided advantage when populations mix and share habitats.

The literature on mixed prairie chicken and sharptail populations shows that historically prairie chickens have given way to sharptails. Although the 2 species have existed at least temporarily in a common area, there are measurable differences in how they used the habitat (Table 81, Appendix). Based on weighted seasonal means of non-radioed prairie grouse, prairie chickens used the agricultural areas at Crex more than the sharptails (52.1% vs 33.2%) while twice as many sharptails as prairie chickens were observed in the shrub and grass-shrub habitat (25.1 versus 12.0) and trees (16.8% versus 6.9%). In all seasons prairie chickens used the agricultural fields more (14-22%) than sharptails.

Habitat use by radio-tagged sharptails at Crex (Gratson 1983) showed that 42% of the radio locations were in grass-shrub/shrub-grass habitat, 8.0% in agriculture and 14.5% in trees. Use of the grass-shrub and shrub-grass

habitats by radio-tagged sharptails was 17% higher and use of agriculture was 25% lower than that seen in the non-radioed sample. The observed yearly habitat use of non-radioed prairie chickens showed the same bias and when compared with radio locations, the non-radioed birds were observed in agriculture twice as often (53.8 versus 23.6%). These apparent differences in habitat use were due to a visibility bias which weighted habitat use toward those types where birds were conspicuous (agriculture and trees). When radio-tagged birds were located by triangulation, they were rarely seen in taller cover. Nevertheless, information from both the radioed and non-radioed birds emphasized the strong association that the sharptail had with shrub habitat and the prairie chicken with agriculture.

Winter food resulting from agriculture was critical to prairie chickens. All of the radio-tagged prairie chickens and many of the sharptails at Crex fed in agricultural fields or elevated platforms with corn. However, a group of radio-tagged sharptails never visited the agricultural fields, but fed on birch and aspen browse all winter (Gratson 1983, Toepfer unpubl. data). Gratson (1983) also monitored radio-tagged sharptails in 2 nearby study areas. These birds abandoned agricultural areas when the fields became snow covered. These birds wintered in adjacent woodland and wetland areas where they ate buds of aspen and

birch. Sharptails are capable of surviving winter without agriculture on a low grade browse diet.

Prairie chickens will browse, but available evidence suggests that they cannot survive for a winter on a diet of browse alone. Hamerstron et al. (1941) indicated that "browse alone will not carry prairie chickens through the winter. Small numbers may be able to supplement a browse diet with an uncertain supply of weed seeds, but to have prairie chickens in quantity in the North Central States, winter grains are necessary". Based on 12,728 observations of feeding prairie chickens in this study, there were only 143 observations (1.1%) of birds budding, and all occurred during the winter.

In 2,396 observations of sharptails feeding, 283 (11.8%) were observed budding, 84% of which occurred during the winter. These are likely minimal representations of budding in both species as a great deal of feeding goes unobserved, particularly when the birds feed in tall cover. However, most observations of budding occurred in trees or tall shrubs.

With their apparent dependence on agricultural fields for a winter food source, prairie chickens in the northcentral states either did not exist prior to agriculture, or moved south to find food as suggested by other grouse researchers. It has been suggested that, with a permanent winter food source above the snow, the

migratory tradition was lost in the prairie chicken. In Missouri, where the winters are milder and snow of lesser amount and duration, the bulk of the prairie chickens' diet consisted of native plants. Cultivated grains were used most when snow covered native vegetation (Tony 1980). Deep persistent snow cover and the inability to subsist entirely on browse may have been the barrier that originally isolated the prairie chicken from the sharptail.

There are 2 basic patterns to grassland removal under which prairie chicken populations have disappeared in the midwest: (1) intensified agricultural activity (cropping and grazing) and (2) natural succession to brushland. The latter was usually associated with an accompanying increase in sharptails. Ammann (1957), in discussing the displacement of prairie chickens by sharptails, stated that the pattern was invariably associated with an encroachment of brush into grassland. Once sharptails became more abundant than prairie chickens, the latter usually disappeared in 5-6 years. Ammann (1957) believed that on several occasions all or nearly all of the prairie chickens remaining in an area disappeared suddenly between springs seasons as if they emigrated. In all cases he believed that the replacement of prairie chickens by sharptails occurred faster than the habitat changed. He also indicated that at least 9 areas in Michigan changed from prairie chicken to sharptail populations during the

period from 1935-55. The presence of an isolated mixed prairie chicken, sharptail population in the midwest without intensive management for prairie chickens appears destined for a temporary existence.

This author is personally aware of at least 8 isolated areas that have had mixed populations of prairie chickens and sharptails within the past 25 years. All but one has become exclusively a sharptail population. The exception has been the prairie chicken management area in central Wisconsin where grasslands have been maintained by brush control. The Portage County Management Area in central Wisconsin has not had any sharptails since 1953 (Hamerstrom and Hamerstrom 1973).

There are areas in Nebraska and South Dakota where prairie chickens and sharptails have existed for 20-25 years (Johnsgard and Wood 1968, and Larry Fredrickson pers. comm.). However, distribution of the 2 species in these areas was not one of a mixed isolated population with limited habitat. These areas were characterized by a region of mixed display grounds with a trend towards single species grounds on either side of a transition zone. This is not the same situation that existed at Crex or in other areas where the 2 species were shared small isolated pockets of habitat.

Based on observations made at Crex, prairie chickens and sharptails appeared at times to act as a single

prairie grouse population. Thus, the presence of both will not mean twice as many birds. In addition, mixed populations will require careful management to maintain both species.

Several areas have recently been proposed for prairie chicken introductions that historically had prairie chicken populations, but currently have substantial sharptail populations. The fact that these areas now contain sharptails indicates that they are better suited for this species and should be managed with this in mind.

It is a mistake to mix prairie chickens and sharptails in isolated habitat because of the high cost of trying to maintain both species. A better approach would be to manage certain areas for sharptails and select and maintain others for prairie chicken reintroductions. The distribution and numbers of sharptails, like the prairie chicken in the past, is now beginning to decrease over much of their range (Miller 1980). The distribution of one subspecies, the Columbian sharptail (Tympanuchus phasianellus columbianius) has been drastically reduced in the western United States and is now restricted to small isolated populations associated with managed public land (Miller 1980 and Marks and Marks 1987). Many of these sharptail areas, like Crex, have long term objectives in their management plans to reestablish prairie chickens.

In view of historical evidence and data presented

here, these objectives seem unwise and may need to be re-evaluated. It is often argued that the prairie chicken and sharptail existed together in the past and should do so today. This is a moot point when considering that none of these isolated mixed populations have survived.

Finally, before attempting to establish prairie chickens in an area with sharptails, one should consider the political ramifications as it may necessitate closing the sharptail season to protect the introduced prairie chickens. Few hunters can tell the difference between a prairie chicken and a sharptail when they flush, particularly in mixed flocks. Consequently any season on sharptails will result in the harvest of some prairie chickens in areas with mixed populations.

Interactions With Pheasants

At least 1-4 cock pheasants were present at Crex from 1977 to 1983 (Table 8) and even though they were within 400 m of the booming ground, the cock pheasants did not harass the prairie chickens as observed by Vance and Westemeier (1979) in their isolated prairie chicken population in Illinois. Pheasants were also present in central Wisconsin with no observed problems. Management practices that increase or improve grassland in an agricultural community, will probably increase pheasant numbers and may lead to problems similar to those seen in Illinois (Vance and Westemeier 1979). It could also create

a public relations problem with sportsmen demanding that the area be managed for pheasants. Thus, it would be best to reestablish prairie chickens in areas where pheasants are absent, exist in low numbers or where potential for their increase is low and when public attitudes and preferences have been evaluated.

Effects Of Removal On Local Populations

One factor rarely considered in wildlife restoration projects is whether or not the removal of individuals has any effect on the population providing the transplants. In this study, an effort was made to obtain information on population levels for the year following the removal of the transplants.

