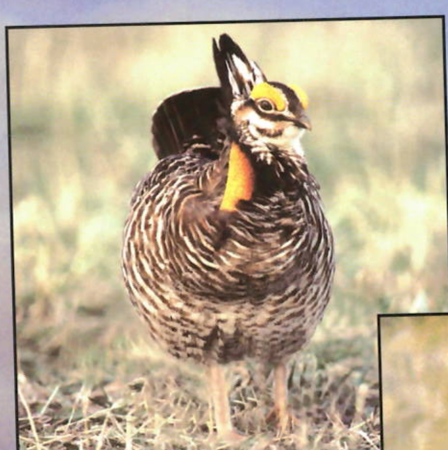
Society of Tympanuchus Cupido Pinnatus, Ltd.

Prairie Chickens & Grasslands: 2000 and Beyond

A Report to the Council of Chiefs

JOHN E. TOEPFER, PH.D.
Greg Septon, Editor



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SOCIETY OF
TYMPANUCHUS
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PINNATUS
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In 1960 the seed was planted for the creation of The Society of Tympanuchus Cupido Pinnatus, Ltd. (STCP) when Dory Vallier said to Bill Sullivan, "Bill, you've just got to help the prairie chicken". Bill responded: "hell, I didn't even know he was in trouble". But soon thereafter, Bill founded the STCP which set out to save Wisconsin's prairie chickens by acquiring over 7,000 acres of remaining critical habitat. The lands have since been deeded to the Wisconsin DNR (with a reversion provision) and the Society has additionally spent well over $1,000,000 to help Wisconsin's watch, threatened, and endangered species.

After over 30 years of working to help Wisconsin's prairie chickens, the Society has certainly seen some good days. But with all the troubles and downward trends prairie chickens were experiencing in other states, the Society had some real concerns. We didn't know whether Wisconsin's prairie chickens were in trouble or not, but following what was happening in other states, we weren't willing to just wait and see. To address these concerns, the Society set the parameters, hired John E. Toepfer, Ph.D. as its principal investigator & research consultant, and in 1996 started a project titled "Prairie Chickens & Grasslands: 2000 and Beyond". After nearly eight years and over $1,500,000, this project is coming to a close. Numerous scientific papers, symposia presentations, and Masters theses as listed in this report have been completed and more will follow.

We may not truly know the fate of the prairie chicken in Wisconsin except through hindsight. But, we believe we do know its fate if the research and recommendations contained in this report are not absorbed in the management recommendations and not immediately and aggressively enacted. The prairie chicken was once common from the East Coast to the Rockies and from the Gulf of Mexico to Canada. Wisconsin now has the only significant population east of the Mississippi and most populations west of the great river have their problems. The prairie chicken is a unique bird. If it is to survive as a self-sustaining population in Wisconsin, immediate and aggressive action must take place. We believe this report can help lead the way in Wisconsin and hopefully be of help to prairie chicken populations throughout the country.

Bernard J. Westfahl

Bernard J. Westfahl
Tympanuchus, President

TO SAVE THE PRAIRIE CHICKEN FROM EXTINCTION

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Editor: Greg Septon, Chairman STCP Projects & Research Committee
Designer: Adria Day, Yellowdog Designs

Introduction

It was in the winter of 1993 that I first met with Council of Chiefs of the Society of Tympanuchus Cupido Pinnatus, Ltd. (STCP) to discuss research and management needs for the prairie chicken in Wisconsin. Since the early 1960's STCP has led the way in supporting prairie chicken conservation in Wisconsin - their mission being to save the species from extinction. I came to Wisconsin at the Council's invitation because they had become increasingly concerned about the status of the prairie chicken in the state and wanted to conduct an independent appraisal of its well-being and future. One of the first questions I was asked by then President Bernie Westfahl was, "what more do we need to know about prairie chickens - what is the biggest gap in our knowledge of their ecology?" My response was, "dispersal of young of the year, or where do the cocks and hens that show up on the booming grounds each spring come from"? After further discussion, the Council asked if I would be willing to come to Wisconsin to work and I said I would.

Shortly after our meeting, I wrote and submitted a research proposal to the Council. The proposal had broad objectives and was by no means conventional. My original objective was simple - to increase our knowledge of greater prairie chicken ecology by filling in the gaps of what we already knew. The objectives were designed to be broad and non-traditional so the project would be descriptive, remain flexible, not be hypothesis driven, and not solely follow the path of past studies that concentrated on nesting and/or brood rearing habitat. The emphasis and possibly overemphasis on nesting ecology is evident when one realizes that there have been eight nesting studies conducted since 1928 in central Wisconsin.

Numerous earlier studies utilized radio telemetry to study movements, nesting, and habitat use but failed to study other important aspects of greater prairie chicken ecology and management. In the beginning, the WDNR wanted our research efforts to focus on evaluating management practices on the Buena Vista Wildlife Area. I however felt that it was in the best interest of the prairie chicken to go beyond this and examine multiple areas of concern in Wisconsin and region-wide. Proceeding along these lines, I decided to address all of the major limiting factors. These factors included food, cover, disease, parasites, pesticides, predation, accidents, space, and genetics. Most of these factors have not been studied in Wisconsin and have received little attention elsewhere. There is no doubt that if STCP had done what others wanted we would have limited the scope of this project and not answered the questions that really needed to be answered.

Research is the "process of elimination" and we hoped to eliminate these unstudied factors one by one and, as objectively as possible, determine what factor or factors were having the greatest effect on prairie chickens numbers. In spite of the rather broad scope of our research, one critical but unstudied aspect of greater prairie chicken ecology/life history was singled out for intensive study and became the focal point of this project - dispersal of young of the year.

Two case studies serve to underscore the problems with past prairie chicken research and management. The first study was in Illinois where for 20 years research looked primarily at nesting habitat and ignored the long-term effects of isolation and fragmentation. In 1992, Illinois translocated birds from Minnesota to increase the genetic diversity of a population that had declined from 250 cocks to less than 20 (Bouzat et al. 1998a, 1998b, Westemeier et al. 1998, Westemeier et al. 1999). The second study occurred in Texas, where multiple factors were examined to determine the exact reasons for declining numbers of the Attwater's prairie chicken (Tympanuchus cupido attwateri) (Morrow et al. 1996, Silvy et al. 1999). In spite of extensive research efforts, they failed to prevent the Attwater's prairie chicken from becoming what many now perceive to be the most endangered bird in the United States.

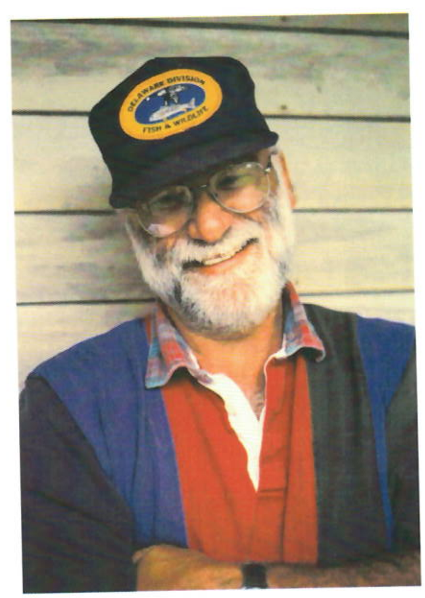
The most unfortunate aspect of much of the past work on prairie chickens is that it has done little to improve the status of the species. This is not only true in Illinois and Texas where populations are on the brink of extinction, but nationwide where the status of the greater prairie chicken across much of its range is one of contracting ranges and/or declining numbers; the exceptions being greater prairie chickens in Minnesota, Nebraska, South Dakota and Colorado (Westemeier and Gough 1999, Svedarsky et al. 2000).

Considering past efforts, we chose to look first at dispersal and some of the traditional aspects of greater prairie chicken ecology while simultaneously examining factors that had received little study. These factors included nesting success, predation, open space, pesticides, accidents, disease, parasites, genetics, and food. This seemed a task all but impossible to complete in just five or even ten years. But nevertheless, this approach was absolutely necessary and allowed us to reveal that other factors aside from the just the amount of grassland cover were also influencing greater prairie chicken numbers.

In April 1996, I began fieldwork on PCG2B with three assistants trapping greater prairie chickens in central Wisconsin. In the following seven years we trapped over 4,600 prairie chickens in seven states. A good portion of the fieldwork has involved trapping and monitoring radio-tagged birds to study prairie chicken ecology. The results of some of this research have already been published in technical journals and more publications are forthcoming. However, at this time we have completed enough analysis to warrant making recommendations in a final report to the Council of Chiefs of STCP Ltd.

This report provides an overview of the results of the research project, Prairie Chickens & Grasslands: 2000 and Beyond 1996-2003. The major results of our efforts are outlined in the pages that follow.

John E. Toepfer, Ph.D.



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Acknowledgements

First and foremost I want to thank the Society of Tympanuchus Cupido Pinnatus, Ltd. (STCP) and its Council of Chiefs past and present for their generous funding, moral & political support, and the opportunity to develop and conduct the research project Prairie Chickens Grasslands: 2000 and Beyond (PCG2B). I would especially like to thank Russ Schallert who served as Tympanuchus and initiated and coordinated this project between 1995 - 2001.

It took 10 years to get this project started and completed. I hope that others will come to know as I have, the dedication, resolve, and commitment that STCP has to wildlife conservation and ensuring a future for prairie chickens. I also hope everyone will come to fully understand and truly appreciate just what STCP has accomplished. By providing the funding and especially the freedom and flexibility, STCP created a scenario whereby myself and associates were able to initiate and carry out research in several areas, ask pertinent questions, pursue hunches, follow leads and do what needed to be done.

During the 1960's and 1970's, in a grass roots effort to save Wisconsin's prairie chickens from extirpation, STCP led the way in purchasing and preserving vital grassland habitat in the remaining portions of its range. Today, these central Wisconsin lands have become the last stronghold for the species in the state. Completion of the research project PCG2B, follows in these footsteps and will become an important part of STCP's ongoing legacy of prairie chicken conservation.

The vast majority of funding for this project was provided by STCP with additional support from North Dakota Game and Fish Department, Minnesota Prairie Chicken Society, Minnesota Department of Natural Resources, U.S. Fish and Wildlife Service, Wildlife Forever and the Crow Creek Indian Reservation. Additional funding and support was provided by the following: Alvin & Marion Birnschein Foundation, Eugenie Mayer Bolz Family Foundation, Herbert H. Kohl Charities, Inc., Wauwatosa Savings Bank Foundation, Milwaukee Foundation Corporation, Foundation for Wildlife Conservation, Antonia Foundation, Wisconsin River Power Co., Peggy Lou Prudell Bequest, James Grootemaat, Jan K. Sedivy, David Uihlein, Toby Sherry, Helen Best and George T. Richardson.

Bernie Westfahl who led STCP during the early 1990's took over the reigns again in 2001 and has helped steer PCG2B to completion. STCP Projects and Research Committee Chair, Greg Septon edited this report and Jeffery Johnson assisted with the section on genetics. Dr. Peter Dunn of the Biology Department at the University of Wisconsin - Milwaukee provided laboratory space, technical assistance and funding for graduate students Renee Bellinger and Jeffery Johnson.

Many individuals were also involved in the trapping, radio marking and the collection of the field data for this Final Report. STCP Research Fellows contributing to these efforts included: David Halfmann, Mike Blondin, Beau Willsey, Mick Hicks, Joel Brice, Dean Van Doren, Matt Larocque, Troy Minks, Kieran Fleming, Chris Lewinski, Carrie Walchezk, Jan Axtell, Eric Rosenquist, Deann De La Ronde, Aaron Pratt, Tim White, Paul Keenlance and John Schmidt. Of the above, David Halfmann has had the longest tenure on the project - 1997-2003. A very special thank you to all the Fellows for their many long days and nights in the field. The late Drs. Fred (Hammy) and Fran Hamerstrom and Professor Raymond K. Anderson should be recognized for providing over 50 years of notes and historical records on Wisconsin's prairie chickens.

Others who provided technical assistance and logistical support include the following:
In Wisconsin, thanks go to the Chequamegon Bird Club for censusing the northern range, University of Wisconsin - Stevens Point (UWSP) professors Raymond K. Anderson, Steve Taft, Eric Anderson, Dave Naugle, Byron Shaw, James Hardin and Evellyn Merrill, UWSP staff: William DeVita, Bob Kilkoyne, and Alexis Priddy, University of Wisconsin - Madison professor Dr. JoAnne Paul-Murphy, Wisconsin Department of Natural Resources (WDNR) staff: Tom Meier, Brian Peters, Tony Geiger, Beth Arthur, Ken Jonas, Rebecca Isenring, Jim Keir, Larry Crawford, Ken Rosenthal, Carrie Milestone, Gary Wolf, Irene Schmidt and Chuck Pils.

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Finally and critically important, many thanks to the countless landowners in Wisconsin, Minnesota, North Dakota, Nebraska, South Dakota and the Crow Creek Indian Reservation who allowed us access to their lands so we could study prairie chickens.

Left: John Toepfer, Fran Hamerstrom, and Ray Anderson.

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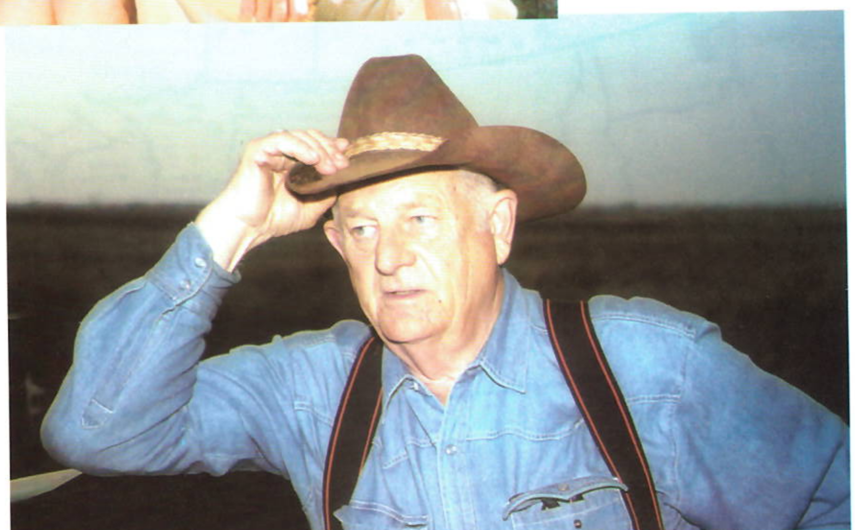

Right: STCP Council of Chiefs member and rancher Doug Hambach. Bottom Left: Native grassland. Bottom Right: Sign, Buena Vista Wildlife Area.

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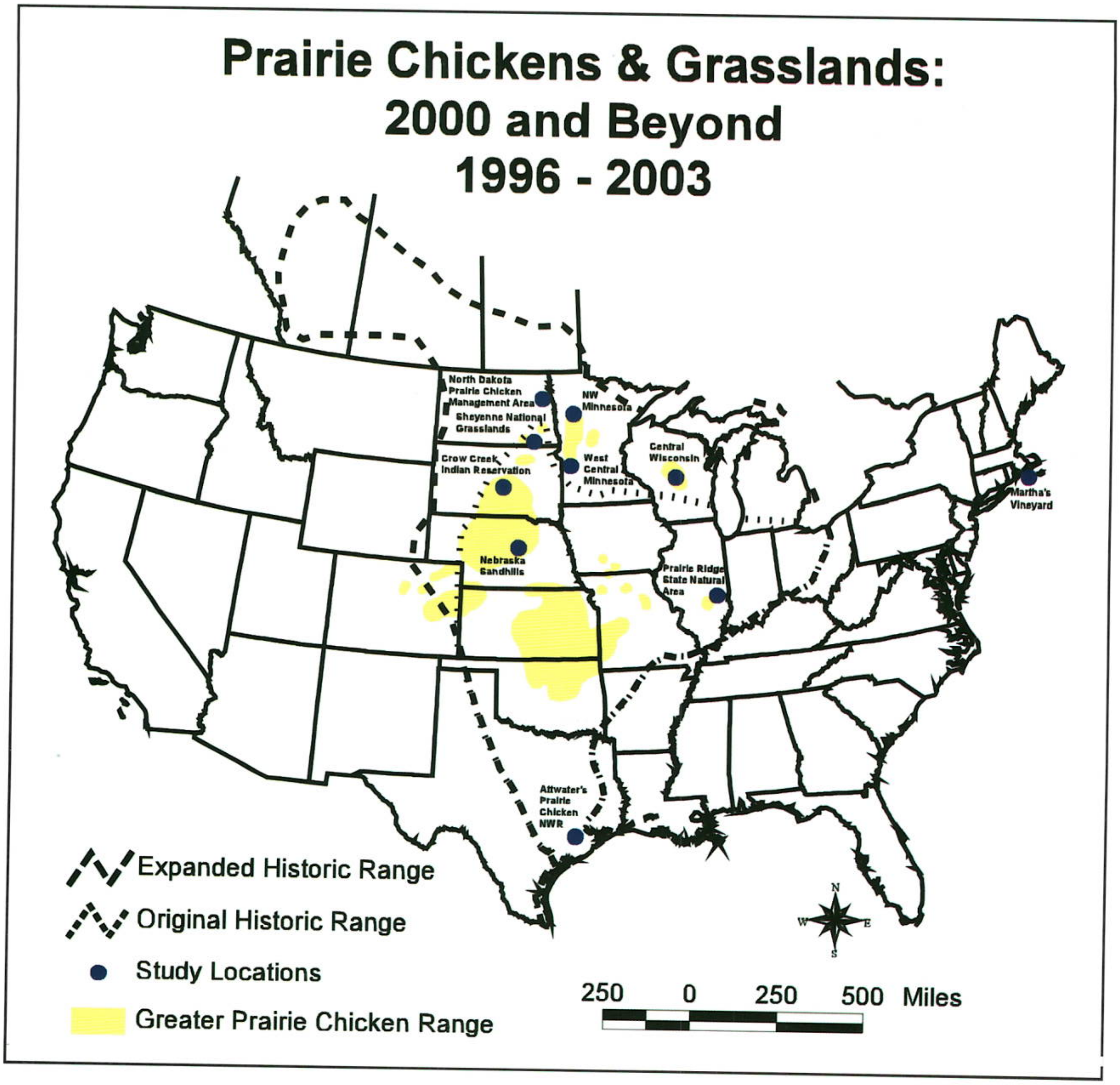


Figure 1. Study areas for Prairie Chickens & Grasslands: 2000 and Beyond, and historic greater prairie chicken ranges.

Study Areas

This project has conducted field research on greater prairie chickens (Tympanuchus cupido pinnatus) in Wisconsin, Minnesota, North Dakota, South Dakota, Nebraska and Illinois (Fig. 1). The emphasis of this report will focus on status and information collected on prairie chickens in Wisconsin, past and present. Results from other areas will be used for comparisons with Wisconsin data where appropriate. All the study areas are agricultural dominated landscapes with varying amounts of scattered patches of grassland, woodlands and woodlots. The grasslands are dominated by exotic cool season grasses. Native grasses are present but not as common. Wisconsin is the most woodland and woodlot dominated landscape and North Dakota is the most open landscape. None of our study areas compared to South Dakota or Nebraska could be considered classical prairie landscapes.