Based on available data, it appeared that removal had no effect on the populations providing the prairie chickens for transplanting. In the West of Stevens Point Area in central Wisconsin the total spring cock count increased from 100 to 145 following the removal of 29 birds; 8(4 cocks and 4 hens) in March and 21 (14 cocks and 7 hens) in April 1976. Counts of cocks on the 5 booming grounds from which the 21 birds were removed in April, 1976 increased, from 42 to 67. The total cock count on the Mead Wildlife Area where 14 birds (8 cocks and 6 hens) were removed in 1976 increased from 128 to 180. The 2 booming grounds from which birds were removed increased, from 19 to 26. In

addition, 8 birds (4 cocks and 4 hens) were removed from the Portage County Area in March of 1976 and cock counts in this area increased, from 131 in 1976 to 231 in 1977.

The cock counts for the 4 western Minnesota counties from which 30 birds (10 cocks and 20 hens) were removed in 1977 declined from 656 to 642 in 1978. However, cock counts in the 6 counties from which birds were not removed also declined from 219 cocks to 198 in 1978 (T. Wolfe pers. comm). Individual booming ground counts were not available for 1978 for western Minnesota.

It appears then that unhunted prairie chicken populations (assuming an equal sex ratio) are capable of compensating for the removal of at least 3-10% of the total spring population. This compensation occurred even when as high as 35 and 50% of the hens and cocks respectively were removed from a single booming ground. The King booming ground, from which 8 of the original 16 regular cocks were removed on 11 April remained at 7 to 8 cocks through the rest of April (12 counts) indicating recruitment did not occur during the spring of removal. These data suggest that replacement as reported by Ballard and Robel (1974), may not always occur, or that by 11 April there were no longer any non-territorial individuals available. Rippen and Boag (1974) found that replacement in sharptails did not occur after the first week of April. Grange (1948), Rusch and Keith (1971), Watson and Moss (1980) and Gullion

(1982) all indicate that numbers of non-territorial and non-displaying grouse vary with density, but disagree on whether the relationship is inverse or direct.

Costs

The minimum cost to the project of obtaining, maintaining and releasing pen-reared birds and capturing and transplanting wild prairie chickens was approximately 60 and 180 dollars per bird respectively. The estimated cost of the pen-reared birds does not include the initial costs to obtain and maintain breeding stock, nor the costs to raise them to 8-12 weeks of age at Jamestown. The cost of capturing and transporting the wild birds is an approximate, but more realistic cost, although research costs were not included and most of the trapping equipment was borrowed from other agencies. Costs in 1986 would have been approximately 93 dollars/pen-reared bird and 240 dollars per wild bird after adjusting the 1974-77 costs to 1985 dollars using the Index of Prices Paid by Farmers for Production Items (Feb-1987). It should be emphasized that the cost per bird is meaningless unless compared to the contribution each type made to the reestablishment effort.

A frequently overlooked reason for a transplant failure is that economic considerations are often given a higher priority than the biological considerations. Even though funds for a transplant effort are usually limited, the biological aspects must be balanced, but not

compromised by economics. There is no return of any kind from an unsuccessful effort.

Finally, the failure to document and learn from previous efforts is a hidden, but very real and high cost of transplant projects. This failure is reflected in the continued use of unsuccessful procedures, costly in both money and wildlife resources. Many failures, are blamed on inadequate habitat rather than poor procedures or lack of knowledge of the animal and its needs. Likewise, one cannot assume that procedures that work for 1 species will work for others. Documentation is an expensive, but very important part of a transplant effort as it can provide insight into why a particular project failed or succeeded.

MANAGEMENT RECOMMENDATIONS

Future Reintroductions

Since the initiation of this project in 1974 there have been at least 6 attempts to re-establish prairie chickens. These recent efforts and countless others over the past 120 years have all failed. The initial build-up of the prairie chicken population at Crex to 25 cocks was encouraging, but the eventual decline to 2 cocks after 14 years indicated that the effort was unsuccessful. However, the information gained from this study should prove useful in future efforts.

There appear to be 5 basic reasons why most transplant efforts fail: (1) poor habitat, (2) lack of an understanding of the animals ecology and habitat needs (3) high mortality due to release of inferior stock (4) birds released at a time or under conditions when they cannot adjust to the stresses of being moved and (5) dispersal from release site. (Also See Studholme 1946, A bird in the bush is worth two in the hand).

One of the most successful re-establishment projects undertaken in recent years is the reintroduction of the peregrine falcon into historical unoccupied habitat (Sherrod et al. 1981). This effort has been expensive but

has met all of the necessary criteria to be considered successful. This project has incorporated personnel knowledgeable in behavior and needs of the bird, made releases in historical habitat and released individuals under conditions where they could gradually adjust to being released into the wild (hack boxes). Finally the releases were evaluated and procedures modified as new information became available.

Pen-reared Birds

The initial impression one has of pen-reared birds is that they are "naive" or behaviorally deficient making them easy prey for predators. However, evidence collected in this study indicated that pen-reared prairie chickens did recognize predators but they had become physically and behaviorally conditioned to living inside a pen. This conditioning resulted in the birds becoming runners rather than flyers, a habit that outside the pen led to reduced flushing and flight distances which in turn made them less able to escape predators. Because of these modifications in behavior and high costs of raising birds in a pen it is recommended that pen-reared prairie chickens not be used in future reintroduction efforts.

Pen-reared birds should only be used as a last resort and a concerted effort must be made to avoid conditioning and improve the physical condition of pen-reared birds. This effort will require large pens and the development of

special breeding and rearing procedures which will be very expensive. Based on evidence presented here 250-300 pen-reared prairie chickens should be gently released in summer. The birds should be released at 12-14 weeks of age before they become completely conditioned to the pen and their physical development deteriorates. Finally, predator suppression should be evaluated and if appropriate must be conducted by qualified personnel at least 2 months before and after the release.

Wild Birds

I suggest to those interested in re-establishing prairie chickens that they use wild birds and consider a combination of the following release procedures. Because of physical deterioration, wild birds should not be held in pens for release. The release of wild birds will eliminate the need for predator control. For an April or spring release, duplicate the procedures used at Crex and construct a small temporary holding pen for a flock of 10-15 pen-reared prairie chickens. The penned flock should contain twice as many cocks as hens to stimulate display in the released cocks. Capture 25-30 cocks on booming grounds in early April, several weeks before the breeding peak and release within 24 hours at the holding pen. If some of the released cocks establish in the pen area capture and transplant 20-30 hens.

Based on the evidence from this study the cocks should be attracted to the penned hens and one may expect 25-33% of the hens to stay in the release area. The key to holding the cocks near the release site was to stimulate sexual activity and initiate display behavior, thus overcoming the stress of being transplanted. A modification could involve implanting testosterone propionate pellets which has been used to increase display intensity in sharptails (Trobec and Oring 1972) and red grouse (Watson and Parr 1981). The latter 2 authors also found that estrogen caused red grouse cocks to display less and even give up their territories.

The preferred approach does not involve the use of a pen. This method requires the capturing, radio-tagging and releasing of 25-30 cocks and 25-30 hens on the capture site booming grounds during the spring. These birds should then be recaptured by nightlighting and transplanted during the summer molt (July, August, or early September at the latest). The use of radios will guarantee that surviving birds can be relocated and captured. The biggest advantage of the summer release is that it could be used to pre-test the quality of habitat in the release area. An initial release of 10-15 cocks and no hens survival of some cocks over winter would indicate that the area will support adult prairie chickens. This would prevent the wasting of hens in inadequate habitat and allow for any necessary

adjustments in the management of the release area before making a total commitment to the project. This method appears to be the best method of establishing prairie chickens near the release site. To date, all (n=8) of the radio-tagged birds recaptured and transplanted in Wisconsin during August that survived for a month or more, established at their release sites. Recently, Fredrickson (1987) reported that at least 12 of 29 (4 of 6 radioed cocks) transplanted in South Dakota during August 1986 were observed in the release area May 1987; 4 of the radio-tagged birds returned to the release site after wintering 4-27 miles away.

The rationale behind the summer transplant is that it permits the transplanted individuals to gradually adjust to the new area as they come out of the summer molt and increase their movement in the fall. This approach is in contrast to most unsuccessful transplant projects, which capture large numbers of individuals usually when they are the easiest to capture, but when conditions are the poorest for the survival and establishment. In essence these birds are being forced into the habitat rather than being allowed to adjust to the move and habitat. Traditionally large numbers of birds have been released to overcome rapid dispersal and/or low survival of released individuals.

It must be emphasized that when transplanting animals, one must to be concerned with the survival and

establishment of individuals. Most of the principles of population dynamics are not operating in a transplant project. One will not have a "population" until the transplanted individuals establish, and survive to reproduce. Until this happens the survival and adjustment of individuals will be the key to success.

Release Area

All too often, areas considered for prairie chicken reintroductions are too small to support a viable population. The recommended minimum size of a prairie chicken management area varies (8-20 sq km, Grange 1948; 10-46 sq km, Hamerstrom et al. 1957 and 1-4 sq km sections, Ammann 1957). However, most of the areas these recommendations were based on no longer support prairie chicken populations. The size and habitat of a potential prairie chicken area is critical and should be large enough to support 100 cocks in the spring. The smallest area that has supported a population of this size for any length of time is the Bogata Management Area in Illinois (Westemeier 1980). The managed grasslands in this area are spread over approximately 20 sq km. However such small isolated populations will be susceptible to being wiped out by a local catastrophe or habitat loss and possibly inbreeding (Frankel and Soule 1981 and Cannon and Christisen 1984). Hence efforts should be made to have several areas within 16-24 km of each other with management objectives to expand

the distribution to keep a population well above 100 cocks. The following recommendations are given regarding other criteria for a release area. Based on the mean distance between booming grounds in central Wisconsin (1800 m) it is estimated that the minimum size of an area necessary to support 100 cocks (8-10/booming ground) would be approximately 25 sq km. An area of this size should consist of 75% open grassland habitat in the 25-100 cm height range and meet the following criteria: (1) a history of a prairie chicken population (2) documented seasonal prairie chicken foods and (3) in regions with heavy snow, food patches and winter roosting habitat in the form of wetland grasses and sedges and (4) the area should not contain sharptails or a large pheasant population.

Areas that should be given consideration for prairie chicken reintroduction include federal and state waterfowl management areas and refuges, Nature Conservancy lands, military reservations and other areas that provide open space and have potential for permanent grass. In areas where distribution of existing populations are limited, efforts should concentrate on making these populations secure before attempting to re-establish birds in other areas. Finally before a prairie chicken transplant effort can be considered successful, the reestablished population should remain relatively stable or increase for at least 10 years.

Habitat Management

It has become axiomatic that undisturbed grassland cover is the primary component of prairie chicken habitat. Today the prairie chicken's distribution consists primarily of isolated populations existing where undisturbed grassland habitat has persisted by accident or been maintained by intensive management. Grasslands in a condition favorable to prairie chickens are difficult to maintain because of their deterioration due to brush succession and their value to man as crop and rangeland.

The information collected in this study from radio-tagged birds in 2 separate areas emphasized the importance of the undisturbed grassland habitat to prairie chickens particularly for nesting and brood rearing. This information substantiates the conclusions of earlier studies.

Prairie chicken habitat is a mixture of tall and short undisturbed and disturbed grassland cover. A critical factor in determining the number of prairie chickens is the amount of residual grassland cover in the 25-100 cm height range present in the spring. It is this portion of the grassland habitat that is used for nesting and brood rearing. Grassland cover in this height class made up 65% and 89% of the year-round habitat used by prairie chickens

during the day and night respectively in this study.

Movements and seasonal distribution of radio-tagged birds indicated that the area within 1.6 km of the booming grounds was used for nesting and brood rearing and was the year-round center of activity for both cocks and hens. Consequently, the management of habitat within this radius of the booming grounds is the key to successfully maintaining or increasing prairie chicken numbers. This area should serve as a management unit or a group of grounds as a complex in which management should focus its activities. The association of the larger booming grounds with the larger blocks of undisturbed grassland clearly indicates that a direct relationship exists between prairie chicken numbers and the amount and distribution of residual grassland cover in the 25-100 cm range.

However, undisturbed grassland will become rank and must be disturbed on a 3-5 year rotation preferably by burning. However, mowing and grazing can serve as alternative means of disturbing cover and controlling brush. When disturbed no more than one-third of the management unit should be disturbed at any one time. The grassland blocks should be large and make up as much of the area surrounding each booming grounds as possible. When smaller grassland blocks must be incorporated into the management scheme they should be at least 32 ha, approximately the size of the egg-laying range used by hens.

The first step to increasing numbers in existing populations is to determine the distribution of booming grounds. Habitat in the vicinity of the larger, more stable booming grounds (20 plus cocks) should serve as a guide for improving habitat surrounding smaller booming grounds. The importance of grassland in the 25-100 cm range cannot be overemphasized, especially for nesting and brood rearing. However management must also consider the year-round needs of the population. In northern portions of prairie chicken range this means that where snow cover exceeds 7 cm and lasts for several months, winter food in the form of agriculture (corn, sunflowers, or soybeans) must be available above the snow. Agricultural practices on private land may eliminate the availability of winter food and food patches may be needed. Based on the distribution of winter food in central Wisconsin, food patches should be located adjacent to the grasslands with 1 for every 3 booming grounds. When located in the grassland complex, food patches should be about 4-6 ha, to minimize loss of grassland habitat. Winter roosting cover in the form of grass/sedge wetland habitat or a mixture of short shrubs and wetland habitats may also have to be maintained or incorporated into the management plan. However, brush should be carefully controlled to prevent excessive encroachment into the grassland habitat.

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APPENDICES

APPENDIX A

TABLES

Table 73. Release chronology, numbers, type, sex, age and number of radio-tagged prairie chickens released, Crex Meadows Wildlife Area, Wisconsin, 1974-77.

Date	Number	Type	Sex		Age				Number Radio-tagged	
					Cocks		Hens			
			Cocks	Hens	Ad	Imm	Ad	Imm	Cocks	Hens
102174	16	Pen-reared	16	0	0	16	0	0	8	0
041875	36	Pen-reared	36	0	0	36	0	0	9	0
042875	15	Pen-reared	0	15	0	0	0	15	0	6
081275	10	Semi-wild	1	9	1	0	9	0	0	3
081275	14	Pen-reared	14	0	0	14	0	0	4	0
090375	14	Pen-reared	14	0	0	0	0	14	4	5
041176	7	Wild Wisc.	6	1	6	0	1	0	3	1
041376	15	Wild Wisc.	9	6	8	1	5	1	3	3
041476	9	Wild Wisc.	4	5	3	1	5	0	1	3
042176	127	Pen-reared	50	77	0	50	0	77	9	10
041877	2	Wild Minn.	0	2	0	0	1	1	0	0
041977	6	Wild Minn.	0	5	0	0	3	3	0	4
042177	4	Wild Minn.	0	4	0	0	0	4	0	1
042277	4	Wild Minn.	0	4	0	0	1	3	0	2
042377	2	Wild Minn.	0	2	0	0	1	1	0	2
042477	2	Wild Minn.	0	2	0	0	0	2	0	1
061577	2	Wild Minn.	2	0	2	0	0	0	2	0
080577	2	Wild Minn.	2	0	2	0	0	0	1	0
080677	2	Wild Minn.	2	0	2	0	0	0	0	0
080777	4	Wild Minn.	4	0	4	0	0	0	2	0

Table 74. Observations of raptors pursuing prairie chickens away from the booming grounds, central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78.