Wisconsin

This is the main study area for this project and we studied prairie chickens throughout the entire range in the state. This range consists of a series of five management areas and the northern range spread through a six county area (Portage, Adams, Wood, Marathon, Clark and Taylor) in central Wisconsin (WDNR 1993). The areas are the Buena Vista Wildlife Area (Buena Vista Marsh), Leola Wildlife Area (Leola Marsh), Dewey Wildlife Area (Dewey Marsh), Paul Olson Wildlife Area, George W. Mead Wildlife Area and the Northern Range (Outlying Areas).

The history of prairie chicken populations and management of these areas has been described by Anderson and Toepfer (1994, 1999) and Westemeier (1971). Land use/cover types have been described by Hamerstrom and Hamerstrom 1973 & WDNR 1993. The current range of greater prairie chickens in Wisconsin and distribution of wildlife areas and areas of influence are presented in Figure 2.

The Buena Vista (46,747 acres) and Leola (12,708 acres) Wildlife Areas respectively contain 11,778 and 1,860 acres of state-managed grassland habitat scattered through an agricultural landscape with scattered woodlots. These grasslands are managed intensively for prairie chickens by the WDNR. These two areas are only four miles apart and have been managed through a disturbance regime of burning, grazing, mowing and herbicides primarily to "control" brush encroachment (Anderson and Toepfer 1999, Keir 1999). This has been the site of much of the prairie chicken research, management and land purchases conducted in central Wisconsin for the past 50 years and has been described by numerous authors (Hamerstrom et al. 1957, Hamerstrom and Hamerstrom 1973, WDNR 1993, Anderson and Toepfer 1994, 1999).

The Paul Olson Wildlife Area (45,325 acres) contains only 1,350 acres of state-managed grassland/sedge. In contrast to Buena Vista and Leola, this area has received little management by WDNR during the past 30 years. This landscape is a dairy grain community, contains more woodland (hence less open space than Buena Vista and Leola) and consists of soils that are heavier than the organic soils on the Buena Vista/Leola (Westemeier 1971).

The George W. Mead Wildlife Area (27,140 acres) is managed primarily for waterfowl and contains only 7,289 acres of grassland/sedge habitat and the rest is woodland. Land use and surrounding landscapes are similar to that on Paul Olson (Anderson and Toepfer 1999, WDNR 1993).

The Northern Range (WDNR 1993) also referred to as the Outlying Areas consists of the Marshfield, Medford and McMillan areas in Marathon, Clark and Taylor counties (Anderson and Toepfer 1999). This area contains no state-managed grasslands and all grassland habitat exists on private land. The landscape is dairy grain and the upland similar to Paul Olson and the Mead upland. Dewey Wildlife Area is an open bog-swamp landscape surrounded by woodland.

Minnesota

The main Minnesota greater prairie chicken population exists in northwestern Minnesota in Polk, Norman, Clay, and Wilkin counties (Svedarsky 1997, 1999, Merril et al. 1999). There are scattered populations in counties to the east but 88% of the population exists in these four counties (Minnesota Prairie Chicken Society 2002 Inventory). This population is associated with the long and narrow gravel ridge created by the western beach ridges of glacial Lake Agassiz (Svedarsky et al. 1999). The landscape is open and consists of large agricultural fields of grain, soybeans, sunflowers and woodlands along waterways and scattered woodlots. The habitat becomes more open as one moves from the north end (Polk County) of the range to the south (Wilkin County) and from east to west to the Red River Valley. This area contains 229,232 acres of grassland; 49,175 are state and The Nature Conservancy managed grasslands, 31,797 acres are managed by US Fish and Wildlife Service and 148,260 acres of grassland habitat are enrolled in the Conservation Reserve Program (CRP) (Svedarsky et al.1999). The CRP grasslands are primarily cool season grasses dominated by smooth brome, and native prairie tracts dominated by warm season grasses most of which also contain patches of exotic cool season grasses. Except for mowing and aerial spaying to eliminate patches of weeds, much of the CRP has been undisturbed since enrollment in 1986.

Since 1999 prairie chickens have been translocated to west-central Minnesota to reestablish a population in vacant grassland habitat and to eventually connect with prairie chickens that exist in northwestern Minnesota and eastern South Dakota. This area is located near Appleton and Ortonville Minnesota. Large areas of remnant tallgrass prairie occur on the terraces of ancient Glacial River Warren (Minnesota River Valley) with smaller blocks of grass being present as you move north from the river valley. Within this landscape, the Lac qui Parle State Wildlife Management Area, Big Stone National Wildlife Refuge, Chippewa and Plover Nature Conservancy Preserves and numerous State and Federal managed lands protect approximately 20,000 acres of grassland habitat. Another 18,000 acres of pasture exists in the 11 townships that surround the Upper Minnesota River Valley but tree encroachment on many of these acres limits their usefulness to prairie chickens. The area has rolling terrain and an agricultural landscape with scattered woodlots. There is little CRP in this region and the main crops are corn and soybeans. Ring-necked pheasants are common in this part of Minnesota.

North Dakota

The main study area in North Dakota is located in Grand Forks County 14 miles northwest of Grand Forks and seven miles west of Manvel, North Dakota. The reintroduction area is associated with the North Dakota Game and Fish Prairie Chicken Management Area, north and south units (3,350 acres). The soils, vegetation and surrounding landscape are described by Jorge et al. (1976) and Jorgenson (1977) and more recently by Beringer (1995). The grasses are primarily cool season grasses with scattered small acreages of native prairie. The study area includes the Oakville Prairie located south of U.S. Highway 2. These areas were located within the Kelly's Slough Wildlife Project Area (Holevet 1990). The area contains a combined total of approximately 37,000 acres of grassalnd habitat with 34,310 acres in CRP (Kobriger 1999). Prairie chickens disappeared form this area in 1980 (Kobriger 1999). Prairie chickens were reintroduced into the area in 1992.

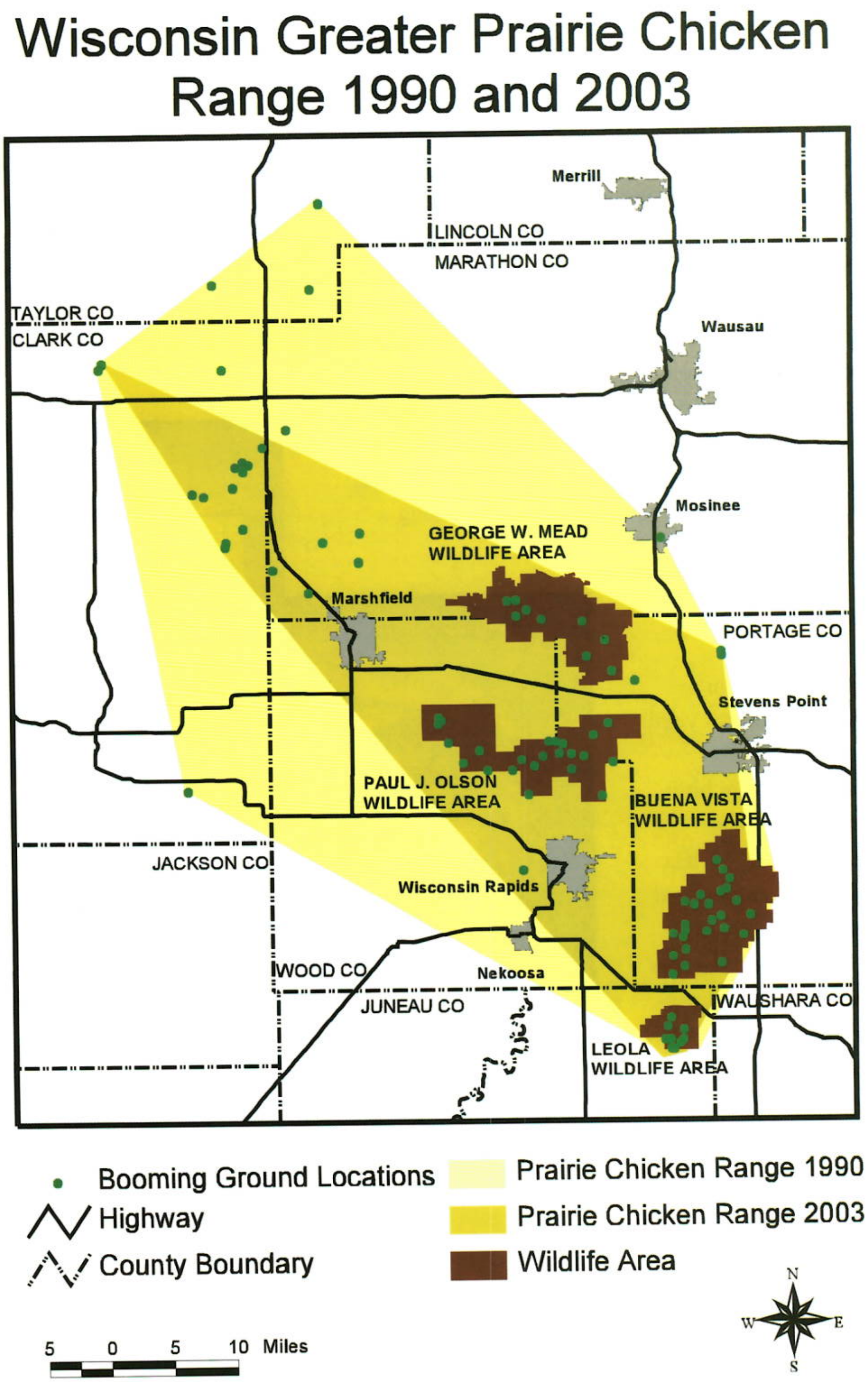


Figure 2. Current range of greater prairie chickens in Wisconsin showing range contraction between 1990 and 2000.

Other Areas

Secondary study areas or those where we trapped prairie chickens for translocation and genetic samples are the Crow Creek Indian Reservation in central South Dakota near Chamberlain and the Fort Pierre National Grassland near Pierre, South Dakota. The birds translocated from Nebraska came from the sandhill region near Burwell. Genetic samples from Illinois came from prairie chickens in Jasper and Marrion County near Newton and Kinmundy (Westemeier et al. 1999). Genetic samples were also collected from prairie chickens and sharp-tails on the Sheyenne National Grasslands in southeastern North Dakota at Lisbon (Newell et al. 1987). We have also conducted cooperative research with the U.S. Fish and Wildlife Service, Attwater's Prairie Chicken Refuge in Texas as part of their recovery program.

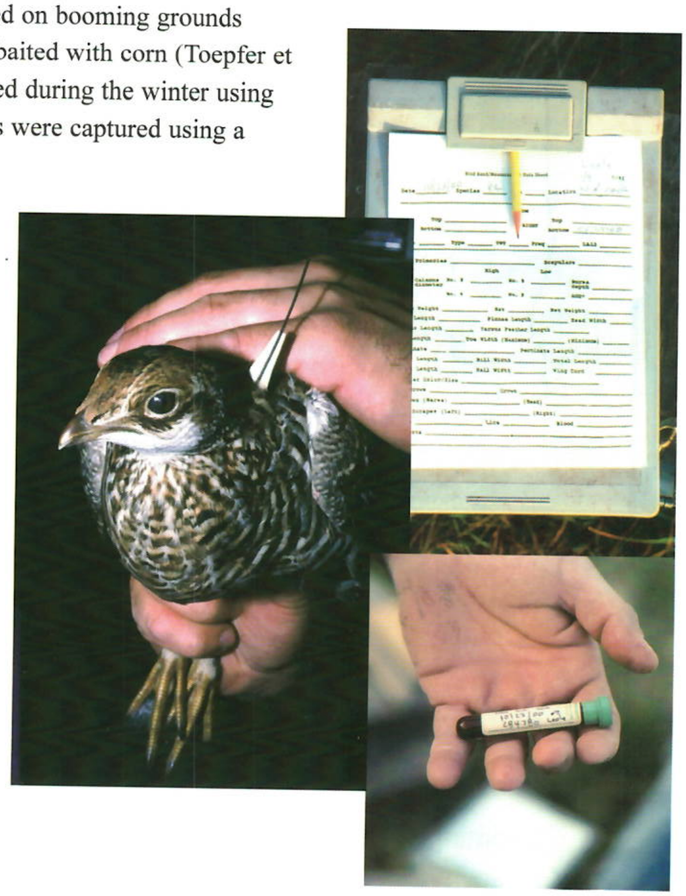
Methods

Censusing

Booming ground surveys and cock counts in Wisconsin followed the protocol established by Hamerstrom and Hamerstrom (1973). One exception is that we used variable power spotting scopes to aid in making our counts.

Trapping

Greater prairie chickens captured during the summer were caught by night lighting to either place or replace a radio package or to radio-mark 4-12 week old young of the year. Birds captured during the fall, winter and spring were trapped on booming grounds using either walk-in traps with chicken wire leads baited with corn (Toepfer et al 1988) or mist nets. Additional birds were captured during the winter using drop nets placed over corn bait piles. Hens on nests were captured using a long handled salmon net.



Radio Telemetry

Radio-marked birds were monitored from a radio-tracking vehicle with a five-element yagii antenna. A hand-held antenna was used to locate nests, dead birds, and to recapture birds by night lighting. An Advanced Telemetry Systems, Inc. scanning receiver 148-151 MHz was used for tracking. Locations were obtained via triangulation (Heezen and Tester 1967). Birds were tracked at least on a weekly basis to monitor weekly and seasonal survival and general movements. At times, birds were monitored on a daily basis to locate nests, brood areas and night roosting areas, and to monitor booming ground attendance by cocks. An airplane with a three-element antenna was used to find birds we could not locate on the ground.

Radio Packages

The radio package we used was a tuned loop collar placed on a herculite bib or poncho (Amstrup 1980) curved to fit an adult prairie chicken's breast contour. The radio package weighed 12-19 grams. Smaller radio packages weighing 6-7 grams with short 4- 6-inch whip antennas on colored herculite ponchos were used on chicks 5-10 weeks of age. The chick bib had a 3-4 inch colored tab that protruded upward through the feathers on the back of the neck. This allowed us to identify young who had already been radioed so they would not be repeatedly recaptured. Smaller radio packages of 2-4 grams were put on chicks 4-5 weeks of age. These radioed chicks were later recaptured at 10 plus weeks when they were large enough to carry the adult-sized tuned loop packages.







Data Collection

Each prairie chicken captured was weighed, measured, radio-marked and banded, and band numbers and radio frequencies were double-checked. Each bird was examined for ticks, injuries, molt status, and age determination. A few body feathers were also collected for possible genetic and/or contaminant analysis. Measurements taken included: bent tarsus length, toe length and width, nail length and width, bill length and width, head width, tail length, calamus diameter, tarsus feather length, weight, crop size, barring pattern in cocks, pinnae length, air sac color and size, pectinate presence, and cloaca diameter A blood smear and three cc of blood were collected from some birds to check for parasites, disease antibodies and cholinesterase levels. Blood was kept on ice until separated via centrifuge and then frozen. Genetic samples were fixed and stored in a lysis solution. The age of chicks was usually known but when not was determined using wing feather development (Baker 1953). Age of adults was determined using three methods: primary feather molt and wear (Ammann 1944), calumus diameter (Caldwell 1980) and scapular feather pattern. Resident greater prairie chickens captured were released at the capture area. A bird was considered a chick while it was still with the hen and an immature once it went off on its own or when the hen left the chick(s). In order to be consistent, the size of ranges and distributions were calculated by connecting the outer most points to form convex polygons (Hayne 1949).

Vegetation

All nests, night roosts, and brood areas were videotaped in a 360-degree panoramic view. Eggs were measured including length and width, and color determined using a Munsell Color book. Nests were marked for relocation by placing a stake 10 paces from the nest. Nests, booming ground locations, night roosts, flush sites, capture sites and mortality sites were located using hand-held Global Positioning System units in Universal Transverse Mercator (UTM) coordinates. Nests were considered successful if one egg hatched. After hatching, nest bowls were collected from each nest and stored for future analysis. Species composition at each nest was determined by recording the species of the two nearest plants at 10 cm intervals along two, one-meter lines, one running north/south, and the second east/west through the center of the nest. Species composition surrounding the nest was determined by recording the species of the two nearest plants every meter along a 10 meter transect in each of the four cardinal directions. A white peg-board with (1" X 1") holes (dot board) was placed in each cardinal direction at the nest and was photographed or video taped to measure height and effective height or the screening height of the cover after Newell (1987) and Sisson (1976). Species composition at night roost sites and brood areas follow the transect described for the area surrounding the nest.

Statistics

I have chosen the format defined above to examine patterns and trends rather than use an array of so called sophisticated statistics that a select few really understand. The first goal of statistics is to describe; the second is to determine the validity of differences between samples. Sophisticated statistics rarely produce sophisticated results and more often than not, generate more discussion about the statistics than the biological significance of the observations. Prairie chickens are adaptable and survive physiologically, behaviorally and habitat-wise within a range of environmental conditions that put maximum and minimum limits on their existence - there is no such thing as an average prairie chicken.

Number of Birds Captured

A total of 4,601 greater prairie chickens were captured during the course of PCG2B. Of these, 1,673 were recaptures. The actual breakdown is: 1,236 cocks, 816 hens and 876 chicks or young of the year. Just about every bird radioed that survived to the following summer was recaptured by night lighting during July to mid-September during the flight feather molt at which time their radio package was replaced so they could be followed for another year. Chicks with radio-marked hens were also captured to monitor dispersal. Table 1 shows number of prairie chickens captured by state, by sex and age. Mortality due to trapping and handling in this project was 2.9%.

Table 1. Number of greater prairie chickens captured by state, sex, age under Prairie Chickens & Grasslands: 2000 and Beyond, 1996-2003.

State	Cocks	Hens	Chicks	Total	Recaptured	Total
Wisconsin	599	289	509	1397	956	2353
Minnesota	428	378	261	1067	566	1633
Nebraska	88	113	0	201	0	201
South Dakota	23	26	10	59	49	108
North Dakota	98	10	96	204	102	306
Total	**1236**	**816**	**876**	**2928**	**1673**	**4601**

A handful of translocated birds because they were moved from Nebraska to North Dakota were held for 36 hours. All other translocated birds were released within 24 hours. Residents were released within 24 hours as well, most within 8 hours. The vast majority of birds night lighted were released at night and were disoriented by spinning them and placing them in the grass so they would not take flight in the dark. All residents were released at or within sight of their capture site.

A total of 561 prairie chickens were translocated during this project. Of these, 255 birds were translocated to North Dakota between 1997-98. These birds originated from Minnesota (32), the Crow Creek Indian Reservation, South Dakota (28) and Nebraska (195). Between 1999-2003, a total of 306 prairie chickens were translocated from northwestern to west central Minnesota. The latter reintroduction project will continue for at least two more years. Twenty-six cocks captured in Illinois in March 2003 to collect genetic samples are not included in the table or totals.