			Prairie Chicken				Raptor		
Raptor Species	Date	Time	N Birds	Habitat	Behavior	Response	Habitat	Behavior	Fate
Falcon	03/05/72	0712	11	Cut corn	Feeding	Out flew	Unknown	Low flight	Unsuccessful
Goshawk	03/29/72	1517	15	Soybeans	Feeding	Out flew	Perch woodlot edge	Low flight	Unsuccessful
Goshawk	04/10/72	0910	1	Corn	Landing	Unknown	Perch pine	Ambush	Successful
Redtail	09/18/72	0545	4	Grass Forb	Unknown	Out fly	Perched aspen	Low flight	Unsuccessful
Goshawk	11/24/72	0801	10	Buckwheat	Feeding	Out fly	Perched elm	High flight	Unsuccessful
Goshawk	12/08/72	0908	16	Buckwheat	Feeding	Out fly	Perched Jack pine	Ambush	Unsuccessful
Goshawk	12/22/72	1445	12	Corn	Feeding	Short flight	Perched red pine	Low flight	Successful
Goshawk	12/27/72	0846	1	St. corn	Feeding	Out fly	Perched red pine	Low flight	Unsuccessful
Goshawk	01/10/73	0950	12	Corn	Feeding	Out fly	Peched pine	Low flight	Unsuccessful
Snowy owl	01/20/73	1435	2	St. corn	Feeding	Out fly	Perched pine	High flight	Unsuccessful
Goshawk	12/16/73	1410	15	St. corn	Feeding	Out fly	Unknown	Medium flight	Unsuccessful
B.Harrier	09/01/74	0823	8*	Grass	Unknown	Flush	Flying	Low flight	Unsuccessful
Goshawk	01/04/74	1114	3	Elm tree	Landing	Out fly	Perch woodlot edge	High flight	Unsuccessful

Table 74. Continued

Raptor Species	Date	Time	Prairie Chicken N Birds	Habitat	Behavior	Response	Raptor Habitat	Behavior	Fate
Redtail	07/14/74	0731	1#	Grass Forb	Unknown	Unknown	Perch elm	Low flight	Successful
Snowy owl	12/31/74	1600	1	Open snow	Loafing	Flew willows	Unknown	Low flight	Unsuccessful
Snowy owl	12/31/74	1612	4	Willow	Roost	Flew willows	Perch fence post	Low flight	Unsuccessful
Goshawk	02/07/75	0808	3	St. corn	Feeding	Out fly	Unknown	Low flight	Unsuccessful
Goshawk	02/08/75	0815	24	St. corn	Feeding	Out fly	Unknown	Low flight	Unsuccessful
Goshawk	02/08/75	0931	44	St. corn	Feeding	Out fly	Unknown	Low flight	Unsuccessful
Goshawk	02/08/75	1020	4	St. corn	Feeding	Out fly	Perch woodlot edge	Low flight	Unsuccessful
Goshawk	02/08/75	1145	21	St. corn	Feeding	Out fly	Unknown	Low flight	Unsuccessful
Goshawk	02/08/75	1146	1	St. corn	Feeding	Out fly	Unknown	Low flight	Unsuccessful
Goshawk	02/08/75	1446	21	St. corn	Feeding	Out fly	Perch woodlot edge	Low flight	Unsuccessful
Goshawk	02/08/75	1612	19	St. corn	Feeding	Out fly	Unknown	Low flight	Unsuccessful
Goshawk	02/13/75	0815	19	St. corn	Feeding	Out fly	Unknown	Low flight	Unsuccessful

Table 74. Continued.

Raptor Species	Date	Time	Prairie Chicken N Birds	Habitat	Behavior	Response	Raptor Habitat	Behavior	Fate
Goshawk	02/24/76	0945	22	Corn	Feeding	Flush	Unknown	Low flight	Successful
Goshawk	02/29/76	1420	1	St. corn	Feeding	Out fly	Unknown	Low flight	Unsuccessful
Goshawk	03/15/76	0920	25	St. corn	Feeding	Out fly	Unknown	Low flight	Unsuccessful
B.Harrier	10/02/76	1737	2	Buckwheat	Feeding	Flush	Flying	Low flight	Unsuccessful
B.Harrier	10/06/76	0835	2	Buckwheat	Unknown	Flush	Flying	Low flight	Unsuccessful
B.Harrier	10/06/76	0846	2	Buckwheat	Unknown	Flush	Flying	Low flight	Unsuccessful
B.Harrier	10/06/76	0850	2	Buckwheat	Unknown	Flush	Flying	Low flight	Unsuccessful
B.Harrier	10/07/76	1000	2	Unknown	Unknown	Flush	Flying	Low flight	Unsuccessful
B.Harrier	10/12/77	0824	5	Buckwheat	Feeding	Flush	Flying	Low flight	Unsuccessful
B.Harrier	10/14/77	0815	2	Buckwheat	Unknown	Flush	Flying	Low flight	Unsuccessful
B.Harrier	10/18/77	0819	3	Corn	Unknown	Flush	Flying	Low flight	Unsuccessful
Peregrine	04/29/78	0620	2	Buckwheat	Feeding	Out fly	Flying	Stoop	Unsuccessful

Table 75. Number of booming grounds that radio-tagged prairie chickens came within 1 km of for at least 2 days by sex and age by season, central Wisconsin, 1972-76.

	Winter						Spring								Fall					Summer							
	Number of Booming Grounds						Number of Booming Grounds								Number of Booming Gds					Number of Booming Grounds							
	1	2	3	4	5	Mean	1	2	3	4	5	6	7	Mean	1	2	3	4	Mean	1	2	3	4	5	6	7	Mean
Cocks																											
Adults	0	5	4	2	0	2.7±0.8	15	2	0	0	0	0	0	1.1±0.3	5	5	0	0	1.5±0.5	3	4	2	0	0	0	0	1.9±0.8
Immatures	0	1	2	1	0	3.0±0.8	3	1	3	0	0	0	0	2.0±1.0	6	2	1	0	1.4±0.7	1	4	3	0	0	0	0	2.3±0.7
Total	0	6	6	3	0	2.8±0.8	18	3	3	0	0	0	0	1.4±0.7	11	7	1	0	1.5±0.6	4	8	5	0	0	0	0	2.1±0.7
Hens																											
Adults	1	3	2	1	0	2.4±1.0	7	7	0	0	0	0	0	1.5±0.5	3	2	1	0	1.7±0.8	1	1	2	0	1	0	0	2.8±1.5
Immatures	0	2	1	1	0	2.8±1.0	0	3	2	2	2	2	0	3.8±1.5	0	2	2	0	2.5±0.6	0	1	2	0	1	0	1	4.0±2.0
Total	1	5	3	2	0	2.6±0.9	7	10	2	2	2	2	0	2.5±1.6	3	4	3	0	2.0±0.8	1	2	4	2	2	0	1	3.4±1.8
Broods															5	4	1	0	1.6±0.7								

Table 76. Frequency (≥1.0%) of plant species associated with day and night locations of radio-tagged prairie chickens during winter and spring in central Wisconsin, 1972-76 and Crex Meadows Wildlife Area, Wisconsin, 1976-78.

	Winter						Spring					
	Central Wisc			Crex Meadows			Central Wisc			Crex Meadows		
Species	Day	Night	Total	Total	Day	Night	Day	Night	Total	Total	Day	Night
AGRICULTURAL												
Standing corn	25.4	8.1	19.7	5.8	8.2	–	1.9	0.5	1.5	11.4	13.4	6.4
Picked corn	2.5	0.4	1.8	0.4	0.5	–	0.3	0.1	0.2	–	–	–
Cut corn	1.6	–	1.0	–	–	–	2.7	0.7	2.1	0.3	0.3	–
Corn pile	16.9	–	11.3	17.9	25.1	–	0.5	–	0.4	0.1	0.2	–
Total corn	46.4	8.5	33.8	24.1	33.8	–	5.4	1.3	4.2	11.8	13.9	6.4
Buckwheat	7.3	–	4.9	2.6	2.9	2.0	1.5	–	1.1	7.5	9.0	3.7
Alfalfa	–	–	–	0.2	0.3	–	–	–	–	0.7	1.0	–
Mowed oats	1.0	–	0.7	0.4	0.5	–	1.4	0.3	0.2	2.0	2.5	0.9
Rye	–	–	–	3.5	–	2.5	–	–	–	12.1	16.8	0.2

Table 76. Continued.

Species	Winter						Spring					
	Central Wisc			Crex Meadows			Central Wisc			Crex Meadows		
	Day	Night	Total	Total	Day	Night	Day	Night	Total	Total	Day	Night
GRASSES/SEDGES												
Andropyron repens	7.0	8.8	7.6	0.3	0.3	0.3	18.8	36.8	24.4	2.0	2.1	1.7
Poa pratensis	5.0	7.2	5.8	–	–	–	42.7	23.4	36.7	0.2	–	–
Phleum pratense	0.3	1.4	0.7	–	0.1	–	7.7	5.8	7.1	1.1	1.1	1.0
Panicum spp.	–	–	–	3.3	3.8	2.1	–	–	–	2.7	2.1	4.0
Bromus inermis	0.3	–	0.2	–	–	–	1.0	0.7	0.9	0.1	0.2	–
Andropogon gerardi	–	–	0.2	5.8	5.8	5.9	1.3	0.2	1.0	10.3	9.8	11.5
Andropogon scoparius	–	–	–	–	–	–	–	–	–	0.6	0.3	1.4
Phalaris arundinacea	0.5	1.6	0.9	–	–	–	0.6	1.0	0.7	3.3	3.4	3.1
Calamagrostis canadensis	–	1.0	0.4	9.6	7.7	14.2	0.1	0.1	0.1	7.5	5.5	12.6
Mulhenbergia spp.	–	–	–	0.3	0.3	0.5	–	–	–	0.7	1.7	0.1
Carex spp.	7.3	12.6	9.0	20.7	14.7	35.4	0.3	0.7	0.4	6.5	6.4	6.8
Carex stricta	–	–	–	5.3	4.0	8.6	–	–	–	4.8	4.1	6.5
Scirpus cyperinus	0.8	6.1	2.5	7.0	5.6	10.4	0.2	0.4	0.3	3.8	2.6	7.1
Carex rugosa	–	–	–	0.2	0.3	0.2	–	–	–	1.5	1.2	2.2
FORBS												
Linaria vulgaris	0.2	0.3	0.2	–	–	–	2.8	0.3	2.1	–	–	–
Pteridium aquilinum	–	–	–	0.4	0.3	0.5	–	–	–	1.6	1.2	2.6
Solidago spp.	8.0	18.5	11.5	0.5	0.6	0.2	10.1	19.9	13.2	1.6	1.5	1.8
Fragaria spp.	–	–	–	–	–	–	1.0	0.1	0.6	0.3	0.3	0.3

Table 76. Continued

Species	Winter						Spring					
	Central Wisc			Crex Meadows			Central Wisc			Crex Meadows		
	Day	Night	Total	Total	Day	Night	Day	Night	Total	Total	Day	Night
SHRUBS												
Alnus spp.	0.2	–	0.1	0.5	0.3	1.1	–	–	–	0.2	0.2	0.2
Populus spp.	1.4	4.3	2.4	0.4	0.6	–	0.8	–	0.5	–	–	–
Prunus spp.	0.5	–	0.4	–	–	–	–	–	–	–	–	–
Corylus americana	–	–	–	4.4	4.0	5.4	–	–	–	5.1	4.1	7.5
Quercus spp.	1.4	0.4	1.0	3.7	2.9	5.7	–	–	–	2.5	1.7	4.4
Comptonia peregrina	–	–	–	4.5	3.9	5.9	–	–	–	7.8	6.8	10.4
Spirea spp.	0.8	8.3	3.2	–	–	–	0.5	4.6	1.8	–	–	–
Salix spp.	7.2	20.3	11.5	0.6	0.5	1.0	1.8	1.6	2.3	0.3	0.2	0.3
TREES												
Populus spp.	1.0	–	2.3	–	–	–	–	–	–	–	–	–
Pinus spp.	1.2	0.1	0.3	–	–	–	–	–	–	0.1	0.1	–
Quercus spp./Ulmus	0.5	–	0.4	2.0	2.8	–	–	–	–	–	–	–

Table 77. Seasonal frequency (≤1.0%) of plant species associated with day and night locations of radio-tagged prairie chickens in central Wisconsin, 1972-76 Crex Meadows Wildlife Area, Wisconsin, 1976-78.

	Summer						Fall					
	Central Wisc			Crex Meadows			Central Wisc			Crex Meadows		
Species	Day	Night	Total	Total	Day	Night	Day	Night	Total	Total	Day	Night
AGRICULTURAL												
Stand corn	1.0	1.0	1.0	5.8	7.7	2.0	8.8	2.0	5.8	8.7	13.3	0.3
Picked corn	-	-	-	-	-	-	1.9	-	1.0	1.1	1.8	-
Cut corn	0.1	-	-	0.1	0.2	-	4.9	0.1	2.7	0.7	1.1	-
Total corn	1.1	1.0	1.0	5.9	7.9	2.0	15.6	2.1	9.5	10.5	16.2	0.7
Buckwheat	0.4	0.3	0.3	4.8	6.7	0.7	4.0	-	2.2	7.4	11.6	7.4
Alfalfa	1.7	0.9	1.4	2.3	2.8	1.3	0.3	0.8	0.5	1.2	1.9	-
Mowed oats	0.8	0.4	0.6	4.0	4.9	2.0	9.7	0.7	5.6	1.5	2.3	-
Rye	-	-	-	5.8	8.2	-	-	-	-	6.5	10.1	-
Mint	0.1	0.1	0.1	-	-	-	1.3	-	0.7	-	-	-

Table 77. Continued.

Species	Summer						Fall					
	Central Wisc			Crex Meadows			Central Wisc			Crex Meadows		
	Day	Night	Total	Total	Day	Night	Day	Night	Total	Total	Day	Night
GRASSES/SEDGES												
Andropyron repens	17.1	31.2	22.0	1.3	1.1	0.5	18.1	30.5	23.7	0.8	0.9	0.6
Poa pratensis	45.8	23.4	38.1	-	-	-	20.6	17.2	19.1	-	-	-
Phleum pratense	7.5	8.2	7.7	0.6	0.8	0.2	3.4	4.0	3.7	0.4	0.2	0.3
Panicum spp.	0.3	0.1	0.2	3.9	3.9	3.7	1.2	0.1	0.7	3.1	3.5	2.2
Bromus inermis	0.7	2.5	1.3	0.3	0.4	0.2	3.2	2.3	2.8	0.3	0.4	-
Andropogon gerardi	-	-	-	9.9	8.8	12.1	-	-	-	8.7	8.0	9.8
Andropogon scoparius	-	-	-	1.4	1.4	1.6	-	-	-	0.4	0.3	0.4
Phalaris arundinacea	0.2	-	0.1	2.2	1.6	3.3	1.1	1.4	1.3	0.6	0.7	0.4
Calamagrostis canadensis	-	0.2	0.1	11.7	12.2	10.8	0.2	1.2	0.7	12.0	8.5	18.1
Mulhenbergiaspp.	-	-	-	2.9	2.3	4.2	-	-	-	0.9	0.8	1.0
Carex spp.	0.7	0.6	0.7	2.8	2.7	3.0	0.4	1.1	0.7	10.1	5.7	18.1
Carex stricta	-	-	-	7.5	6.4	9.9	-	-	-	5.2	3.6	8.1
Scirpus cyperinus	0.2	0.2	0.2	8.5	7.6	10.4	0.2	0.5	0.4	8.7	5.7	14.2
Carex rostrata	-	-	-	1.8	2.0	1.4	-	-	-	1.2	1.0	1.6

Table 77. Continued.

Species	Summer						Fall					
	Central Wisc			Crex Meadows			Central Wisc			Crex Meadows		
	Day	Night	Total	Total	Day	Night	Day	Night	Total	Total	Day	Night
FORBS												
Linaria vulgaris	3.2	3.8	2.2	3.2	–	–	0.9	3.1	1.9	–	–	–
Pteridium aquilinum	–	–	–	2.2	1.7	3.2	–	–	–	0.8	0.8	0.8
Liatris spp.	–	–	–	–	–	–	–	–	–	1.0	1.4	0.4
Trifolium repens	2.1	1.1	1.8	1.5	1.8	1.0	1.8	1.2	1.5	0.1	0.1	0.2
Urtica dioica	0.6	0.5	0.6	–	–	–	1.0	0.4	0.6	–	–	–
Solidago spp.	13.0	19.0	15.1	2.1	2.5	1.3	8.3	21.7	14.3	1.9	2.1	1.6
Fragaria spp.	0.8	–	0.5	1.1	1.6	0.1	0.2	–	0.1	–	–	–
Unknown		0.2	–	0.1	–	–	–	–	–	–	–	–
SHRUBS												
Alnus spp.	–	–	–	0.2	0.4	0.2	–	–	–	1.0	1.1	0.9
Populus spp.	0.6	0.2	0.5	–	–	–	3.5	0.7	2.3	–	0.1	–
Prunus sp.	–	–	–	–	–	–	2.1	–	1.2	–	–	–
Corylus americana	–	–	–	6.1	4.3	10.1	–	–	–	5.2	4.2	7.0
Quercus spp.	–	–	–	2.4	1.4	4.5	0.3	0.2	0.2	3.6	3.1	4.4
Comptonia peregrina	–	–	–	6.3	3.6	12.0	–	–	–	6.5	5.3	8.6
Spirea spp.	0.8	5.0	2.2	–	–	–	1.0	5.5	3.0	0.1	0.0	0.2
Salix spp.	1.1	2.5	1.6	0.4	0.5	0.2	1.8	5.3	3.3	0.2	0.2	0.3

Table 78. Mean distance (m) from display grounds and random points to nearest tree(s) and screening treeline(s), treeless area and area of open space (ha) surrounding display grounds in central Wisconsin, 1972-1976 and Crex Meadows Wildlife Area, Wisconsin, 1976-1984 and western Minnesota, 1977.