Trapping and radio-tagging large numbers of prairie chickens did not appear to adversely affect the study populations in central Wisconsin as most areas increased more than they declined. Buena Vista/Leola increased 3 of 7 years, Paul Olson increased 5 of 7, Mead 4 of 7 and the Northern Range increased 2 of 3 years. This is what one would expect if there were no effects of trapping on the following year's population. In Minnesota where birds have been trapped every year since 1992 (11 years with 446+ birds removed) the population, increased 7 of 11 years and the North Dakota population increased 4 of 5 years when birds were trapped. Toepfer (1988) reported that in 1976 in central Wisconsin when 43 birds (26 cocks, 17 hens) or 9.4% of the population were translocated from Paul Olson and Mead to Crex Meadows, the Paul Olson/Mead population increased 42.4%.

Spring Census

The greater prairie chicken booming ground survey and counts conducted in central Wisconsin on the Buena Vista and Leola Wildlife Areas began in 1950. These counts span a period of 54 years, 1950-2003. The Paul Olson and Mead Wildlife Areas have been surveyed since 1962 and 1969, respectively. The McMillian Wildlife Area and Fernwood have been surveyed since 1980 and the "Outlying areas" have been surveyed by volunteers since 1989. The results of these surveys and a historical account of the Wisconsin Prairie Chicken Project 1950-1998 have been discussed and summarized by year and area by Anderson and Toepfer (1999).

Over the past 54 years countless individuals have been involved in collecting these census data. A total of 46 years of data were collected and compiled under the direction of just three individuals. Drs. Fred and Fran Hamerstrom working for the Wisconsin Conservation Department (now the Department of Natural Resources) surveyed for 22 years or 1950-71 (Hamerstrom and Hamerstrom 1973) and Professor Raymond K. Anderson, College of Natural Resources, University of Wisconsin, Stevens Point (UWSP), surveyed for 23 years or 1971-93 (Anderson and Toepfer 1999). Anderson worked on the census with the Hamerstroms 1962-71 and initiated his Paul Olson survey in 1963. In all, he counted prairie chicken booming grounds in central Wisconsin for 32 years until 1993 when he retired.

Since 1994, the census counts have been coordinated by various individuals with the College of Natural Resources, UWSP including Dr. Lyle Nauman and Paul Keenlance 1994-96, Dr. Evelyn Merrill and Keenlance 1997-99, Dave Naugle 2000, Rebecca Powers 2001 and Dr. Lyle Nauman 2002-03. Booming ground surveys of the Mead Wildlife Area and vicinity and the Leola Wildlife Area have been conducted by local Wisconsin DNR wildlife project managers and their field staff. The managers involved were/are: Oswald Matson, John Berkhan, Bruce Gruthoff, Jim Keir and Tom Meier. I was involved in the central Wisconsin booming ground counts for 20 years, 1967-78 and 1996-2003.

Census procedures have followed those outlined by Hamerstrom and Hamerstrom (1973). The exception has been the Leola Wildlife Area where in recent years the census period has been restricted to a 3-4 day period during mid-April (J. Keir, pers. comm.). Leola is a relatively small area to census at 20 square miles.

The central Wisconsin Prairie Chicken Census conducted by the College of Natural Resources, UWSP was funded through a legislative grant prepared by R. K. Anderson in the early 1970's. Funding for the survey has been reduced over the years and this past fiscal year has been eliminated by the administration at UWSP. At this point in time there is no funding available at UWSP to census prairie chickens on the Buena Vista and Paul Olson Wildlife Areas for 2001 and beyond. Since 2001 we have conducted our own booming ground survey of the Buena Vista and Paul Olson to get accurate counts and locations of the booming grounds for our research purposes. We have found discrepancies between the "official" census and ours. The errors were minor in 2002 and were limited to errors in booming ground location and compilation of data. In 2001 we found location errors again but our survey also found six booming grounds that were missed by the official survey; all were small 3-6 but totaled 26 cocks. And, in 2003 we found two major booming grounds of 10 and 11 cocks that were missed by the official census. This is an error of only 7% in the number of cocks but a 10-17% error in the number of booming grounds. The reasons for the errors are related to the compilers of the data not knowing where most of the booming grounds are located. Counters also use binoculars and at times have trouble telling cocks from hens. Finally, the counters are not properly trained and depend too much on the previous year's map to locate booming grounds. Consequently they do not make a concerted effort to listen for new booming grounds or ones that have shifted location.

Population Status

Historical Range

The history of the greater prairie chicken or pinnated grouse in Wisconsin has been one of a dramatic expansion from the southern third of the state in the 1800's to the entire state (Hamerstrom and Hamerstrom 1941), an estimated twofold increase from 21,000 to 56,768 square miles. The contraction of the range has been just as dramatic - from every county in the state to approximately 21,618 square miles in 1950, to 4,504 in 1963, and to 1,943 in 1973.

The expansion of the range of prairie chickens was due to land use changes that created the ideal mix of small agricultural fields and grassland from cleared and burned woodland. The ensuing contraction was a result of fire suppression, succession, afforestation and expansion of agricultural fields and has been discussed by numerous authors (Schorger 1944, Grange 1948, Hamerstrom et al. 1957, Robbins 1991 and Anderson and Toepfer 1994, 1999). The range contraction continues today and since 1990 the prairie chicken range in Wisconsin has contracted 50% from approximately 2,202 square miles to 1,077 (Fig. 3).

Current Status of Wisconsin Greater Prairie Chicken Population

We assisted with the annual spring booming ground census from 1996 through 2000. Between 2001-2003 we also conducted our own census of Buena Vista/Leola and Paul Olson and the Northern Range. Consequently, we have first-hand knowledge of the location and landscape habitats of most of the booming grounds in Wisconsin.

Up until the last two years, (Keir 2003) management activities and land purchases by WDNR have focused on the Buena Vista and Leola. Yet, the populations in these two areas comprised only half of the greater prairie chickens in Wisconsin in 1990. The long-term population trend based on 10 year averages (1970-2000) for the Buena Vista and Leola are stable, while trends for Paul Olson, Mead and Northern Range are downward

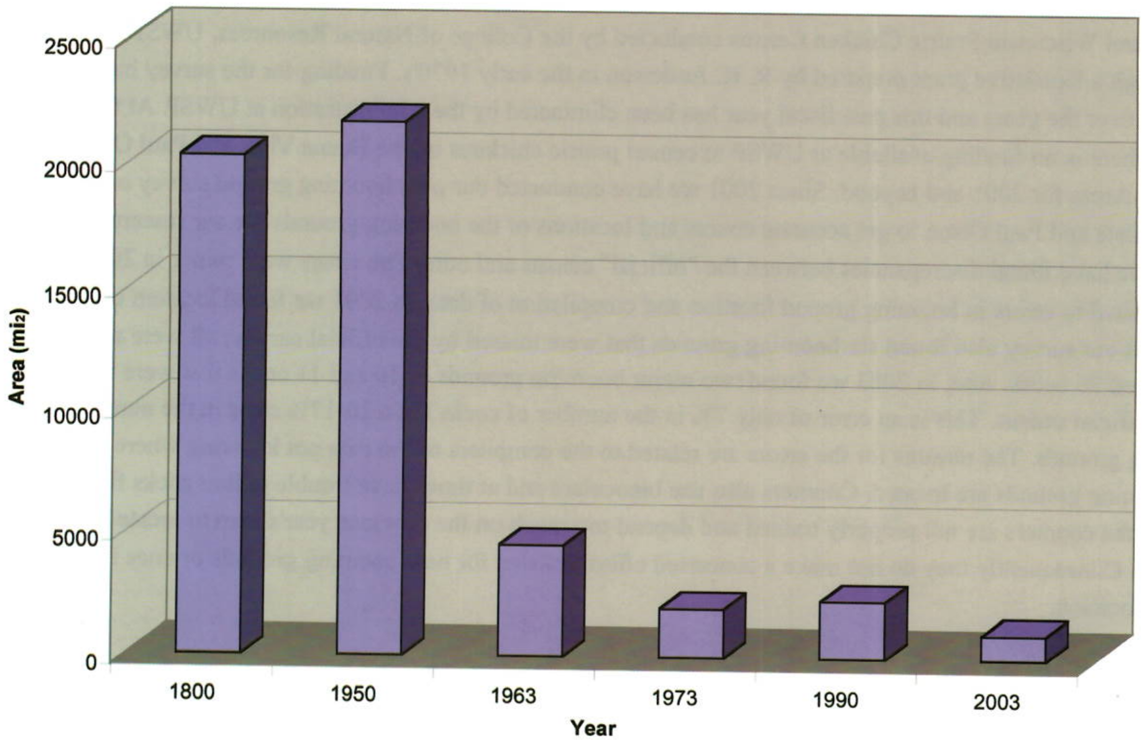


Figure 3. Changes in Wisconsin greater prairie chicken range 1800-2003.

(Hamerstrom and Hamerstrom 1973, Anderson and Toepfer 1994, 1999, Keir 2003, Toepfer unpub. data). Fig. 4 presents greater prairie chicken population trends (booming cocks) by decade for the various management areas in central Wisconsin.

The health and fate of a threatened/endangered species can often better be understood by looking at what has happened on the fringe of its range rather than in the core areas or best habitat. In Wisconsin, this fringe would be the northwestern portion of the greater prairie chicken range or the Northern Range (McMillan and Outlying census areas). In 1991, there were 134 cocks counted on 19 booming grounds in this portion of the range which represented 21% of the total Wisconsin population. In 2003, in this area, there were only 31 cocks on six booming grounds - a decline of approximately 75% in thirteen years. This portion of the greater prairie chicken population may be on its way out as it now makes up only 5% of the total population. And, from 1990-2003, the Northern Range has contracted 82% from 443 to 79 square miles.

During the last ten years, the booming ground south of Neillsville has disappeared, as has the booming ground at the Mosinee airport (Meier and Jonas pers. comm.) and Searles Cranberry. The lone booming ground at Dewey that has been there since 1970 may also be on the way out. The rapid decline of birds seen in the Northern Range is a symptom of loss of grassland habitat. This has resulted in range contraction that will only serve to restrict the movements of birds to the core areas further reducing genetic variability.

The concept of range contraction was recognized and concern first raised by Hamerstrom and Hamerstrom (1973) and more recently by the local wildlife managers. In a 1994 memorandum to Bill Vander Zouwen, WDNR Wildlife Management - Madison, Tom Meier, Project Manager for the Mead Wildlife Area stated: "If we

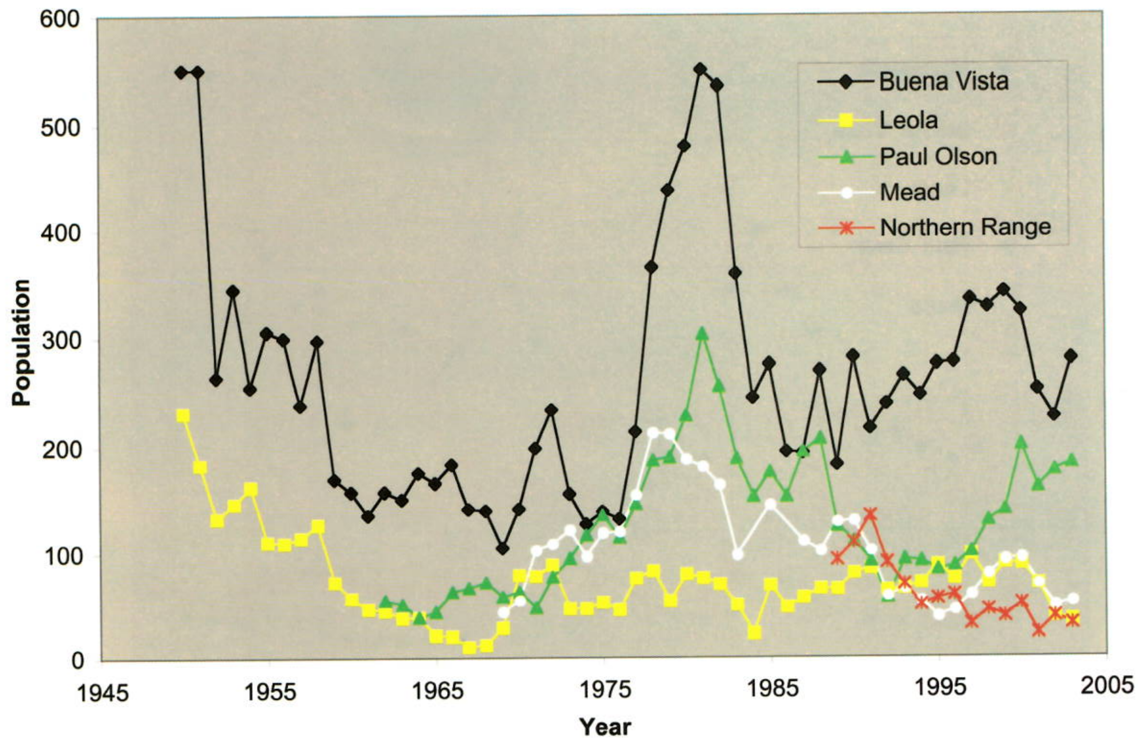


Figure 4. Greater prairie chicken population trends by area for central Wisconsin 1950-2003.

do not make a concerted effort in the near future to reverse current population trends for the prairie chicken in the Paul Olson, Mead, Unity - Colby area, I fear that the statewide range for this species will become severely limited". Unfortunately, this is exactly what has happened.

The contraction of the range that has been occurring is the result of a core management philosophy that evolved in Illinois out of necessity as it is easier for wildlife administrators to deal with solid blocks because it concentrates management resources in a limited area. This philosophy aims to develop and manage those areas with the best habitat creating a core area that presumably will result in long-term security for the population. In Wisconsin, this core area has been the Buena Vista and Leola Wildlife Management Areas. In the long-term, these two core areas by themselves (123 square miles, 17.3% grassland reserves) and Paul Olson and Mead (281 square miles, 5.1% grassland reserves) are too small to sustain a viable greater prairie chicken population. This type of core management philosophy has been followed in Texas, Illinois, Missouri, North Dakota and Oklahoma and all of these populations are in trouble. Population security for prairie chickens can only be created by spreading both the habitat and the population over a relatively large area and maintaining connectivity. Hamerstrom and Hamerstrom (1973) recognized this and stated that "the loss of Carson-Sigel-Sherry Area (now called the Paul Olson area) would break the connection and leave Buena Vista/Leola isolated from Mead, a loss which would be more important than the mathematical number of birds in the Carson-Sigel-Sherry Area".

The Minnesota greater prairie chicken populations have been discussed in detail by Svedarsky et al. (1997, 1999). An updated comparison of population trends for northwestern Minnesota and Wisconsin is presented in Fig. 5.

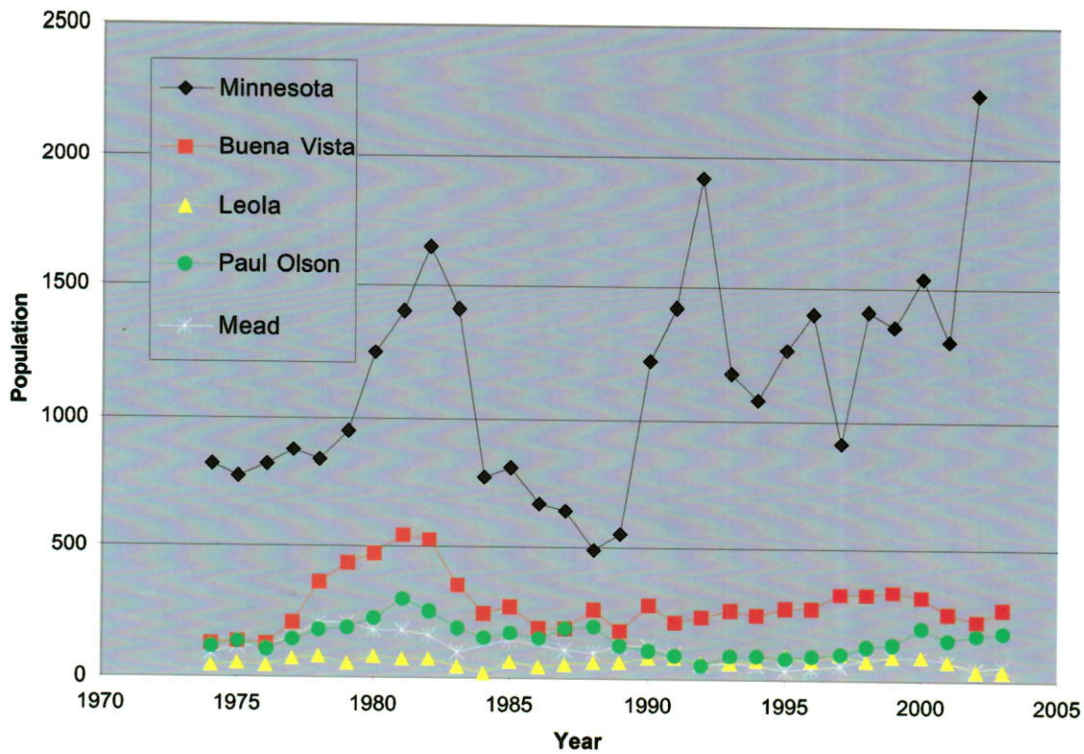


Figure 5. Updated comparison of population trends for northwestern Minnesota and Wisconsin.

Local Range Changes

Contraction of the local range based on booming ground distribution has also occurred within most of the management areas in Wisconsin, especially on the Buena Vista, Leola and Mead (Fig. 6). The exception is the less intensively managed Paul Olson area where the population, except for 1,700 state-managed acres, is entirely associated with private grasslands. Paul Olson has expanded since 1968 from 16.6 to 76.4 square miles.

On the main management areas of Buena Vista and Leola, the range has become confined to a smaller and smaller area further increasing density. In fact, recent grassland purchases on Buena Vista have further concentrated habitat confining the birds to an even smaller core area. In 2003, the distribution of birds covered approximately two-thirds of the area occupied in 1950. This contraction has resulted in an increase in density leading to more large booming grounds.

The numbers of cocks on Wisconsin booming grounds has also increased which has concentrated birds even more. In 1950, 1972 and 1981, respectively, 29%, 27%, and 39% of the booming grounds had 12 or more cocks. In 2003, 44% of the booming grounds had twelve or more cocks. This increase in the number of cocks per booming ground is a symptom of concentrating management efforts in a core area that will further serve to reduce genetic variability. This is in contrast to Minnesota, Nebraska and North Dakota where only 24.2%, 21%, and 33% of booming grounds respectively exceed 12 cocks.

Both the Minnesota and North Dakota populations have responded to large amounts of CRP grassland by expanding their range. This has consequently resulted in more but smaller booming grounds. As habitat was

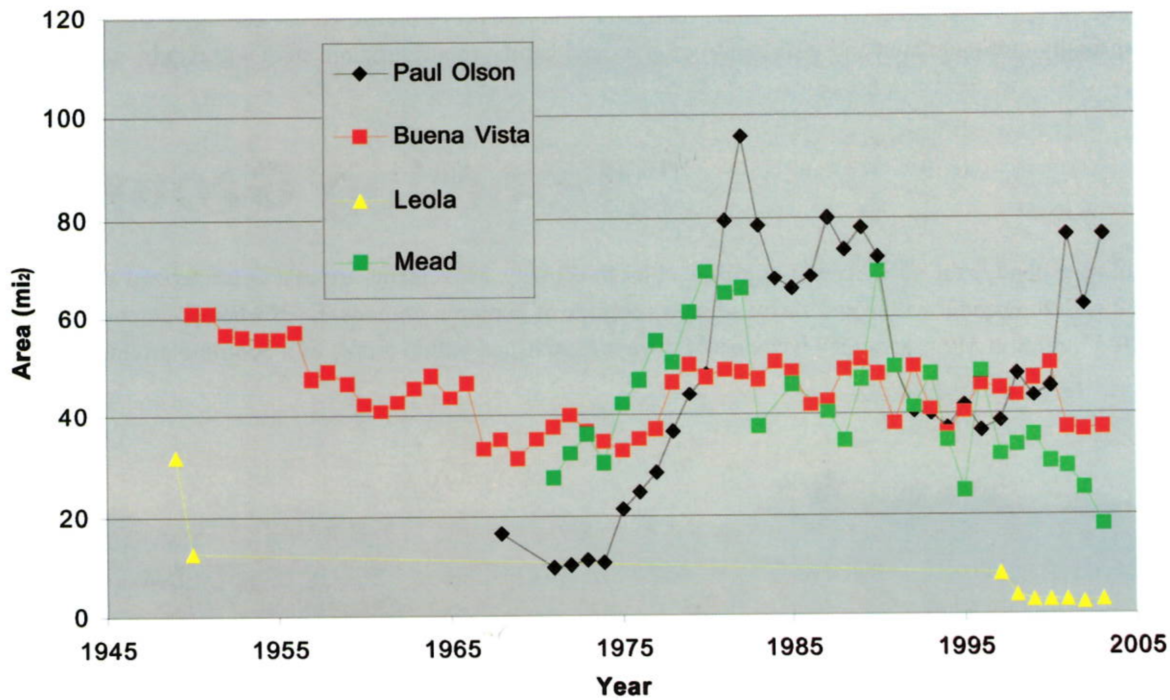


Figure 6. Changes in area of booming ground distribution for wildlife areas of central Wisconsin 1950-2003.

added through the Conservation Reserve Program, the number of grounds with 12 or more cocks declined in both the Minnesota Twin Valley area (61.0 to 24.3%, Mean 16.5 to 10.1 cocks/ground) and North Dakota 1998-2003 (50.0 to 33%, Mean 12.6 to 9.7 cocks/ground).

An isolated range such as we have in Wisconsin is nothing more than a population fenced in by the distribution of habitat creating a "zoo" or a "museum" population (Johnsgard 2003).

The initial scatter pattern proposed by Hamerstrom et al. (1957) for the Buena Vista contained smaller reserves scattered over a larger area (73 square miles). However, the Hamerstrom's also recognized the need for flexibility in the grassland reserves and stated that "if the area should be as thoroughly changed to plow-land as southern Wisconsin now is, the plan would fail. That is unless it were modified to one of three alternatives: increase the number of reserves, consolidate into fewer larger self-supporting units with a smaller population, or abandon the program." The scatter pattern of grassland reserves on the Buena Vista today covers approximately 37 square miles, a level 50% less than originally recommended This contraction has resulted in increased density and larger booming grounds.

By contrast, grasslands on Paul Olson are scattered over a larger area (62 square miles) and the range of the population has expanded. From a population perspective, the same amount of grass in one large block under today's land use pattern may not be as good or as practical as grassland spread out over a larger area that should create more and smaller booming grounds.

This "ecological patterning" or scatter pattern of grassland reserves within an open agricultural landscape was in contrast to solid block managing. Ecological patterning as proposed by Hamerstrom et al. (1957) is a practical approach or the applied application of Leopold's land ethic. This aspect of prairie grouse ecology - size of population, especially minimum area and distribution of grassland habitat (configuration, size) will require additional research.

Booming Grounds

The booming ground is the social center of prairie chicken ecology. Movements are best characterized as being associated with the habitat within and surrounding a complex of booming grounds. Even when young hens have moved 20-35 miles in Minnesota they have nearly always established within a mile of a booming ground or

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dancing ground. The booming grounds are also important genetically as they are the places where hens select the cock they will mate with. What all this means is that the booming ground is the center of prairie chicken ecology and the habitats surrounding them should be the focal point of management.

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Booming grounds are generally located in open areas away from woodlots in short cover and are usually higher than the surrounding terrain. This is so the cocks can see and be seen. The type of cover used for booming grounds varies and has changed dramatically in Wisconsin over the past 25 years. In 1972 all but one of the 18 booming grounds on the Buena Vista were on grass, either pasture or hay land. In 2000 over half of the 31 booming ground were on plowed ground. In Minnesota most booming grounds are in the plowed agricultural fields.

The role of the booming ground in prairie chicken ecology cannot be overstated as most, if not all, of the life history of individual birds occurs within a mile of a booming ground. This concept goes back to Schwartz (1945) who believed that each booming ground had its own "sphere of influence" with its own group of cocks and hens. This idea is supported by years of radio tracking that indicate the majority of radio-tagged regular adult cocks of adjacent booming grounds rarely come together, and that areas used by these adult cocks show little overlap

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unless an individual shifts booming grounds. The exceptions are during periods of deep snow and reduced food resources, which can concentrate birds from a large area at a single food source.

The impression one gets is that cocks, especially adults, do not want to leave the "sphere of influence" of their home booming ground unless they are forced to by poor conditions. Toepfer (1988) found that 84.6% of surviving cocks remained on the booming ground on which they displayed the previous year - their home booming ground. Most of the shifts to new booming grounds occurred between the first and second booming season. Immature cocks however are more likely to shift and visit different grounds throughout the year as they attempt to become a regular on a home booming ground. Hens are much more mobile and have larger home ranges than males (Toepfer 1988, Toepfer and Eng 1988 and Rosenquest 1996). Hens, especially immatures are more likely to shift areas as conditions change. This same pattern was reported by Hamerstrom and Hamerstrom (1973). A summary from Toepfer (1988) found that adult cocks have the smallest home ranges followed by immature cocks and adult hens. Immature hens have the largest ranges with some dispersing up to 35 miles.

During the breeding season adult hens will establish an area near a particular booming ground where they will eventually nest - their home booming ground. Adult hens shift to the habitat around the booming grounds where they will nest nearly two weeks earlier than immatures (Toepfer 1988, Toepfer and Eng 1988). Most adult hens also show fidelity to a nest area. Toepfer and Newell (1987) found that of nine hens whose nests were located two years in a row, all were in the vicinity of the booming grounds they initially nested near. All were within 1,000 yards of their previous year's nest and four of the nine nested within 100 yards. However this is variable and there are exceptions as we have had some hens in their third year return to their natal area to nest after dispersing 8-14 miles as immatures.

Of 7,809 radio locations and 17,783 observations of non-radioed prairie chickens during all seasons in central Wisconsin, all were within 7.2 km (4.5 miles) of a booming ground with 91% within 2 km (1.2 miles). Means adjusted for season - mean distance to nearest booming ground for radio locations was 1.0 km (0.62 miles) and mean for 8,000 random points 2.6 km (1.62 miles) (Toepfer 1988).

On the Buena Vista, at least one booming ground has been on the same knoll since 1966.
The general habitat of this booming ground changed from a heavily grazed knoll in a 160-acre pasture to a plowed field with a center pivot. During this time, the booming ground has varied in size from 7-35 cocks. At least 2 other booming grounds on the Buena Vista have been in the same quarter section since the Hamerstroms started their work in 1950. All are associated with permanent grassland reserves purchased in the 1960's and 70's by STCP and the Dane County Conservation League. At least two other booming grounds on the Buena Vista have been in the same quarter section since the Hamerstroms started their work in 1950. Other booming grounds have been in the same general areas for many years. But what is most intriguing about booming ground locations is that when the population increases and new booming grounds reappear after a long absence, the cocks often end up in the exact same 40 acres that cocks used 30 years ago.

Density

One of the measures of the effectiveness of prairie chicken management has been density, or the number of cocks per acre of state-managed grasslands. However there is a common misconception by many that greater prairie chickens spend all of their time on these state owned grasslands. First, it is important to understand that prairie chickens have large seasonal and annual home ranges (Toepfer 1988, Toepfer and Eng 1988) and make extensive use of habitats other than just the state-managed grasslands. The state-managed grasslands are important as they are the foundation of habitat and are used for such critical activities as night roosting. These grasslands are essential for nesting and early brood rearing. But, adjoining private lands play a very significant role as well.

Habitat use studies of radio-marked birds in Wisconsin, Minnesota and North Dakota all indicate that greater prairie chickens spend more time on private land than managed land. Their daily movement pattern from mid-September to May (nine months) is to feed and loaf in the agricultural fields and night roost in grassland or wetland cover (Wisconsin Buena Vista: Hamerstrom and Hamerstrom 1973, Toepfer 1976, Toepfer 1988, Halfmann 2002. North Dakota: Toepfer and Eng 1988, and Beringer 1995, Minnesota: Rosenquist 1996, Illinois: Rubin 1994, Tim Trempe and Paul Keenlance pers. comm.). In addition, many birds, especially cocks during the molt, spend much of their time in agricultural fields. In central Wisconsin, soybean and potato fields are most often used and some cocks have been known to spend the entire summer in these fields.

In Minnesota, hens with broods at six weeks of age through fledging begin to feed in the agricultural fields during the day (soybeans and wheat) and night roost in the adjacent CRP or native prairie grasslands. Many stay in the soybeans and wheat fields day and night. Some radio-marked birds have spent all of the late spring and summer in grassland but when it got cold, all shifted to a pattern of night roosting in grass and feeding during the day in agricultural fields. Prairie chickens have adapted to using agricultural fields to obtain food. It is this mix of available cover and food that provides the best scenario for prairie chickens and I am aware of no greater prairie chicken population that exists totally in a grassland environment. Contemporary prairie chicken habitat in the Midwest is a mix of undisturbed grass and agricultural land. Any density figure that does not include the amount of non-grassland/private land habitat will be misleading with regard to the quality of habitat and management.


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The density of prairie chickens is now greater in Minnesota than Wisconsin. This is true however only if one properly considers the entire state ranges and includes both managed and private lands in their calculations. Overall, the range-wide density for Wisconsin is approximately 1.0 bird per square mile. In Minnesota it is approximately1.5 per square mile. Unlike the fragmented Wisconsin range, the Minnesota range is long (170 miles) and continuous providing the opportunity for genetic exchange. Genetic diversity for the time being in Minnesota is comparable to Kansas and Nebraska (Bellinger 2000 and Westemeier et al. 1998).

If one does not look at the big picture and instead calculates density only using birds per acre of managed grassland, then in Wisconsin, on the Buena Vista, the density is 1 bird per 30 acres. If one follows the same manner of calculation, then Illinois has the highest density at 1 bird per 18 acres (1 bird per 23 acres at Marion County with 2,200 acres and 1 bird per 15 acres in Jasper County with 1,200 acres).

These numbers are based on the 2003 Illinois census and grassland acreage accounts (Scott Simpson, personal comm.). In 2003, on managed lands in Illinois there were 86 cocks - an increase of six over 2002. To put this in perspective, of all states where prairie chickens occur and are monitored, Illinois has exhibited the highest densities of all and averaged about one cock per 7 acres for 19 years (Westemeier et al. 1999 and Kirsch 1974). But by 1992, they had only 18 cocks left and a population with low genetic variability. Density, especially when applied only to managed areas, is not a very good way to evaluate management practices.

In central Wisconsin, we should have been managing on a range-wide basis with less emphasis on the Buena Vista and Leola. Bergerud and Gratson (1988) stated Wisconsin prairie chickens are "probably the most intensively managed grouse in North America". This is not true and to be exact should have more aptly stated that the prairie chickens on the Buena Vista and Leola are the most intensively managed grouse in North America as the other wildlife areas are not managed to the same level as Buena Vista/Leola.

High densities of wildlife are not necessarily reflective of good wildlife management (white-tailed deer, geese). In view of their genetic status, the high densities in Illinois and in central Wisconsin on the Buena Vista/Leola should not be considered the model for good prairie chicken management. The key is not to concentrate prairie chickens but instead to spread them and their management out over a relatively large area while maintaining connectivity (Hamerstrom et al. 1957, Hamestrom and Hamerstrom 1973).

What should be obvious is that the two populations (Illinois & Buena Vista in Wisconsin) that have reported the highest densities of birds per acre on state-managed grasslands are isolated, and have experienced significant declines in genetic diversity. In hindsight, the current status of the prairie chicken in Wisconsin with emphasis on high local densities is indeed the result of an emphasis of management and land purchases on Buena Vista/Leola. The concentrated grassland reserves and high density of prairie chickens on Buena Vista/Leola may superficially look good on paper and suggest good management.

However, these management practices have actually resulted in a serious contraction of range and a loss of genetics creating a critical situation. Rectifying this and securing a future for Wisconsin's prairie chickens will require the timely implementation of a quality, range-wide management/recovery plan; a plan that with the recommended land acquisitions will be expensive to carry out.

Open Space

In their "Guide to Prairie Chicken Management" in 1957, the Hamerstroms stated that prairie chicken habitat has to have grass and open space. This implies large treeless areas or open vistas. Here in the Mid-west much of the open space is no longer true grassland. Instead, it consists of savanna habitat or grassland and open agricultural fields interspersed with woodlots, windrows and scattered trees. Greater prairie chickens have an aversion to being closed in by woodland or overhanging cover. In 1957, the Hamerstroms reported the abandonment of a booming ground due to the growth of a pine windrow. An artificial windrow placed near a booming ground also caused some cocks to abandon the ground and others to shift their territories away from the trees. And when placed on the edge of the booming ground, the birds abandoned the area (Anderson 1969). Toepfer (1988) reported that booming grounds on the Buena Vista were farther from trees and woodlots than random points. Trees are not the only objects that limit open space. In western Minnesota a booming ground of long standing recently shifted a half-mile due the placement of a larger gravel pile within a quarter mile of the original location.

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Since the start of PCG2B six woodlots from 2 to 200 acres have been cleared on the Buena Vista and the Mead. In all cases, the creation of additional open space resulted in the development of a new booming ground adjacent to or where the trees once stood. In 2002 after over 400 trees were cut on the Buena Vista by WDNR, a traditional booming ground moved and became established around the stump of a large solitary cottonwood. Similarly, in the west-central Minnesota project area, a booming ground moved 600 meters north to a previously unused hayfield when 3 large windrows were removed on adjacent private land.

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Peterson (1979), in a study of great horned owl (Bubo virginianus) and red-tailed hawk (Buteo jamaicensis) ecology reported that these raptors cannot effectively hunt areas without an adequate perch. He further stated that great horned owls and red-tailed hawks removed 35% of the spring population of ring-necked pheasants (Phasianus colchicus) in southern Wisconsin and were depressing populations. Toepfer (1988) and PCG2B found that over 80% of greater prairie chicken mortality was probably due to predation and at least two-thirds of the remains of adult greater prairie chickens were fed upon by raptors.

In 1999, experiments were conducted to increase open space surrounding the SERR booming ground on the Buena Vista. The removal of scattered trees by the WDNR increased the treeless area surrounding the booming ground from 140 to 540 acres (almost four fold) and increased annual survival of cocks from this booming ground by at least 20%. Survival at two control booming grounds, one in a natural open area (648 treeless acres) and another in a savanna area (230 treeless acres) did not change (Table 2).

In Wisconsin, there is a need to open the landscape on the Paul Olson and Mead by removing the scattered solitary trees within and on the borders of the grassland reserves. Because these wildlife areas have less open space than others, woodlands on state owned land should also be cleared and converted to grasslands. On Buena Vista and Leola, there is a need to remove solitary trees and clumps to eliminate raptor perches within and on the fringes of the grassland reserves. Private landowners in these areas should also be contacted and encouraged to assist in the removal of solitary trees and woodland patches to improve grassland habitat for greater prairie chickens and other grassland birds.

Table 2. A comparison of survival (March 15 – June 30) of radio-marked cocks by booming ground on the Buena Vista marsh 1999 – 2001 and 2000 – 2001.

	Before Tree Removal		After Tree Removal	
Landscape Type	**1999-2000**	**Treeless Area (acres)**	**2000-2001**	**Treeless Area (acres)**
Savanna-SERR	33.3 (5/15)	140	55.5 (5/9)	*540
Savanna-Hakes	38.1 (8/21)	230	37.5 (3/8)	230
Open-Hanson	55.5 (5/9)	648	50.0 (5/10)	648
Total	**40.0 (18/45)**		**48.2 (13/27)**	

*March 2000 sixty trees removed from area expanding treeless area by 400 acres.

The clearing of woodlots is an expensive undertaking but the cutting of solitary trees that serve as perches for raptors is cost productive, as it will increase survival. Convincing private landowners to clear woodlots may be difficult but cutting single trees is not as difficult. In a cooperative venture with private landowners, David Traubau, the Minnesota DNR manager at Lac qui Parle WMA cut over 5,000 trees on private lands to open the landscape for prairie chickens.

The American public has a liking for trees and if a large parcel of land is not growing trees, being grazed, or growing a crop, it is considered wasteland by many. Planting a tree or trees is considered an act of conservation by many yet grasslands and associated wildlife are in decline. This love for trees and disdain for grasslands will have to be changed if prairie chickens are going to remain a natural component of the Great Plains landscape.

Food

In central Wisconsin, corn food plots are planted for greater prairie chickens on the Buena Vista Wildlife Area. Historically, corn has been the staple cold weather food for greater prairie chickens (Schmidt 1936, Hamerstrom et al. 1941). Many, including this author feel that the expansion of greater prairie chicken range northward was enhanced by the presence of a food source above the snow in the form of standing corn and corn shocks.

Recent observations of radio-marked prairie chickens indicate they do not utilize the food plots on the Buena Vista as they did in the 1970's, when they began feeding in them with the first snow (Toepfer 1988). Today's varieties of corn are taller and unless sufficient snow falls or is blown into the standing corn, the chickens cannot reach the ears. If and until the snows blow, birds instead feed in soybeans and picked corn, and at times appear to have a difficult time finding food.

The corn food plots at the Mead Wildlife Area are not used by prairie chickens unless deer are feeding in them or the standing corn is knocked down. At the Mead, it has become a standard management practice to knock down the corn to make it accessible to the chickens (Tom Meier, pers. comm.). Another solution but a more costly one would be to plant shorter varieties of corn or plant a portion of the food plot to a shorter variety of corn.

Winter food use is influenced by availability. Observations of prairie chickens feeding during the winter in North Dakota indicate they prefer sunflowers over soybeans and soybeans over corn (Toepfer and Eng 1988). This was

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determined by watching radio-marked birds feeding in three adjacent agricultural fields. These observations found that before a snow cover the birds fed in sunflowers. Once the sunflowers were made unavailable by snow, the birds shifted to an adjacent windblown soybean field between two picked cornfields. When additional snow covered the soybeans, the chickens began feeding in the picked corn. When the snow melted in late winter, the birds shifted back to the sunflowers.