		Distance Nearest Trees		Treeless Area		Distance Screening Treeline		Area Open Space	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range
CENTRAL WISCONSIN									
Booming grounds	n=104	1059± 347	241-2714	390±254	53-1051	1413±420	241-6432	682± 387	107-1855
Random Points	n=106	649±260	121-845	153±111	8-402	971±322	121-3801	328± 212	63-817
CREX MEADOWS									
Booming grounds	n= 27	1283±290	382-2051	542±207	120-752	1956±265	502-4824	1222± 297	596-1798
Mixed grounds	n= 13	947±385	201-2694	324±248	101-753	1617±369	201-4826	861± 349	158-1495
Dancing grounds	n= 86	573±396	40-2936	152±189)	11-667	1191±487	101-4824	519± 370	28-1494
Random Points	n=103	486±195	41-2051	86± 69	18-251	778±293	40-3802	217± 157	50-566
WESTERN MINNESOTA									
Booming grounds	n= 25	1051±442	302-3479	406±371	112-1407	2659±849	261-19899	2437±1374	304-4890
Random Points	n= 25	769±320	52-2051	217±150	19-453	1960±811	101-6536	1406±1046	96-3100

Table 79. Mean distance (m) from display grounds to nearest tree(s), screening treeline(s), treeless area (ha) and area of open space (ha) surrounding display grounds relative to the number of cocks, central Wisconsin, 1972-76, Crex Meadows Wildlife Area, Wisconsin, 1976-84 and western Minnesota, 1977.

		Nearest Trees Mean	Treeless Area Mean	Nearest Screening Woodlot Mean	Open Area Mean
CENTRAL WISCONSIN					
1	n=12	928±277	292±187	1563±536	849± 554
2-5	n=12	862±286	258±183	1282±433	574± 400
6-9	n=26	1089±291	98±203	1399±421	668± 375
10-15	n=12	1264±228	517±184	1521±355	764± 331
16-20	n= 6	1585±339	818±297	1672±124	883± 130
>20	n= 2	1830± -	1052± -	1699± -	907± -
CREX MEADOWS					
Booming grounds					
1	n=11	1184±325	470±220	1878±348	1143± 395
2-5	n= 8	1309±147	544±128	2017±236	1293± 263
6-25	n= 4	1548± -	753± -	1993± -	1247± -
Dancing grounds					
1	n=14	860±461	294±207	1467±544	764± 489
2-5	n=46	542±358	131±175	1073±476	431± 327
6-9	n= 7	543±398	134±166	1362±372	620± 279
10-15	n= 6	277± 77	26± 13	1272±344	537± 261
16-20	n= 3	347± -	38± -	1104±363	410± 275
WESTERN MINNESOTA					
Booming grounds					
10-15	n= 2	957±157	293± 93	3066±813	3091±1626
16-20	n= 2	1056±107	351± 71	3620±460	4150±1046
>20	n=12	1062±481	421±403	2420±892	2073±1379

Table 80. Comparaison of seasonal habitat use (%) between non-radioed prairie chickens and sharptail grouse Crex Meadows Wildlife Area, 1976-78. Number of locations are in parentheses.

	Prairie Chickens (3,311)	Sharptails (3,054)
Winter		
Agriculture	54.4 (514)	40.4 (333)
Grass	14.3 (135)	9.4 (77)
Shrub Grass	0.8 (8)	7.2 (59)
Shrubs	13.7 (129)	9.0 (74)
Trees	12.6 (119)	26.7 (220)
Other	4.2 (39)	7.4 (61)
Total	(944)	(824)
Spring		
Agriculture	56.0 (202)	28.4 (225)
Grass	19.7 (71)	14.5 (115)
Shrub Grass	7.8 (28)	13.5 (107)
Shrubs	0.5 (2)	7.1 (56)
Trees	2.2 (8)	25.4 (201)
Other	13.9 (50)	11.1 (87)
Total	(361)	(791)
Summer		
Agriculture	47.5 (125)	27.8 (65)
Grass	31.9 (82)	23.0 (54)
Shrub Grass	3.7 (21)	29.5 (69)
Shrubs	4.9 (13)	7.7 (18)
Trees	-	-
Other	8.0 (21)	11.9 (28)
Total	(262)	(234)
Fall		
Agriculture	55.8 (974)	36.1 (435)
Grass	13.8 (240)	10.6 (128)
Grass Shrub	8.3 (144)	18.0 (217)
Shrubs	3.4 (60)	8.2 (99)
Trees	12.8 (223)	15.2 (183)
Other	5.9 (103)	11.9 (143)
Total	(1,744)	(1,205)

Table 81. Seasonal percentages of single species and mixed species flocks by sex for radio-tagged prairie chickens and sharptails, Crex Meadows Wildlife Area, Wisconsin, 1976-78. Number of flocks are in parentheses.

	Prairie Chickens				Sharptails			
	Cocks		Hens		Cocks		Hens	
Season	Pure	Mixed	Pure	Mixed	Pure	Mixed	Pure	Mixed
Winter	28.3(17)	71.7(43)	2.5 (1)	97.5(38)	68.8(11)	31.3 (5)	41.7(15)	58.3(21)
Spring	83.3 (5)	16.7 (1)	33.3 (4)	66.7 (8)	100.0(10)	0	60.0 (3)	40.0 (2)
Summer	60.0 (3)	20.0 (1)	0	0	100.0 (6)	0	0	0
Fall	52.9(27)	47.1(24)	58.8(10)	41.2 (7)	100.0 (8)	0	41.7(15)	58.3(21)
Total	43.0(52)	57.0(69)	22.1(15)	77.9(53)	87.5(35)	12.5 (5)	42.9(33)	57.1(44)