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In the winter of 2000-01 we undertook a cooperative effort with WDNR and a private landowner on the Buena Vista Wildlife Area. Utilizing a front-end loader we scraped a series of 4, one-quarter mile long strips in the snow cover (8 inches) of a harvested soybean field. This was done to expose the waste grains. Within 24 hours of the scraping, 6-8 radio-marked birds that had abandoned the area covered by the snow began feeding in the scraped strips. Food plots are not provided in Minnesota but the more open landscape and regularity of high winds tends to keep portions of agricultural fields open allowing prairie chickens access to waste grains.

The scraping or plowing of snow from agricultural fields has potential to provide prairie chickens with winter food especially when food plots are not present or as an emergency measure to provide food during winters with heavy snows. It also permits flexibility to provide food where winter food is lacking or where food plots failed. However, this method is labor intensive, expensive, and the scraped strips can be quickly filled in by blowing and new snow. North Dakota Game and Fish has used this method to provide winter food to pheasants (Kobriger, pers. comm.).

The importance of winter food, especially the amount of standing corn on winter survival of greater prairie chickens can best be demonstrated by survival data from radio-marked birds in western Minnesota. During the winter of 1996-97 this region experienced 10 blizzards and snow completely covered the agricultural fields from November to April. The following winter (1997-98) was an open winter and agricultural fields were rarely covered with snow. Winter survival in western Minnesota during 1996-97 (blizzard winter) was only 33.8% (24/71). This was in marked contrast to a winter survival rate of 85.4% (35/41) during the open winter of 1997-98. Winter survival for the six-year period 1992-98 was 69.7% (225/323).

Survival in the blizzard winter of 1996-97 varied between Polk (North Area) and Norman/Clay (South Area) Counties and was directly related to the amount of standing corn. In the South Area where no standing corn was left, survival (25.0%, 13/52) was approximately half that of the North Area (57.9%, 11/19) where at least 1,000 acres of standing corn was left on Tilden Farms.

The limited access to standing corn today means that greater prairie chickens have to feed on other foods. In the Midwest, this often means soybeans, and soybeans do not provide greater prairie chickens with the same energy as corn. Robel et al. (1979) and Robel and Arruba (1986) found that bobwhites fed corn and sorghum assimilated 85% of the energy while bobwhites fed soybeans assimilated only 45%. The literature indicates that hen mallards fed soybeans lost significantly more weight during the winter than those fed other agricultural foods (Loesch and Kaminski 1989). Bogenschutz et al. (1995) reported that raw soybeans contain proteins that inhibit digestive enzymes lowering digestibility and depressing fat absorption in the diet.

Historically, corn has been the staple cold weather food for prairie chickens, waterfowl and many other upland game birds. It is common knowledge among biologists that the acreage of soybeans planted within the greater prairie chicken range has increased dramatically in the past 10 years. This soybean acreage has replaced corn, sunflowers and grain and has created a large amount of waste that is readily used by prairie chickens.

There is a need to have a better understanding of how cold weather feeding on soybeans by prairie chickens and other birds affects their body condition and reproduction. Bobwhite quail have been declining in the east for the past 20 years despite intensive habitat management. One theory associates the decline in bobwhites with the increase in acreage planted to soybeans (Kerstern 1998). My hypothesis as to the reduction in number of chicks fledged by prairie chickens is that hens feeding on soybeans may not be building up the fat necessary to go through incubation (25 days) and then successfully brood their chicks. There are other possible hypotheses: predation, pesticides, genetics and weather. We are currently analyzing the carcasses of greater prairie chicken cocks collected feeding in soybeans and corn in northwestern Minnesota. If differences in body condition are found, then a more rigorous study will need to be conducted. Until we develop a better understanding of the affects of soybeans, corn should be first choice for food plots for prairie chickens.

Nesting Success

There have been eight prairie chicken nesting studies conducted in Wisconsin, 1929-2003. Overall nest success averaged 50.8% based on 546 nests. (PCG2B, Keenlance 1998, Golner 1997, Bergerud and Gratson 1986, Toepfer 1988, Grange, 1948, Hamerstrom 1939 and Gross 1930). The averages from each study varied from 45.5-55.3%. Nesting success in central Wisconsin has remained at or near 50% for the past 73 years. Nesting success is important but at this time it is not a dominant factor in limiting greater prairie chickens in central Wisconsin. However differences in nesting success between areas do have important implications for future grassland management in Wisconsin and other states.

Since 1996, we have located 370 nests in central Wisconsin and nesting success has averaged 52.3%. Nesting success varied between management areas and based on the eight-year mean was highest on Paul Olson (58.9%), Mead (58.8%), and Buena Vista (50.5%), and lowest at Leola (42.2%). The differences in nesting success between management areas reflects differences in quantity and quality of grassland cover as related to management practices. Nest success for the combined management areas showed the same pattern where success was higher for the less intensively managed areas; 58.9% (n = 119) for Paul Olson/Mead, versus 49.0% (n = 251) for Buena Vista/Leola.

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Success was lower on those areas with the most state-managed grasslands and the most active disturbance programs. Buena Vista/ Leola are managed under the same disturbance regime - rotational burning and agricultural activities (food plots/hayfields/grazing). Paul Olson and Mead have heavier soils and are less intensively managed. Because of similarities in management and soils, for nest success analysis, Buena Vista/Leola have been combined, as have Paul Olson /Mead. Nests from the Northern range have been pooled with nests form Paul Olson/Mead. A single nest from Dewey was excluded from this analysis.

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We found overall nesting success was slightly higher on private land (54.1%, n = 122) than state-managed land (51.3%, n = 248). But success was quite a bit higher on the less intensively managed state grasslands on Paul Olson/Mead (63.0%, n = 46) versus the more intensively managed Buena Vista/Leola (48.5%, n = 202). The higher nesting success on Paul Olson/Mead suggests that nesting habitat on state-owned managed land and private land in these areas may have better residual cover than Buena Vista/Leola.

We have found no evidence of low or declining egg hatchability reported by Westemeier et al. (1998). However, we have not been able to obtain good data because many of the hatched nests are disturbed before we can check them, and or eggs are missing from the clutch and we do not know their fate or status.

There is no evidence that greater prairie chickens prefer native grasses or that natives create better nesting habitat. Past research indicates that non-native grasses dominate nesting cover at prairie chicken nests on the Buena Vista. Both Toepfer (1988) and Golner (1993) found cool-season grasses dominated the cover at nests on the Buena Vista. Even when native grasses were present nearby, hens seemed to select non-native grasses for nesting. In this study we found that in eight years, only 11 of 370 (2.4%) nests had native grasses as dominants (over 50% native grasses). Overall, quack grass (Andropyron repens), Kentucky blue grass (Poa pratensis) and reed canary (Phalaris arundinacea) were dominant at prairie chicken nest sites in central Wisconsin. Quack grass was most abundant at nests on Buena Vista/Leola and reed canary was dominant at Paul Olson. Mead was a mix of cool season grasses, quack, blue grass, and brome. These are all non-native cool season grasses.

Historically, the Buena Vista was a Tamarack (Larch laricina) swamp, and not native grassland (Zedler 1966). Hence there never was, and currently is, very little native prairie or native grass (probably less than 10%). With non-native grasses dominating, and the main species utilized by nesting prairie chickens in Wisconsin, especially on the Buena Vista, management should focus on maximizing the amount of residual cover.. McKee et al. (1998) found that the amount of residual litter cover was the best indicator of nesting success. The current burning patterns on Buena Vista/Leola are typically used to discourage cool season grasses which would reduce residual cover (Svedarsky et al 2003).

The current management regime on Buena Vista follows the findings of Halvorson and Anderson (1980) who indicated that burning maintained cool-season grasses without reducing density, frequency or percent cover. This is contrary to the standard thinking that burning suppresses cool-season grasses. However this study was conducted in 1978 when water levels and soil moisture in this region were much higher. This would explain why burning at that time did not impact cool season grasses.

The hydrology on the Buena Vista has changed over the past 30 years. During the 1970's it was so wet you could not drive off the roads. And at times, you could not even drive on the roads themselves without getting stuck. In contrast today, the water table is lower and soils are so dry that one can now drive a vehicle just about anywhere on, or off the roads. Under these drier soil conditions grasses, especially cool-seasons are negatively impacted by the current April burning regime. This untimely burning reduced residual production by cool-season grasses which may be why nesting success is lower on Buena Vista/Leola than Paul Olson/Mead and private lands. Sample (1997) indicated that the timing of burning can influence plant species composition. Spring burns tend to suppress cool-season grasses and promote warm-season grasses while the opposite is true of mid-to late summer burns.

On the Buena Vista between 1996-2003 we found only one nest (0.3%) in a fresh burn and that was a re-nest found in June 1996. In addition we have found only two nests in burns that were two years old. This suggests that nesting hens are avoiding the 1-2 year old burns. We suspect that one reason for this avoidance may be due to the suppression of residual development due to burning on the lighter organic soils and the dominance of cool-season grasses on the Buena Vista/Leola.

This pattern of avoiding one and two year old burns raises concerns about the cumulative effects of disturbances. The present burning regime compromises grassland nesting habitat for up two years. Hens do not nest in grass the year of the burn or the year after. Hence in any given year on the Buena Vista there are two years of non-nesting habitat created by burning.

For example, if 1,000 acres are burned in a given year, those acres are basically eliminated as possible nesting habitat. If this burning regime continues and another 1,000 acres are burned the following year, that year you will have a total of 2,000 acres of unsuitable nesting habitat. Now let's say another 600 acres are grazed annually. This too eliminates potential nesting habitat and is cumulative with 1,200 acres of less than optimal nesting habitat created in the second year. Then, add another 400 acres of farm units where the acres are plowed/disked/idle. In the second year of this activity another 800 acres of habitat will be affected. When one adds up the numbers you soon see that in any given year, there would be a total of 4,000 acres of habitat eliminated as potential nesting cover.

The Buena Vista as of 2002 was comprised of 11,778 acres of grassland reserves.
If one were to apply the management regime described above, it would result in over a 30% reduction of available nesting habitat in any given year. Unfortunately, this is the very management regime that is currently in effect on the Buena Vista. Eliminating this amount of nesting habitat each year surely has an effect on nest distribution and nesting success.

One certainly has to appreciate the need to control brush on grassland ecosystems and still maintain suitable nesting habitat. However there may be better ways to do so other than the burning, farming, grazing and mowing regime currently practiced on Buena Vista. Grazing and mowing are two management methods used together to control brush. But eliminating grazing and just mowing in mid to late summer could accomplish the same task. At the least, grazing should be deferred until after nesting season.

Burning as currently conducted on Buena Vista/Leola appears to be suppressing development of residual cool-season grasses. Management practices here need to be modified to leave more residual cover (less disturbance) to improve nesting success. This would best be accomplished by burning on a longer rotation and using mowing and grazing as late season disturbances to increase vigor of cool-season grasses and increase residual cover. Nesting on Paul Olson/Mead would be enhanced by adding more grassland and mowing brush in existing low areas.

While nesting success itself has been relatively stable near 50%, one has to examine other factors to see how management might increase production. The most likely possibility would be to increase the number of nesting prairie chickens by increasing the amount of residual grass in the spring.

In CRP fields in northwestern Minnesota we have seen the positive results of leaving cool-season grasses undisturbed for five years or more. In a study of radio-marked hens (n = 370) between 1992-2001, we found nesting success increased from 33.1% (n = 204) during the first five years (1992-96) to 47.6% (n = 166) during the second five-year period (1997-2001). These CRP fields have been undisturbed for 12-16 years now and as a result of just leaving them alone, they have become better nesting habitat. Nesting success of radio-marked hens (n = 143) in native praire remained constant (55%) during thesame period.

In 1996, nesting success in South Dakota was 66% (n = 15). In North Dakota between 1997-2000, nesting success was 58% (n = 47). Overall nesting success for Minnesota, North Dakota and South Dakota combined was 56.3% (n = 575).

Recruitment/Brood Rearing

The number of hens that fledge chicks and the number of chicks fledged per hen are the two main factors limiting greater prairie chicken populations. Chicks are considered fledged at 10 weeks of age.

Average brood sizes of radio-marked greater prairie chickens indicate that hens in North Dakota and Minnesota fledged one more chick per hen than those in central Wisconsin 1996-2003 (Table 3). Other researchers are reporting similar problems with reduced production in other parts of the greater prairie chicken range where populations are on the decline. Nests are hatching at a good rate (50%) but hens are losing most or all of their chicks during the first four weeks after hatching. The cause(s) of this mortality are not known at this time.

Chick survival varies between states and has varied over time. Radio-marked hens in Wisconsin fledged more chicks in the early 1970's (4.3, n = 11) and 1985-86 (4.6, n = 14) (Toepfer 1988, Gratson and Bergerud 1990) than today. Historical brood sizes for prairie chickens summarized for several states by Ammann (1957) averaged 6.5 with averages ranging from 5.5 - 8.3. Sisson (1976) reported an average brood size (three-quarter grown) in Nebraska of 6.7 (n = 33) and in Kansas, Horak (1985) reported an average of 7.1 in August. These average brood sizes are 2-3 chicks greater than we see in Wisconsin and higher than overall averages and most years in Minnesota and North Dakota.

Current chick survival in Wisconsin is lower than in other states and has declined since the mid - 1980's. Chick survival between the two main management complexes, Buena Visa/Leola and Paul Olson/Mead does not appear to be different as averages are comparable. This indicates that lower survival is not due to differences between the areas but to some common cause. This cause has yet to be determined.

The reduced survival of chicks appears to be a major factor in limiting population growth in Wisconsin. Predation by harriers has been blamed by some but that aspect has been discussed in the section on raptors. Harriers are not as common at Paul Olson/Mead as they are at Buena Vista/Leola where there are larger field and more acres of open grassland.

It is important to understand that prairie chicken hens with young chicks are very attentive and brood (keep warm) them for up to five weeks after hatching. The high loss of chicks during this period suggests that chicks may be weak and/or the hen may not be in good enough physical condition to keep a larger number of chicks warm. Up until 10-14 days chicks are not capable of thermoregulating and are dependent upon high quality food and the hen for warmth (Potts, 1980, Rands and Paulhayward, 1987). Once chicks reach 6 weeks of age, survival to 12-16 weeks of age is generally high at 75-85%.

The condition of a hen after 25 days of incubation is critical to the survival of chicks, especially to the number that she can successfully brood. Condition of the hen is a function of the quality and quantity of food during winter, prenesting and especially incubation. Hens in poorer condition will fledge fewer chicks. Moss et al. (1975) showed that the condition of the hen affected the number of eggs laid, their hatchability, and the survival of chicks. Riley et al. (1998) reported that in pheasant broods, most mortality occurred during the first two weeks and that size at hatch influenced survival, which suggests that egg quality and condition of the hen are probably important.

The quality of food could be related to an increase in the amount of soybeans used by prairie chickens for food. I

Table 3. A comparison of greater prairie chicken mean brood sizes for Wisconsin, Minnesota and North Dakota, 1972-2003.

Year	Wisconsin	Minnesota	North Dakota
1972	4.0 (11)	-	-
1985	4.6 (7)	-	-
1986	4.7 (7)	-	-
1996	4.2 (11)	4.5 (8)	-
1997	3.5 (24)	4.1 (4)	5.3 (5)
1998	3.6 (21)	4.0 (6)	4.5 (16)
1999	3.5 (8)	5.5 (5)	5.1 (10)
2000	3.3 (7)	4.5 (8)	4.0 (4)
2001	2.8 (9)	6.3 (12)	5.6 (5)
2002	3.5 (5)	3.6 (11)	-
2003	3.6 (7)	5.5 (18)	-
Total	**3.5 (92)**	**4.8 (72)**	**4.9 (40)**

saw one of the first soybean fields on the Buena Vista in 1972 and the acreage has increased to present day levels where it is now planted in one-third of the agricultural fields. Soybeans are not common on Paul Olson and brood sizes are also small in this area. Soybeans are a common crop in northwestern Minnesota and North Dakota where broods sizes are larger than in Wisconsin.

We are fortunate to have found a major limiting factor - chick survival. Unfortunately we do not know the exact cause or reason for such low survival. Possible explanations are genetics, pesticides or condition/size of hen. The possibility that genetics may be involved is supported by recent work in Texas. Morrow (USFWS pers. comm.) found that survival of Attwater's chicks in pens was lower than wild Minnesota prairie chickens raised under similar conditions. The pen-reared Atttwater's released in late summer that survive to nest are hatching eggs, but so far none have fledged chicks. Morrow (pers. comm.) also found that average weight of Attwater's prairie chickens has declined since Lehman (1941).

All or any of these could suggest a possible genetic connection. We have Hamerstrom's weight data for the 1950's and 1960's and will eventually compare it with weights in the 1970's (Toepfer 1988) and with those collected in PCG2B to see if the size of prairie chickens in Wisconsin has declined since the 1950's.

Warner et al. (1999) has reported pheasant chick survival based on brood sizes has also declined from the early 1950's to the early 1990's, (7.7 to 4.2) and indicated that brood habitat has declined in quality, quantity and distribution due to clean farming.

The quality of brood habitat could be a problem for prairie chickens in Wisconsin, as some managers believe that recently disturbed grassland is required for broods. However, there is no evidence to support this contention and I have not yet been able to find a source in the literature that indicates that this statement is true. Svedarsky (1979) and Toepfer (1988) indicated that hens with broods moved their broods to recently disturbed areas but sample sizes were small and chick mortality was high in Minnesota. Hens have successfully raised broods at

Paul Olson (1996-2002) where there is no management. Also, most of the grasslands in this area are on private land and have been undisturbed for more than 3 years, some for 10 or more years.

There have been two WDNR and STCP sponsored radio telemetry nesting and brood rearing studies conducted on the Buena Vista since 1993 by Golner (1997) and Keenlance (1998). Summarizing from Keenlance (1998): hens without broods selected areas disturbed the year of study, hens with broods selected grass, grass forb and forb grass areas and avoided forb and shrub forb areas. They also avoided areas disturbed the year of data collection and selected for areas 3-4 years since disturbance. Golner (1997) found hens selected grass and grass forb areas. He also found that hens without broods selected recently disturbed areas, hens with broods avoided areas disturbed the year of study and spent the majority of time in areas disturbed within 3-5 years. And, 8 of 14 hens selected areas left idle for 4, 5, and 6 years. Neither author found that hens with broods selected recently disturbed areas and neither reported any figures on chick survival.

Our work in Minnesota indicates that some hens with young broods do shift to recently disturbed areas (35.8%). Yet at six weeks of age it is common for hens with broods to feed in agricultural fields especially wheat and soybeans. These hens often night roost in the adjacent CRP grasslands but some hens keep their broods in these agricultural fields both day and night. In Minnesota where brood survival has been higher than Wisconsin (Table 3) the vast majority of broods (64.2%) spend the first six weeks in the brome dominated CRP fields. The majority of these fields (78%) were enrolled in CRP in 1986 and other than periodic spraying and selected strip mowing of weeds the grass and sod have been undisturbed for 17 years. Brush encroachment has not been a problem except where the sod has been disturbed. During the past four years (1999-2003) the Buena Vista/Leola and Paul Olson/Mead populations in Wisconsin have declined 26.3% and 13.5% respectively. In contrast, during the same period, the Minnesota and North Dakota prairie chicken populations associated with the undisturbed brome grass complexes have increased 81% and 93.6% respectively. Prairie chicken broods do not require recently disturbed grasslands or native prairie to thrive.

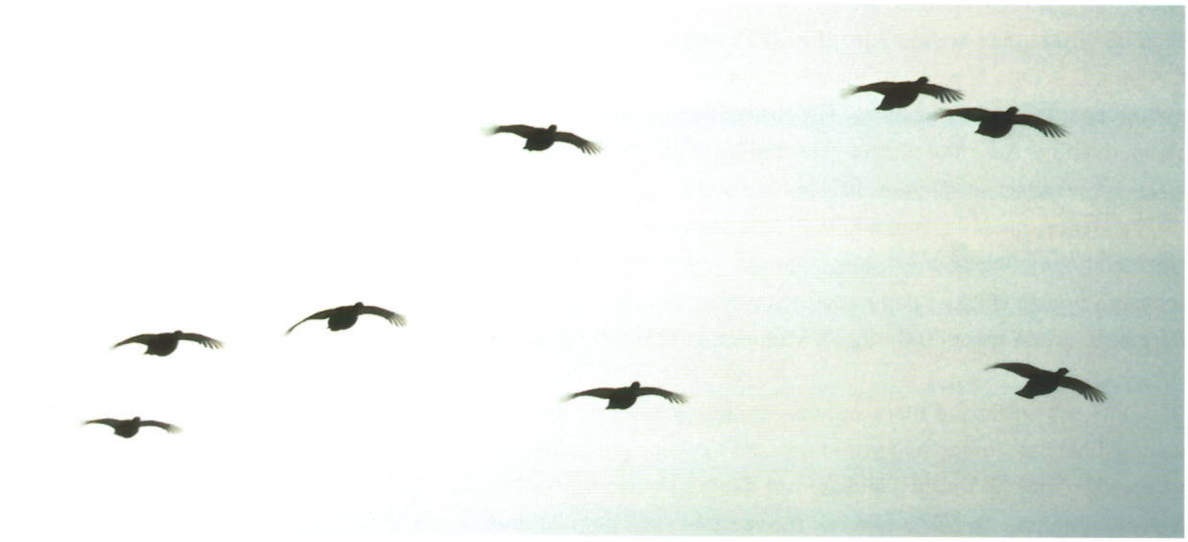
Dispersal

Until PCG2B, this was the most unstudied aspect of greater prairie chicken ecology. Over the past seven years, 1996-2003 we monitored the dispersal of over 500 radio-marked juvenile birds in central Wisconsin. The first three years (1996-98) of the dispersal portion of the study have been written up in Halfmann (2002). The data for 1999-03 are being added and a manuscript is being prepared for publication.

The results of the Wisconsin dispersal study indicate that there is regular movement of birds (primarily young hens) between Buena Vista and Leola Wildlife Areas and between Paul J. Olson and Mead Wildlife Areas but little movement between these subpopulations. Halfmann (2002), found during the three-year period that only 14% of juvenile greater prairie chickens dispersed between subpopulations. Of the dispersal movements between subpopulations, those between Buena Vista and Leola and between Mead and Paul Olson were the most frequent. Dispersal between the northern Paul Olson/Mead areas and southern Buena Vista/Leola areas was virtually nonexistent. For the most part this pattern has not changed with the inclusion of the dispersal movements of radio-marked young birds between 1999-2003. The only major addition is that two immatures trapped in winter dispersed (20.4 and 24.7 miles) from Paul Olson to the Outlying Areas in 2000-01.

Concurrent monitoring of a radio-marked adult sample of 3,000 birds failed to detect any significant number of movements between the northern and southern areas or management complexes (Buena Vista/Leola and Paul J.

Olson/Mead). There were only two major movements made by adults between management complexes and both were made by hens. One hen, a juvenile that dispersed from Buena Vista and nested near the town of Spencer in the Northern Range (37.5 miles), returned to the Buena Vista before her second nesting season and nested in the same field where she was hatched. The second, another juvenile hen, exhibited a similar pattern and dispersed



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from Paul Olson to Serle's Cranberry (12.4 miles) to nest and then returned to Paul Olson for her second nesting season. The largest movements made by adult cocks were limited to the management area boundaries. The largest movement made by adult cocks occurred on the Buena Vista where several cocks moved between the north and south ends of the Wildlife Area, a distance of approximately 10 miles.

Juvenile hens have moved from Buena Vista to Dewey Wildlife Area (one) and to near the town of Spencer (one) and from Mead to Dewey (three) (Halfmann 2002, Toepfer unpubl. data). The juvenile hen that moved from Mead to Dewey in 2001-02 hatched a nest there and fledged one chick. The juvenile hen that moved from Buena Vista to Spencer in 1997 hatched a nest and fledged four chicks and the survivors remained within several miles. These longer movements seem to be associated with population increases in the subpopulation from which the juvenile hen dispersed. These exchanges however have not been enough to maintain the genetic variability that existed in the early 1950's (Bellinger 2001). Hamerstrom and Hamersrom (1973) documented numerous movements of banded cocks and hens moving from Buena Vista north to Paul Olson and Mead in the 1950's and 60's. They recorded no movements going the other direction (south). These one-way movements are not surprising as Hamerstrom and Hamerstrom (1973) did not band birds at Paul Olson or Mead and thus wouldn't have had any means of identifying birds that moved south from these areas. Toepfer (1988) recorded the only reverse (south) movement and that was made by a banded cock from Paul Olson to the Buena Vista in 1976.

At this time, the southern Buena Vista and Leola complex must be considered a biologically separate and distinct management unit as should the combined northern complex consisting of Paul Olson, Mead and the Outlying Areas. Historically these two areas had booming grounds within five miles of each other (Westemeier 1971) and in essence were biologically connected. Since there was regular movement between these areas in the past by both adult and immature cocks and hens (Hamerstrom and Hamerstrom 1973, Westemeier 1971), and none today, it will be necessary to develop a grassland habitat corridor between these areas especially between Buena Vista/Leola and Paul Olson/Mead to reconnect the subpopulations, encourage movement and exchange genes.

Dispersal research on radio-marked prairie chickens conducted in western Minnesota with smaller samples sizes during the same time frame indicate that the dispersal distances of juveniles, especially hens, are greater than those seen in central Wisconsin and North Dakota with movements of 15-30 miles occurring every year between 1992-2003. These data are not part of PCG2B and are currently being compiled and analyzed but they warrant comment at this time because of their importance to overall management and the problems associated with fragmentation and loss of connectivity. The distribution of prairie chickens in northwestern Minnesota is oriented north-south and is long and narrow (Svedarsky et al. 1997) And, unlike Wisconsin where there is a 17 mile gap between subpopulations; Minnesota's habitat and booming ground distribution is relatively continuous (Merril et al. 1999). Hence, juveniles and adults in Minnesota can disperse without barriers of non-habitat. Wisconsin's fragmented population now exhibits isolation within isolation restricting dispersal. Hopes of ever linking Wisconsin's prairie chicken population to another is slim at best. The greater prairie chicken populations nearest to Wisconsin are in Iowa (360 miles), Minnesota (325-400 miles) and Illinois (500 miles).

Prairie chickens are strong fliers and very mobile but our evidence indicates that they are not good at pioneering unoccupied habitat. Range expansion appears to occur gradually as birds move relatively short distances into unoccupied habitat (2-3 miles) and are not likely to move unless individuals are pushed by competition due to an increase in numbers. In North Dakota, the reestablished population at Grand Forks remained in a core area of 50 square miles for four years. This occurred despite the presence of 5 square miles of unoccupied open grassland habitat only 5-9 miles to the east. In 2001-02, after a population increase of 71%, cocks from the core area began to expand forming new booming grounds 3 miles to the east. A second population increase in 2002-03 of 54% resulted in additional expansion with booming grounds developing 4.5 miles south and 9 miles east of the core area. In northwestern Minnesota, increases during the past three years have resulted in new booming grounds that are not only showing up in peripheral habitat, but also increasing within the existing complex of booming grounds. Consequently, there are more booming grounds but the booming grounds have become smaller over the past twelve years.

One thing is certain; dispersing young prairie chickens find other prairie chickens. It is rare to find a prairie chicken alone as 92% of flocks observed in central Wisconsin were in flocks of two or more (Toepfer 1988). The exception would be hens during egg-laying.

When radioed juvenile hens in Minnesota have moved 25-30 miles into areas we were not familiar with, they have all been found in the vicinity of an established booming ground. In 13 years we have yet to find a dispersing juvenile end up off by itself. During our studies, the farthest a juvenile hen ever ended up away from a booming ground was 2.3 miles. And, all dispersing cocks ended up on established booming grounds.

Dispersal movements are made in a hopscotch manner with individuals or small flocks (2-4) moving from the vicinity of one booming ground/group of birds to another until they can fit in and/or find a place where they are comfortable. Most juvenile cocks and some hens disperse to the nearest booming ground/group of birds and remain there for the rest of their lives. Once established on a booming ground most cocks (84.6%) that survive to the following year remained on the same booming ground for the rest of their lives (Toepfer 1988).

Survival/Predation

There have been two survival studies conducted on banded greater prairie chickens in central Wisconsin, both on the Buena Vista. One was Hamerstrom and Hamerstrom (1973) from 1950-1970 (942 birds) and the other, Toepfer, Tesky and Anderson 1972-80 (270 birds) summarized in (Toepfer 1988). Annual survival for sexes and ages combined was 54% from 1950-70 and 48.9% from 1972-1980. Both studies had a single cock survive for eight years. These two independent studies put greater prairie chicken annual survival in central Wisconsin at approximately 50%. Both studies also indicated that survival was slightly higher for hens than cocks.

Preliminary analysis of annual survival data for radio-marked birds 1996-98 (our best data) shows that annual survival is 49.4% which is comparable to that of banded birds. Survival was higher for cocks (60.6%) than hens (41.3%). Survival was highest for Paul Olson (56.4%), followed by Buena Vista (51.2%), Mead (43.8%) and Leola (29.4%). Survival was higher for cocks than hens in all areas except Leola. The latter area is intensely farmed for vegetables and cocks spend a good deal of time in the agricultural fields.

The pooling of survival data is misleading as the highs and lows within an area are averaged as shown in Table 2 in the Open Space section. Survival varied not only between areas but also within areas and even between booming grounds. These high survival areas and population sinks at this time appear to be related to differences in landscape patterns.

The next step will be to conduct a detailed examination of survival of our large sample of radio-marked prairie chickens in the respective study areas and states; and then do a breakdown of Hamerstrom and Hamerstrom (1973) and Toepfer (1998) survival band series. This will be done for years, seasons, periods, by areas and by individual booming grounds. This survival series will emphasize sex, age and landscape patterning rather than differences between areas especially an analysis of open space or size of treeless areas and its influence on survival.

Mortality Factors

It is difficult to determine what killed a radio-marked prairie chicken unless one actually sees what happens. Even then, injures, condition or disease could be contributing factors to mortality. At best, all one can do is read the "sign" where the radio was found and determine what fed upon the remains. Radios found with no feathers, bones or signs of predation were classified as unknown predation. We have never recaptured a bird that lost a radio package so if the radio package is found, the bird in all likelihood is dead. All kill sites and radios found were located using GPS for future reference and analysis so we can relate mortality factors to landscape features. Remains of dead birds were also collected and stored for future reference.

In central Wisconsin during the five-year period, 1996-2001 we located and retrieved the radios of at least 713 radio-marked prairie chickens that had died or been killed. Predation appeared to be responsible for 78.9% of the mortality, unknown causes 13.2%, electric wire collisions 6.5%, auto collisions 1.0%, and fence collisions 0.6%. A breakdown by type of predation categories showed that unknown predation was 60.7%, raptor predation 27.4% and mammalian predation 11.9%. Overall, based on remains and sign, raptors accounted for over two-thirds (69.9%) and mammals one-third (30.4%) of the predation. Toepfer (1988) documented a similar predation pattern on the Buena Vista 30 years ago for 54 radio-marked prairie chickens where overall predation was 86.7%, with 57.8% attributed to raptors and 28.9% to mammals. Toepfer and Eng (1988) also found that predation was the likely cause of mortality in greater prairie chickens in North Dakota and that raptors were responsible for two-thirds of the losses.

Determining exactly what killed a bird based on remains is difficult and I again emphasize that unless one observes the event, the best they can do is assume that whatever fed upon the remains (if any) is what killed the bird. One problem in today's studies is that after a bird is killed or dies one often finds only the radio package. Hence, results from radio telemetry studies using this type of radio package can underestimate mammalian predation. This is because mammals usually move their kills and in contrast with raptors, they consume most of the bird leaving just the radio and little or no sign. The situation is further complicated by mammals scavenging raptor kills. Raptors leave remains behind (bones, flesh, and internal organs) that are an easy meal for scavenging mammals or other raptors. These remains are often taken and consumed leaving the radio behind masking the signs of feeding by raptor(s). We have no evidence of raptors scavenging from mammal kills.

Rusch and Keith (1971) however found that most of 157 ruffed grouse carcasses set out in their study were scavenged. Kenward (1977) reported that 18% of pheasants killed by goshawks were scavenged by another hawk and 16% were scavenged by mammals. Toepfer (1988) using sign (stripped tendons) as an index reported that 17% (n = 39) of probable predator kills of radio-marked prairie chickens showed evidence of scavenging and that 29.2% (n = 24) of presumed raptor kills were scavenged by mammals. Recently, Bumann & Stauffer (2002) reported that mammalian scavengers disrupted 42 of 64 ruffed grouse carcasses and that mock avian kills were scavenged more frequently than whole carcasses.

There is little doubt in my mind based on our work with several thousand radio-marked prairie chickens in Wisconsin, Minnesota and North Dakota, that predation and specifically that of perching raptors is the main mortality factor on greater prairie chickens. We also know that the presence of woodland especially scattered trees in a savanna landscape reduces the survival of prairie chicken cocks and probably hens as well.

Raptors

The fact that two-thirds of the remains of all prairie chickens found dead exhibited signs of being fed upon by raptors (feather circles, stripped tendons and/or bone) (Toepfer 1988) implies they are a major mortality factor. There are at least eight species of raptors common in central Wisconsin that can probably kill an adult prairie chicken including the red-tailed hawk (Buteo jamaicensis), rough-legged hawk (Buteo lagopus), barred owl (Strix varia), northern harrier (Circus cyaneus), northern goshawk (Accipter gentilis), Cooper's hawk (Accipiter cooperii), snowy owl (Nyctea scandiaca), bald eagle (Heliaeetus leucocephalus) and the great horned owl (Bubo virginianus). All of these raptors hunt from perches (i.e. trees, fence posts, telephone poles, tall shrubs and sign posts). Overall, the rough-legged hawk, northern harrier and red-tailed hawk were the most common of the above species observed in central Wisconsin, Minnesota and North Dakota.

Even though each of these species could have an effect on prairie chicken mortality, some are more prominent than others. For example, the Cooper's hawk and barred owl are not commonly observed in the savanna habitat of central Wisconsin and probably have minimal impact on prairie chickens. And because of their hunting and feeding habits and limited presence, bald eagles are likewise considered of little threat. Goshawks have also been observed occasionally but their population declines over the past two decades is the likely explanation for so few being seen in this study. The rough-leg, though common in some winters was not thought to be a serious threat to prairie chickens. And although the snowy owl is certainly capable of taking a prairie chicken, during our observations we only witnessed the one we radio marked hunting mice. However the gyrfalcon (Falco rusticolus) may be a more serious contender as their style of hunting lends itself to pursuing chickens on the open landscape.

Both species generally arrive in late fall and winter and leave in the spring. Thus, as spring is the period of highest mortality for prairie chickens, it follows that those raptors most commonly found during this period will likely have the greatest impact on prairie chicken mortality. The three most common raptors species observed in central Wisconsin during the spring are the red-tailed hawk, northern harrier and great horned owl.

One of four great horned owls radio-marked during our study.
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Peterson (1979) reported that great horned owls and red-tails removed 3.8% of pheasant populations during winter and 35.5% during spring and that red-tails were responsible for half of the annual mortality. He concluded that along with other predators these two species were reducing pheasant numbers below carrying capacity. It is likely that a similar seasonal pattern occurs with prairie chickens. The increase in mortality in prairie chickens coincides with the return of red-tails and the hatching of young great horned owls in early March.

Toepfer (1988) compared mortality factors of pheasants (Dumke and Pils 1973) with prairie chickens and found that over 80% of mortality for both species was due to predation. Pheasants were more susceptible to predation by mammals than raptors (70.7% versus 29.0%) and prairie chickens were more susceptible to predation by raptors than mammals (57.8% versus 29.5%). Toepfer (1988) indicated that prairie chickens have been killed by red-tails, northern harriers, goshawks, Cooper's hawks, snowy owls and great horned owls. Of the observed kills, 82.2% had been made by raptors that typically hunt from a perch.

In February and March 1998 we radio-marked four adult red-tailed hawks (3 males and 1 female) and four great horned owls (3 males and 1 female) with 2-year backpack radio packages. These birds were captured using bal-chatris (Berger and Hamerstrom 1962) and Swedish goshawk traps (Meng 1971). In early spring of 2000 we trapped 18 additional red-tails and radio-marked 12 with experimental bib collars designed to fall off. This appeared to work but in 2001 a bird was found bridled by the bib and two bibs fell off after a year and a half. We thus abandoned this package and have recommended to the USFWS that this not be used on red-tails.

The purpose of this phase of the research was not to conduct a detailed study of the ecology of these two species but instead was to see how they used the grassland/savanna landscape, especially the single trees scattered throughout the Buena Vista. The movement and habitat information on raptors will in time be treated under a separate venue. Here we will cover just the highlights of what we observed as they relate to prairie chicken ecology and management. Although we never observed radio-marked red-tails or great horned owls chasing prairie chickens, we did gain some insight into how these two species actually hunt in the savanna landscape.

Two of the four red-tails (both males) we radioed left the Buena Vista in November and returned by mid-March. In the one red-tail pair we radio-marked, the male left the area during the winters of both years he was followed (1999 and 2000) while his mate remained on or near the Buena Vista. It appears that at least half of the red-tails leave the Buena Vista during the winter. The male that remained on the Buena Vista over winter was a bird originally captured and banded by Fran Hamerstrom in 1983. This male was followed for two years and only left the Buena Vista to night roost during very cold weather (below zero) in a large spruce or clump of pines in a woodlot about 2-5 miles south of his territory. It was typical for these red-tails that did not migrate to temporarily expand their breeding ranges by 3-8 miles. This was likely a response to the fact that half the local red-tails migrated leaving many of the breeding territories unoccupied during winter.