APPENDIX B

FIGURES

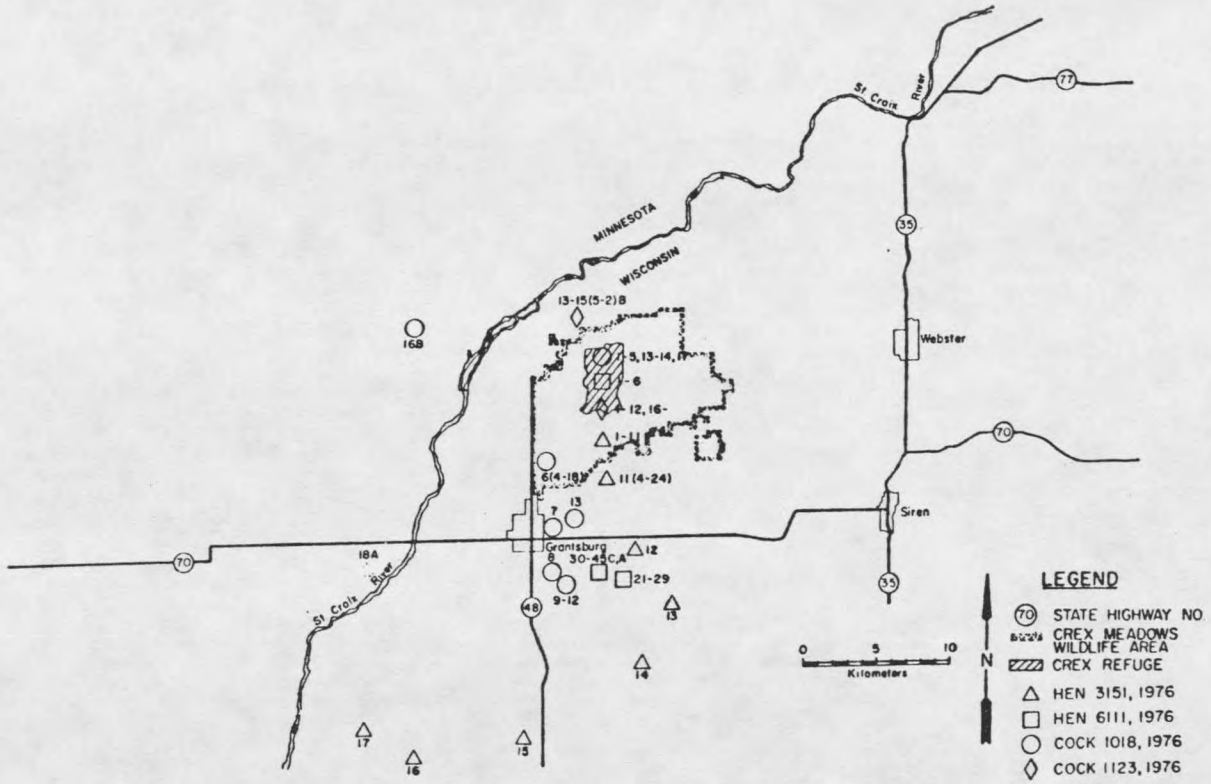


Figure 70. Locations relative to the number of days since release for radio-tagged prairie chicken hens (3151, 6111) and cocks (1018 and 1123) transplanted in April, Crex Meadows Wildlife Area, Wisconsin, Area (A=Dead, B=Next location at Crex).

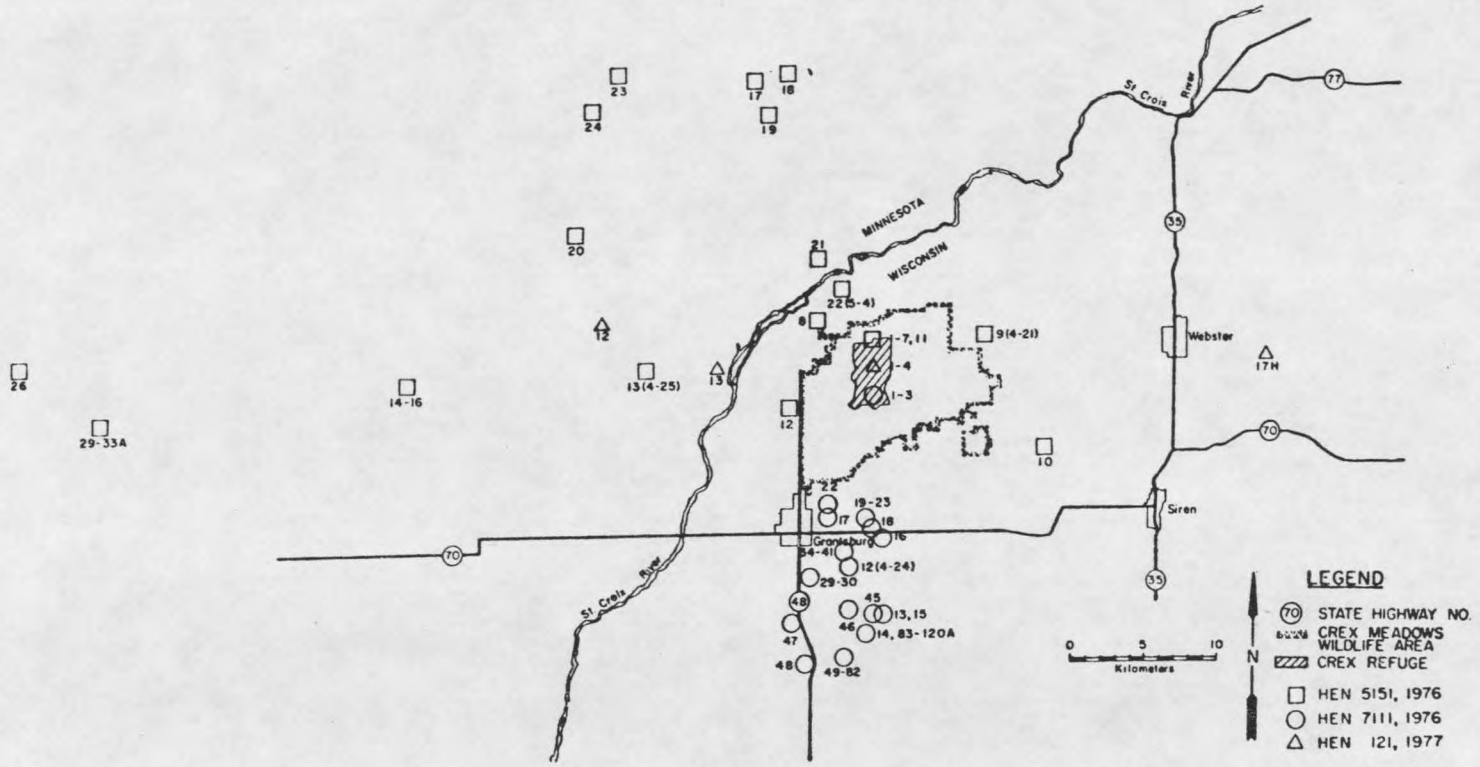


Figure 71. Locations relative to the number of days since release for radio-tagged prairie chicken hens (5151, 7111, 121) transplanted to Crex Meadows Wildlife Area, Wisconsin in April 1976-77. (A=Dead, B=Next location at Crex, E=Recaptured and returned to Crex).

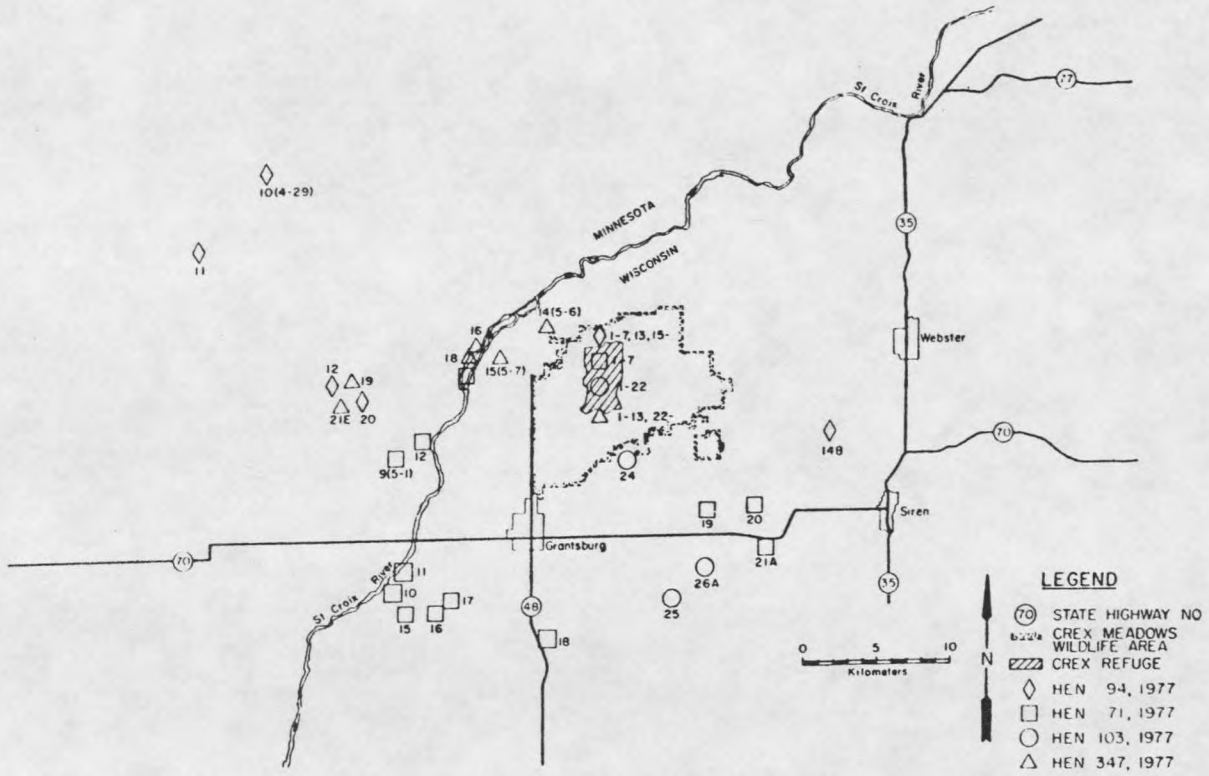


Figure 72. Locations relative to the number of days since release for radio-tagged prairie chicken hens (94, 71, 103, and 347) transplanted Crex Meadows Wildlife Area, Wisconsin, in April 1977 (A=Dead, B=Next location at Crex, E=Recaptured and returned to Crex