The typical daily movement pattern for red-tails on territories was to night roost in the woodlots. During the mornings and evenings they would then hunt from the woodlot edges or move out into the open grassland and use single trees, small clumps of 3-5 trees, telephone poles and fence posts for hunting perches. The red-tails would fly from 0.25-1.25 miles from their roosting areas to various hunting perches. When actively hunting, they did not remain on a specific perch long but instead moved from perch to perch in a manner that would suggest they were trying to ambush prey near the perch.

The great horned owls remained in the area year round. One young male appeared to wander around for about nine months and settled down when he obtained a mate. At times, he was located seven miles from where he was caught. Great horned owls would return to the woodlots to roost during the day and those with patches of conifers appeared to be preferred. Like red-tails, the great horned owls moved out into the savanna areas to hunt. However, some owls ranged 3-4 miles farther from their day areas than red-tails. Great horned owls would at times follow the drainage ditches perching on large cottonwood trees along the way hunting the grassland/agricultural edges.

In 2001 we captured and radio-marked a female snowy owl on the Buena Vista to see if it was hunting and killing prairie chickens. Berger & Hamerstrom (1962) had reported a snowy owl killing a prairie chicken on a booming ground. But our radio-marked snowy remained within 2 miles of its capture site and was never observed hunting prairie chickens. Instead, it spent most of its time at a captive elk enclosure presumably hunting rodents feeding on the daily food provided for the elk. This bird remained on the Buena Vista all winter and left in mid-April. Interestingly, this same bird was recaptured in northern Canada during the winter of 2003.

Hamerstrom et al. (1957) stated that the best predator control is to provide good habitat. The way to reduce predation by great horned owls and red-tails would be to reduce their numbers or modify habitat so they are less efficient. Predator control would not be acceptable to the public. However, reducing the size and number of woodlots found in prairie chicken habitat would reduce the number of breeding areas for raptors, hence reducing their numbers. The removal of trees scattered throughout the grassland would also prevent perching raptors (red-tails, Coopers hawks and great horned owls) from hunting the open grasslands. A study on tree removal and survival is covered in this report. These measures would serve to effectively segregate predator and prey making it difficult for raptors to get close enough to catch prairie chickens.

Concerns have also been raised about the impact of northern harriers on prairie chickens; especially chicks and juveniles on the Buena Vista. Although, harriers are not generally known to prey on adult prairie chickens, recent work by Thirgood and Redpath (1999) in Scotland has found that harriers may be affecting red grouse populations. Red grouse are much smaller than prairie chickens and more likely to be caught by a harrier. Because of the larger size of adult prairie chickens, harriers are more likely to forego them and instead focus on chicks and juveniles. Prairie chicken chicks and juveniles have been reported killed by harriers (Svedarsky 1979, Toepfer 1988) and the remains of chicks 4-8 weeks old have been found in harrier nests during this project.

To address these concerns, we examined Fran Hamerstrom's harrier nesting data for the Buena Vista to see if there was any relationship between the number of nesting harriers and the number of prairie chickens the following spring. It was felt that if harriers were killing a significant number of chicks and juveniles, their impact would be greatest when the number of their nests was highest. As a result, if predation by harriers was significant, one might also expect to see a reduction in the number of cocks on booming grounds the following spring.

The analysis of 35 years (1959-95) of nesting data was somewhat of a surprise. What we found was that when there were more harrier nests on the Buena Vista, the number of cock prairie chickens the following spring did not decline but instead increased 58.3% (7/12) of the time when there were 16 or more nests. When there were 15 or fewer harrier nests, the number of cock prairie chickens increased the following year 47.8% (11/23) of the time.

At the extremes, there were 20 plus nests on the Buena Vista four times. Three of these times (75%) cock numbers increased the following spring. And, when there were five or fewer nests (9 times) cock numbers increased four times (44.4%). The maximum number of harrier nests ever recorded on the Buena Vista was 34 in 1979 and the cock population increased 11% the following spring. It appears that the number of nesting harriers is not negatively impacting prairie chicken numbers on the Buena Vista. Actually, the opposite appears to be the case and that whatever factors are attracting harriers are also creating good conditions for prairie chickens. However this relationship needs to be examined further and the effects on individual booming grounds examined relative to not only the number of nests, but to success and number of young fledged.

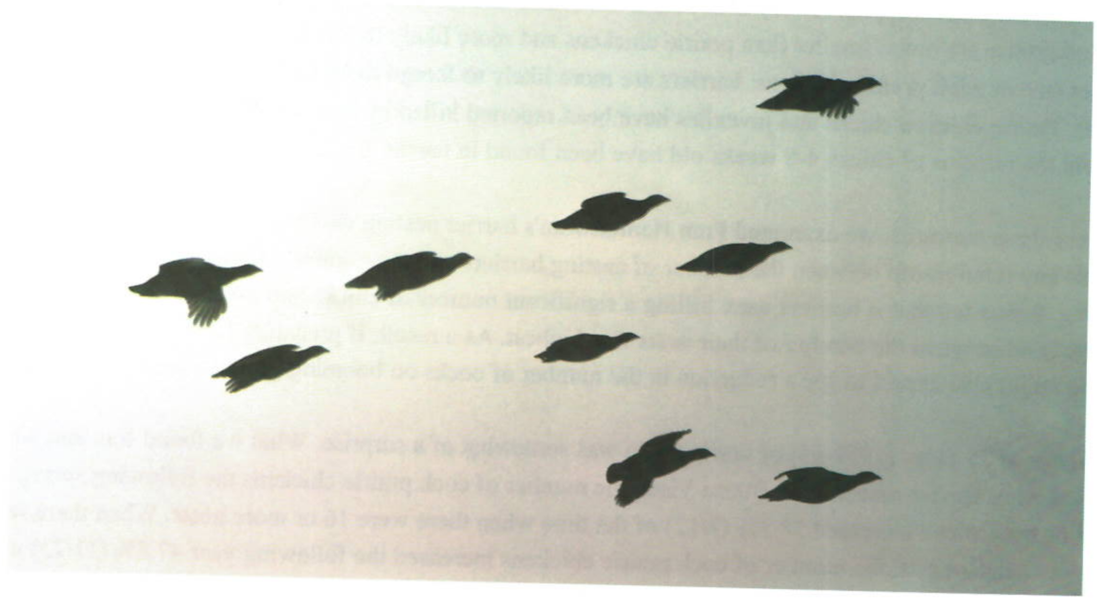
Accidents

There are three major categories of accidents that greater prairie chickens are susceptible to: automobiles, hay mowing, and wire collisions. Greater prairie chicken automobile collisions are rare and there is little that can be done about it. They typically happen on hard surface roads when the birds become confused and freeze or a hen with a brood or young birds use the road as a travel lane or cross back and forth. In both instances the birds in the cover along the edge of the road flush or run when they are surprised by a fast moving vehicle.

Losses to hay mowing are not common any more and are a function of the timing of mowing and height of the hay during nest initiation in late April. The key to keeping prairie chickens and other ground nesting birds out of hayfields is to keep the cover short so it is not attractive to nesting hens or hens with broods. This means mowing late in the season during late August and early September so there will not be adequate regrowth to produce enough cover that will attract nesting hens when they are initiating first nests in late April and early May.

Hayfields on Buena Vista are mowed after July 15 and regrowth is limited.

We have never had a radio-marked hen nest or take a brood into one of the hayfields on the Buena Vista. All of the hens we have found killed by mowers (n = 3) were found on private land on Paul Olson or Mead and were



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killed on nests or with young chicks. Private hayfields are mowed twice during the summer, usually the last week of May or first week of June and then again in early to mid-July. If growing conditions are right there will be enough regrowth to create taller cover that will be attractive to nesting hens, especially re-nesting hens and hens with chicks. Hayfields on private land because of regrowth are also attractive to nesting hens, Hayfields are not common in northwestern Minnesota, consequently mortality due to mowing was likewise not common.

In 1999, we used a cable-chain drag (Higgins et al. 1977) to search for nests in state hayfields on the Buena Vista. These hayfields were on state land and were surrounded by prime nesting cover. We searched three hayfields totaling 41 acres during the last week of May and found no nests or broods. Three grassland control areas adjacent to the hayfields totaling 175 acres were searched and we found three active prairie chicken nests and one brood. The present practice of mowing hayfields after July 15 (even later would be better) leaving the cover short makes them less attractive to nesting hens the following spring. In eight years, based on nest dragging and radio telemetry - we have never found a radio-marked hen nesting, or with a brood in a state hayfield. We suspect that the size of the hayfields on Buena Vista could be expanded. These fields are currently used as partial payment for the planting of food plots. However, the sharecroppers would like to take the hay earlier so it would be of better quality. This would be workable based on what we know as the impacts on chickens would be even further reduced if these fields were mowed three times a season with the third time in late August. This would limit re-growth so the cover would be too short for nesting the following April. Unfortunately we were only given permission to conduct this experiment for one year as there was concern that the cable chain dragging was disturbing the nests of other grassland birds.

Since the start of this study, we have found numerous dead prairie chickens that have probably collided with the electric distribution wires that run along the sides of roads and highways. Wire mortality is the most common accident that befalls prairie chickens and can be rather dramatic. Ligon (1951) reported high mortality to prairie chickens when the first telegraph wires went up along the railroad in New Mexico. He further stated: "the great number of chickens killed by hitting the new wires provided a ready supply of meat for construction workers." In Wisconsin, of 713 birds found dead at least 46 (6.5%) were suspected of colliding with electric transmission wires. The suspected mortality rate ranges from 4 -14% of our radio-marked birds in any given year and was highest in years with a snow cover.

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We have found birds suspected of colliding with wires in every prairie chicken area in the state of Wisconsin except Leola and every state we have worked in as well. This type of mortality appears to be directly related to density or miles of wire in the area. Wisconsin, with the highest density of wires also had the highest mortality rate. Within the Wisconsin prairie chicken range, the Buena Vista has the most wires and highest mortality rate in the state. Leola has only one short open stretch along the road and none along any of the grassland reserves. In Minnesota between 1996-2003 we found only three birds that we suspect had died due to collisions with electric distribution wires. This type of mortality does not appear to favor any sex but is biased towards immatures.

Wire collisions occur year-round but are rare during the summer months (May - September) when birds are less mobile because they are molting and do less flying. Wire collisions occur October through April and peak in January. This is the period when prairie chickens are most mobile as they shift to and from wintering areas. Snow covers food, which at times forces chickens to adjust feeding, and roosting patterns. These shifts to unfamiliar areas make birds more likely to collide with wires. What is most surprising is that a radioed bird can fly between a night roosting area and a feeding area negotiating wires countless times. Then, one day for no obvious reason it collides with a wire and is found in good condition dead on the road or in the ditch bank.

Electric transmission wires with the large "H" type towers are not common in either the Wisconsin or Minnesota study areas but are present. They are much higher than distribution wires making it less likely that birds would collide with them. We have found only one dead bird under such wires and that was in Wisconsin. But we admittedly have not searched for the remains of birds under and around them to any degree.

Superficial examination of collision sites indicates that they are typically open stretches of wire that run between a feeding area(s) and night roosting areas. The presence of trees under the wires appears to limit collisions as it causes birds to fly higher as they approach the wire. Prairie chickens must see wires because at times we often see individual birds adjust flight patterns to go between, or rise over the wires, sometimes doing so at last minute. We believe that birds collide as a result of confusion, when taking flight, or when in a loose flock and as they fly single file. In the latter case one lead bird adjusts to wires and the one following it (literally tailgating) does not have time to adjust and collides with the wire. We have seen prairie chickens fly under, over and between wires. We have only witnessed five birds collide with wires in seven years. Two were thought to be due to confusion as they were flushed by an automobile and the other two were the result of one bird closely following behind another. Three of these birds were not killed by the collisions but suffered broken wings and had to be chased to capture them.

We also observed one bird collide with wires, fall to the ground and then fly off apparently unhurt. If we hadn't actually seen these collisions, none of these prairie chickens would ever have been found and/or known to have collided with wires. The typical scenario is that we find a dead bird intact either in the road or along the roadside. We also find dead radioed prairie chickens in the ditch adjacent to the road or within 100 meters of the wires. Without radios, these latter birds and those in the road ditch would not be found.

Out of curiosity, using a dog in October 1997, we searched under and on either side (100 yards) of 3.0 miles of electric distribution wires and found the remains of three prairie chickens in the grass either under, or within 50 yards of the wires. Two were intact and one had been fed upon by a raptor. It is thought that all three were killed when they collided with the electric distribution wires.

It is likely that we underestimate the percentage of mortality due to wire collisions and that it is a significant mortality factor where there is a high density of wires along roads. It is possible that only one-third of the birds that collide with the wires are actually being found. We feel that our radio-marked estimate is best but it too is likely a minimum estimate as we have no idea how many wire-killed prairie chickens are taken away by scavengers and never found.

Wire mortality can be relatively high. In 1998-99, we found seven birds dead (three radioed) along a 3-mile stretch of wires, 2 miles of which are along the grassland reserves. Prairie chickens have been found along these lines by the Hamerstrom's and WDNR personnel since they were put in, and by this author in 1972. This stretch of wire runs north south on the west edge of the Buena Vista along County Highway F all the way to Highway 73. In 1999-2000, we found only one bird, (radioed) along this stretch. The difference in collisions and mortality between years was more snow in 1998-99 and more important, a patch of standing corn adjacent to these lines that was purchased for use as a food plot by WDNR. The location of this food plot made it necessary that the chickens fly over the wires as they moved between their main night roosting areas and the food. Three miles of these wires were taken down on February 13, 2003 and put underground and we have not found a bird dead near this road since.

We have also found two radioed birds dead beneath three-stranded barbed wire fences that apparently collided with the wire. As with electric transmission wires, we suspect that we do not find all the birds that collide with fences either. However, we feel that the incidence of 4-14% of the radioed birds colliding with wires is a realistic minimum. In Wisconsin, this could mean the loss of 100 to 200 healthy birds every year.

This type of mortality was also reported by Toepfer (1988), and occurs throughout the range of the greater prairie chicken in Wisconsin and the U.S. Don Wolfe of the Sutton Avian Research Center in Oklahoma has also reported concerns about wire collisions. Collisions with electric distribution wires and fences are likely a significant mortality factor to prairie chickens and prairie grouse in general.

Wires are a factor locally when they are present in certain situations and widespread when there is a high density of them throughout the range. One solution is to put colored visual markers on the wires to make them more visible. The long-term solution would be to request that all new power lines within the greater prairie chicken range or at least those in high use areas be buried. In addition, food plots should not have wires along their borders nor be in places where prairie chickens have to fly over the wires to reach them.

Disease

One hundred and seventy-four blood samples from prairie chickens have been analyzed for disease exposure by Dr. Joanne Paul-Murphy at the School of Veterinary Medicine, University of Wisconsin, Madison. The samples were collected from prairie chickens in Wisconsin, Minnesota and North Dakota during the period June 26, 2000 to March 29, 2001. Samples were taken from cocks and hens and young of the year at least 8 weeks of age. The samples have been tested for antibodies indicating exposure to the following diseases: Salmonellosis (Salmonella typhimurium), Mycoplasma gallisepticum Mycoplasma multocida and Avian Cholora (Pastinella mitooda). All the samples tested so far have been negative. One hundred and forty-two samples from Wisconsin and Minnesota prairie chickens for 2002 are currently being tested for New Castle disease, Avian Influenza, Infectious Bursal, Infectious Bronchitis and West Nile virus.

We also provided blood samples from prairie chickens from Minnesota, Wisconsin, Nebraska and North Dakota to the Sutton Avian Research Center in Oklahoma for analysis for reticuloendotheliosis virus (REV) or "bird AIDS" and all tested negative (Wiedenfeldt et al. 2002). REV has been found in the endangered Attwater's prairie chickens in Texas and is a threat to the captive breeding flock. Individuals that test positive have to be destroyed or quarantined. In 2002 and 2003, West Nile virus was detected in Attwater's prairie chickens at the Houston Zoo and at Texas A & M. At this time, there is no evidence that West Nile virus causes mortality in prairie chickens. West Nile virus arrived in Wisconsin and Minnesota during the summer of 2001 and we have observed no increase or any unusual mortality in our monitoring of a sample of several hundred radio-marked prairie chickens during the summers of 2002 and 2003. The rapid movement of West Nile virus from the southern to northern states and its spread by mosquitoes is a warning of just how rapidly a disease can spread and how easily prairie chickens could be threatened by a disease.

Our research suggests that at this point in time, diseases and parasites do not appear to present a threat to the well being of Wisconsin prairie chickens. The greatest potential for introducing disease to prairie chickens will likely come from pen-reared ring-necked pheasants (Phasianus colchicus) from shooting preserves; especially where pen-reared birds are indiscriminately released by private citizens. The potential for a disease to be passed from ring-necked pheasants is ever present as pen-reared pheasants are regularly released in the prairie chicken management areas.

The presence of rock doves (Columba livia) and the dramatic increase in sandhill crane (Grus canadensis) and wild turkey (Meleagris gallopavo) numbers in central Wisconsin could be cause for concern. Rock doves and turkeys feed in the agricultural fields used by prairie chickens, and cranes use both the grasslands and agricultural fields used by prairie chickens. The potential for introducing new exotic parasites and/or diseases that could infect and impact prairie chickens is high. The sandhill crane, which is migratory and winters in Florida (Toepfer and Crete 1978) has greater exposure to diseases and parasites and will present the greater threat to prairie chickens. The dramatic build up in snow geese (Chen caerulescens) in Texas is thought to have introduced the European round worm to the environment and to the Attwater's prairie chicken. The potential for prairie chickens to be exposed to an exotic disease and/or parasites through other species is high and the situation warrants watching.

Genetics

The majority of greater prairie chickens in Wisconsin are currently found in four management areas that are 6 to 37 miles apart. Despite their close proximity, population genetic analyses using microsatellite DNA (6 loci) indicate that there is significant genetic subdivision among the four contemporary management areas (Johnson et al. - in review). In contrast, there was no genetic subdivision in the same four areas using samples collected 50 years ago by Fred and Frances Hamerstrom (Johnson et al. - in prep.). These results suggest that further habitat fragmentation and isolation of greater prairie chicken populations within a relatively small area has helped reduce contemporary levels of genetic variability by decreasing the number of individual birds breeding in the total population and stimulating the effects of genetic drift within existing management areas.

The absence or reduction in gene flow among management areas has reduced the total number of birds contributing to the next generation in the total population. As such, this has allowed the reduction of genetic variability through genetic drift (Templeton et al. 2001, Frankham et al. 2002). A historical comparison between the genetics of prairie chicken wings collected by the Hamerstrom's from hunters on the Buena Vista in 1951 with blood from the birds caught 1997-2000 indicated that there has been a 26% reduction in microsatellite DNA allelic composition since 1951 (Bellinger 2001, Bellinger et al. 2003). In addition, a comparable reduction in allelic composition has occurred in the remaining three management areas (Mead, Paul Olson, and Leola) using samples collected between 1951-1954 compared to contemporary samples (Johnson et al. - in prep.).