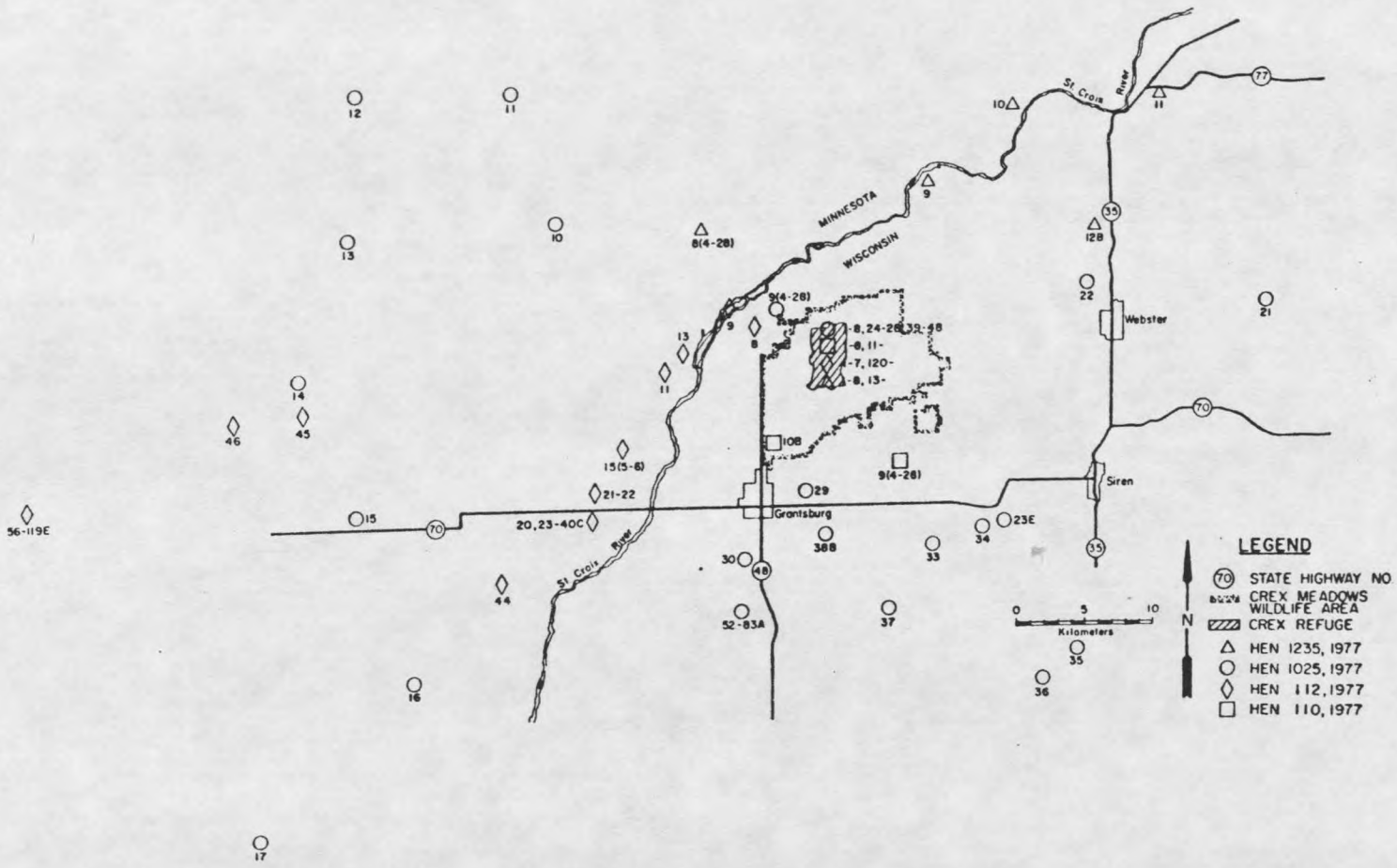


Figure 73. Locations relative to the number of days since release for radio-tagged hens (1235, 1025, 112, and 110) transplanted to Crex Meadows Wildlife Area, Wisconsin, in April 1977 (A=Dead, B=Next location at Crex, E=Recaptured and returned to Crex).

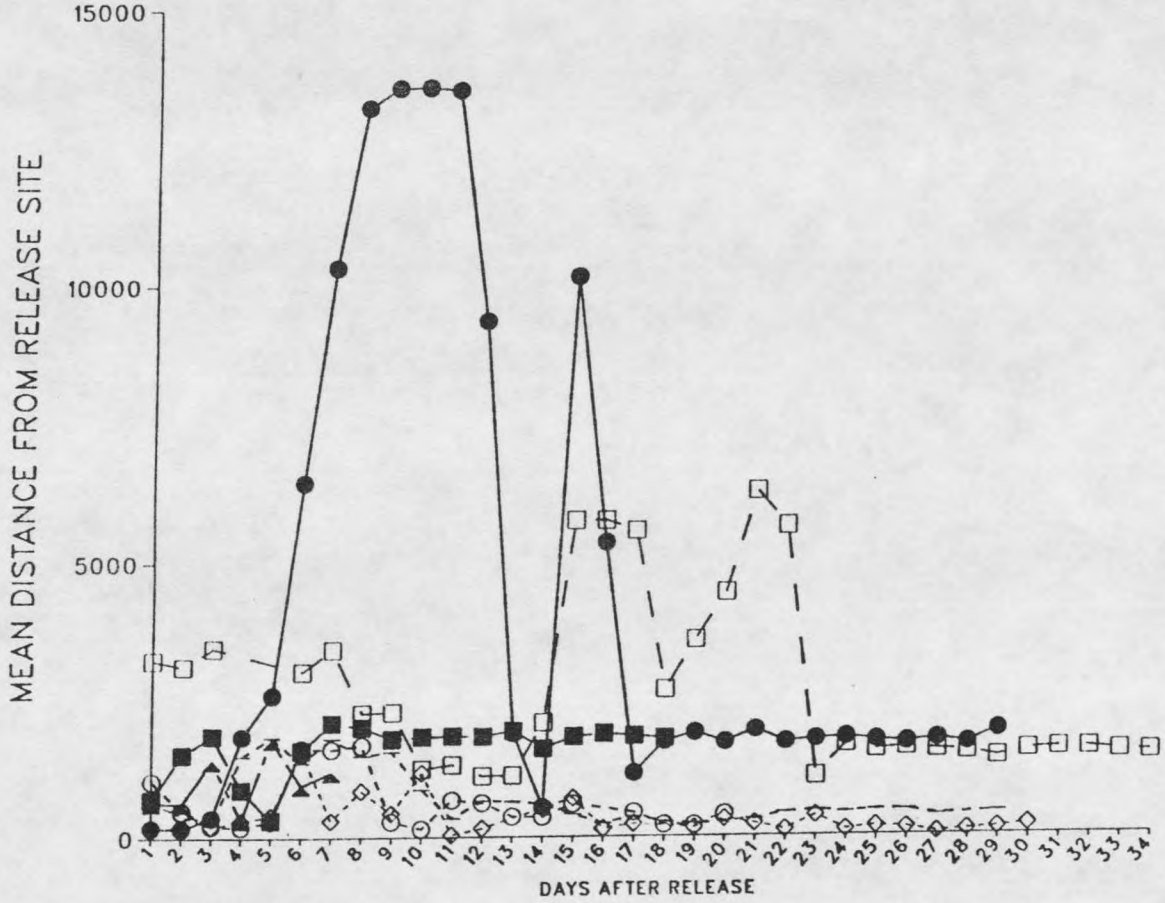


Figure 74. Mean daily distance from release site for transplanted radio-tagged prairie chicken cocks, Crex Meadows Wildlife Area, Wisconsin, April 1976.

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