Likewise, when compared to other contemporary populations (i.e., Kansas, Nebraska, Missouri, and Minnesota) throughout their current range, microsatellite and mtDNA diversity is significantly lower in Wisconsin (Johnson et al. 2001, Johnson et al. - in review). Just fifty years ago, haplotype diversity in Wisconsin and its respective subpopulations was higher (0.900), and levels were comparable to present day populations in Nebraska (0.900-0.968), South Dakota (0.958) and Kansas (0.858). However, today prairie chicken subpopulations in Wisconsin have lost a significant number of haplotypes. The number of mtDNA haplotypes has declined from 23 in 1951-1954 (sample size = 73 birds) to 7 in 1998-2000 (sample size = 80), and haplotype diversity in Wisconsin has declined from 0.900 to 0.641 (Johnson et al. - in prep.). Fig.7.

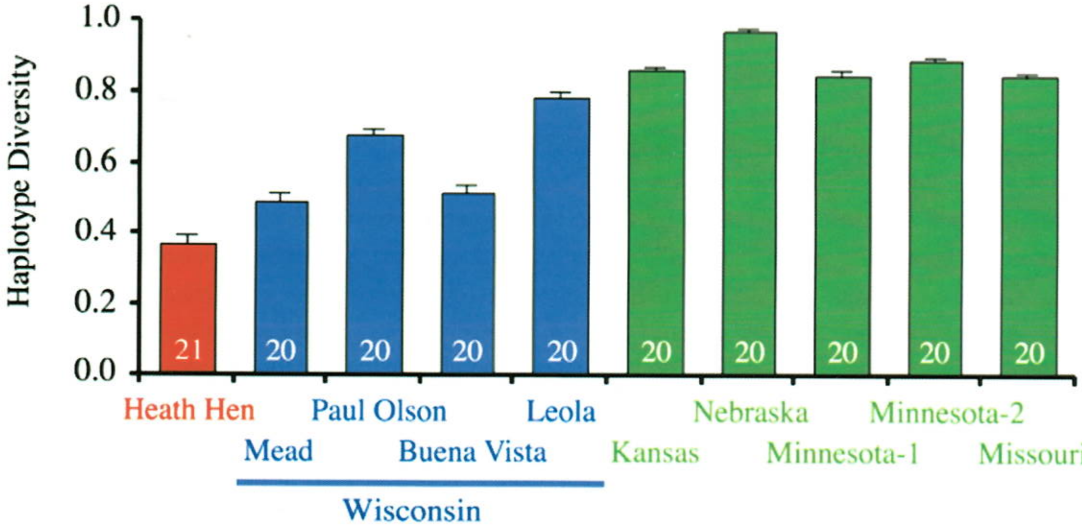

Figure 7. Population mtDNA control region haplotype diversity. All samples are from populations collected between 1998-2000, with the exception of the extinct Heath Hen population collected from Martha's Vineyard, Massachusetts between 1890-99. Population sample sizes (*N*) and standard error bars are indicated for each population. *N* is the number of individual samples used per population to quantify haplotype diversity for each population.

The above data indicate that the Wisconsin population has reduced levels of gene flow among management areas and consequently each management area has been exposed to genetic drift raising concerns that the population has lost genes related to fitness (Wright 1969, Lande 1998, Reed & Frankham 2003). The greater prairie chicken population and respective subpopulations in Wisconsin today exhibit the lowest haplotype diversity of any population in the US; while the number of haplotypes for the Mead and Paul Olson are comparable to those of the extinct Heath Hen using museum samples collected between 1891-99 (3-4 versus 4 haplotypes; Johnson et al. - in prep.).

A recent nationwide comparison of greater prairie chicken genetics indicates that historically, the range of the species was contiguous and interconnected as one large metapopulation (Johnson et al. - in review). This comparison further indicates that contemporary populations have become geographically fragmented and genetically isolated. However, despite isolation and fragmentation, Wisconsin and Illinois are the only populations that have documented reduced levels of genetic variability to date (Bouzat et al. 1998a & b, Westemeier et al. 1998, Bellinger et al. 2003, Johnson et al. - in review). These results further support that population subdivision/reduced gene flow and subsequent reduction in the number of breeding birds among management areas in Wisconsin has stimulated a reduction in genetic variability. Therefore, given that Wisconsin's management areas are subject to similar environmental effects due to their close proximity to one another (Hamerstrom and Hamerstrom 1973, Anderson and Toepfer 1999), population subdivision in combination with reduced genetic diversity is likely to decrease population persistence (Lande 1998, Templeton et al. 2001).

The first step towards reestablishing genetic variability in Wisconsin will be to reconnect the management areas and create a single population without restrictions to gene flow throughout the entire area. This will necessitate the establishment of a permanent grassland corridor between Buena Vista/Leola and Paul Olson/Mead and the

Outlying areas. In addition, in order to maintain genetic diversity and avoid the creation of a "zoo population" similar to Illinois, at least 28,000 acres of permanent grassland habitat will have to be added into the former range away from the Buena Vista/Leola subpopulation. It is further recommended that management practices be implemented within the existing management areas that will increase prairie chicken numbers and density to the point where a larger portion of the birds will likely disperse into newly acquired/protected habitat on their own.

As part of the project, Prairie Chickens & Grasslands: 2000 and Beyond (PCG2B), U.W. - Milwaukee researcher and STCP Fellow Jeffery Johnson is in the process of completing a range-wide genetic analysis of the prairie chicken populations across the country. Thus far, based on the genetic analysis of Wisconsin prairie chickens occurring in the outlying areas and at Mead, it is clear that these subpopulations may soon be lost. Considering this fact and what we now know about the genetics of the extinct Heath hen in the years prior to its disappearance as well as what we know about the genetics of the few remaining Attwater's prairie chickens, it may be prudent to begin the introduction of new genes into Wisconsin's population (translocations) while we still have an opportunity and before we reach a similar downward spiral.

To prepare for this likely possibility, we must begin genetic and disease analysis of likely translocation sources from outside the state so the necessary scientific groundwork will be laid if/when translocations are initiated. The genetics work is continuing and PCG2B has been involved in examining the genetics of the isolated greater prairie chicken populations on the Sheyenne National Grasslands in North Dakota. As a beginning to translocating birds, genetic analysis of progeny is currently underway in two states where translocations have occurred. In Illinois, birds from other states (KS, MN, NE) were brought in with the aim of improving genetic diversity and increasing a very small remnant population (Westemeier et al. 1998, Westemeier, et al 1999).

Illinois translocated birds from Minnesota, Kansas and Nebraska into its population between 1992-98, years before they had any genetic information. The release of these birds has obviously improved the situation as the cock count in 2003 was up to 82 from a low of 19 cocks in 1992. Initial analysis of Illinois genetic samples collected from 26 cocks in March 2003 show that genetic variablility is now 0.887 and the number of haplotypes 8 (Johnson, Toepfer and Dunn unpubl. data). The contemporary Illinois blood samples are currently being analyzed by Bouzat so they can be compared with his earlier work (Bouzat 1998a).

Likewise, genetic analysis is underway to determine what the results have been in North Dakota where greater prairie chickens from other states (South Dakota, Minnesota & Nebraska) were reintroduced into formerly occupied range with the aim of restoring an extirpated population. Finally, in a cooperative research effort with the USFWS Attwater's Prairie Chicken National Wildlife Refuge, PCG2B has been involved in the genetic evaluation of historical and contemporary samples collected from Attwater's prairie chickens.

These data will provide critical background information as to where greater prairie chickens for translocation into Wisconsin should come from and what effect these translocations will have on genetic diversity. However, before any greater prairie chickens are translocated into Wisconsin from outside sources, real world field experiments utilizing Wisconsin birds translocated to another state should be conducted to determine directly/exactly what these genetic infusions/mixes will yield.

We also need to closely monitor the remaining subpopulations in the state so we will know if/when some measure of fitness indicates that the population is experiencing inbreeding depression whereby genetic introgression (i.e., translocations from outside Wisconsin) will be deemed necessary.

This raises the question as to what effects the decline in genetic variability and haplotypes has had on the Wisconsin population. We have not found any evidence of a reduction or decline in egg hatchability in prairie chicken eggs in Wisconsin similar to Westemeier et al. (1998). However, the collection of these data are not easy to obtain and get a precise measure (see section on brood rearing/recruitment). It is also likely that Wisconsin is at or near the point where Illinois was in 1972 when they had several hundred cocks. Wisconsin currently has approximately 270 cocks on the Buena Vista. There are signs that do raise concern. The number of chicks fledged per radio-marked hen in Wisconsin has declined over the past twenty years and is lower than that for other states (see section on recruitment). There are also several phenotypic expressions that suggest physical changes over the past 50 years that are likely associated with changes in genetic variability.

Mean pinnae length for cocks has declined over the past 50 years from 7.8 cm (n = 111) in the early 50's, 7.8 (123) in the 1960's to 7.6 (n = 123) in the early 1970's to 7.4 (n = 235) in the early 1990's. Hens have also shown a decrease in pinnae length from 4.0 cm (n = 74) in the 1950's to 3.7 (n = 126) in the 1990's. Likewise current Wisconsin mean pinnae lengths (centimeters) are less than those for greater prairie chicken cocks in other states (Kansas 7.9 n = 12, South Dakota 7.9 n = 17, Nebraska 7.8 n = 20, and Minnesota 7.8 n = 109). All of these populations have much higher genetic variability than any of the subpopulations in Wisconsin.

One thing is certain and that is genetic variability in Wisconsin greater prairie chickens is low, and it will either remain the same or will continue to decline until the effects are more obvious. It is not a question of if this will happen, but rather when, and the solution will be to introduce new genes from a healthy populations with a higher genetic variability.

Parasites

Morgan and Hamerstrom (1941) found that 43.6% of 22 Wisconsin greater prairie chickens contained internal parasites. The examination of 34 frozen and thawed greater prairie chicken carcasses examined between 1996-2001 found that only 7 (20.6%) contained internal parasites. Some parasitologists consider frozen carcasses biased as some parasites can be destroyed in the freezing and thawing process. In our examinations of non-frozen carcasses, one of seven (14.3%) adult birds examined contained internal parasites. Thus the frozen sample referred to above would appear to be representative. The overall incidence of internal parasites was 19.5% (8/41).

Overall, there appears to have been a decline in the internal parasite loads in greater prairie chickens since the 1940's. A likely explanation is that the numbers of intermediate invertebrate hosts have been reduced by pesticides and hence the birds are exposed to fewer parasite eggs and consequently have fewer internal parasites.

This general survey was conducted byAlexis Priddy under the supervision of Dr. Steve Taft, Department Biology, UW-Stevens Point. Three taxa were identified: Nematoda in 2 of 41 (4.9%), Cestoda 4 of 41 (9.8%) and Trematoda 2 of 41 (4.9%). Gizzard worm (*Dispharynx nausta*) and Gape worm (*Syngamus trachea*) were found in two different adult birds. During the summer of 2001 tests with throat swabs using InPouch ™ Tritrichomonas Foetus test kits for Trichomonas gallinae were negative for both adults (n = 35) and chicks (n = 22) tested in central Wisconsin. Internal parasites do not to appear to present a threat to the well being of Wisconsin prairie chickens at this point in time.

A total of 3,821 birds were checked for ticks in Wisconsin and Minnesota between 1996 and 2003. This involved checking the head and neck of captured birds for ticks by feel to detect a tick, or a nodule where one had been attached. Overall incidence was very low as only 13 (0.03%) had ticks present (Range 1-10) and all ticks were found during the five- month period June through October. Only one tick was found in Minnesota and that was found in June on a cock captured on a booming ground. Ticks were found on only 12 (0.05%) individuals in Wisconsin (1 adult cock, 5 adult hens, and 6 chicks). The incidence was higher on chicks than adults. All of the birds in Wisconsin found with ticks except one hen were found near the SERR booming ground. Why ticks were limited to this area is not known. During the period of known presence, incidence was 1.1% and 0.14% in Wisconsin and Minnesota. Two genuses, Haemahysalis and Ixodes were identified....Ixodes in Minnesota and both genuses in Wisconsin. Four of the chicks had both genuses present. The only other external parasite documented on prairie chickens were biting lice (Mallophaga), which were common on birds during spring and summer but no measure of incidence, or infestation was attempted.

Pesticides

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There has been little work done on the impacts of agricultural pesticides on prairie chickens; this despite the fact that they spend much of their time in or around agricultural fields. We collected blood from prairie chickens in central Wisconsin and Minnesota to examine pesticide exposure using cholinesterase depression (Mineau 1991). Cholinesterase analysis was conducted by the USGS at Patuxent Wildlife Research Center. Results indicate that greater prairie chickens, especially cocks, are being exposed to the organophosphate and carbamate insecticides. Cholinesterase levels from prairie chickens sampled during the summer of 2000 indicate that 39.4% of 89 birds (50 cocks, 29 hens and 10 juveniles) in Wisconsin and 25.0% of 32 birds (16 cocks, 10 hens, and 6 juveniles) in Minnesota showed signs of being exposed to some type(s) of carbamate and/or organophosphate cholinesterase inhibiting insecticides (Tredeau et al. 2000, Fairbrother et al. 1989, Smith 1987). Exposure appears to impact cocks (Wisconsin = 49%, Minnesota = 43.5%) and Wisconsin and Minnesota juveniles (100% and 33% respectively) more than hens (Wisconsin = 10.3%, Minnesota = 10.0%).

The latter makes good biological sense as cocks are still displaying in agricultural fields during May and June when spraying starts and many spend the whole summer in soybean fields. However, there are questions as to whether values for juveniles are valid, as cholinesterase levels may vary with age in juveniles (Fairbrother et al. 1989).

There were several "hot spots" on the Buena Vista and Mead where over 70% of the birds sampled (based on blood samples) appear to have been exposed and affected by pesticides. We have observed on numerous occasions in both Wisconsin and Minnesota the actual ground and aerial spraying of radio-marked prairie chickens while in agricultural fields (soybeans, wheat, potatoes, corn, carrots, sunflowers). There is no doubt that prairie chickens are being sprayed by these agricultural pesticides. Yet we have not found any odd behavior, sick radio-marked prairie chickens or mortality that we can associate directly with the spraying of agricultural fields.

Previous pesticide work on the Buena Vista on brain cholinesterase levels collected from grasshopper sparrows (Ammodramus savannarum) indicated that levels were depressed and dropped as the spraying season advanced (Deeley 1980). They also found that aerial spray from adjacent agricultural fields was drifting at least a half-mile into the grassland reserves.

In 2001, we washed the feet and lower legs of prairie chickens with a toothbrush and an ethanol wash (Gervais et al. 2000, Buck et al. 1996, Hooper et al. 1989) to check for pesticide residues. A total of 115 recaptured radio-marked prairie chickens were foot washed; 43 birds (14 cocks, 18 hens, and 11 chicks) in Wisconsin and in 72 birds (6 cocks, 21 hens, 45 chicks) in Minnesota. Foot washing was done from August 5 to December 20 in Wisconsin and from July 24 to October 4 in Minnesota. Twenty-nine of the Minnesota birds (67.4%) and 35 (48.6%) of the Wisconsin birds were known to have been regularly feeding in agricultural fields before they were captured. The cocks sampled in December were captured on a booming ground in a plowed potato field.

The foot washings were analyzed by the University of Wisconsin - Stevens Point, College of Natural Resources certified Environmental Task Force Lab. The analysis was conducted using a Varian Saturn Ion Trap chromatograph/mass spectrometer (GC/MS). The samples were scanned from 45-450 atomic units (amu) for a period of 45 minutes while the sample eluted from the GC. Samples were evaluated for nitrogen and phosphorus containing pesticides, organophosphorus and organochlorine containing pesticides.

Surface soil samples from four agricultural fields in central Wisconsin regularly used by radio-marked birds were analyzed in same manner as the foot wash. The following compounds were found at levels of 10 ug/kg or higher: Alachlor, Atrazine, Metolachlor, Metribuzin, Pendimethalin, Trifluralin. Alachlor and Atrazine were the only compounds found at all four sites. None of these compounds were found in the foot wash from birds captured at these or other agricultural or grassland sites.

Significant amounts of DDE were found in the foot wash of three birds from Minnesota. These samples were considered contaminated and it was concluded that the organochlorines came from the DEET in the insect spray that trappers we putting on their hands to repel mosquitoes. None of the other foot wash samples contained compounds that would raise any concerns for the well being of the birds. Five plastic bands removed from two-year old birds that contained residue inside the coils were analyzed in the same manner as the foot wash and no pesticides were detected.

In the book, Cholinesterase-inhibiting Insecticides: Their Impact on Wildlife and the Environment, Mineau (1991) stated: "Cholinesterase measurements will therefore provide us with a probabilistic assessment of impact rather than an absolute one. It is best to look at cholinesterase as one component of a battery of impact assessment techniques that also includes the monitoring of reproduction and survival. If, however, biological impact data are unavailable, (or even if some data exist but they are largely negative), but the cholinesterase field data indicate extensive cholinesterase depression in a large segment of a valuable non-target population, then, in my opinion, prudence requires that the pesticide use in question be viewed with some alarm and that regulatory action be implemented to reduce exposure."

We now know that a portion of the prairie chickens in Wisconsin and Minnesota are exposed to agricultural pesticides. What if any effects these chemicals have on prairie chicken health, survival and reproduction is not known at this time. However the high exposure rate of cocks indicates that the situation warrants watching.

Urban Sprawl

Since 1996, one hundred and twenty-one new homes have been constructed in the Paul Olson Wildlife Area. This is an average of 20 new houses per year or about one new house per square mile. These developments and single houses eliminate grasslands and restrict open space. The Paul Olson Wildlife Area contains approximately 1,784 acres of state owned land of which 1,350 acres consist of grassland/sedge reserves. The threat of housing

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developments and urbanization is greatest on Paul Olson and in the Outlying Area but new houses have recently begun to show up on the Buena Vista and Mead Wildlife Areas. The only way to protect these open grasslands from development is through easements or purchase. Over the past ten years numerous parcels consisting of thousands of acres of potential prairie chicken habitat have been bought and sold on the Paul Olson and Outlying areas. A total of 420 acres have been purchased by WDNR.

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Of special interest is a booming ground we located with 14 cocks in 1996 called Rothwell which was along County Highway V, about a mile south of Spencer. This booming ground was adjacent to a 220-acre patch of open grass/forb habitat. For the next year this adjacent area was used by radio-marked birds for loafing and night roosting. In 1998 however, construction on what was to become a 12-unit housing complex was initiated on this property. As construction progressed, the Rothwell booming ground began to decline and by 1999, only a single radio-marked cock remained. This bird abandoned the area that year and moved 3.5 miles to the northwest. He survived for at least six and a half years as he was captured as an adult in 1997. He was affectionately referred to as "the survivor".

In view of the declines in the Outlying Areas between 1991-2003, this has probably been a common occurrence; especially where there are no permanent grassland reserves and chickens are dependent upon habitat on private lands. One need only look at how urbanization and industrialization has affected the Attwater's prairie chicken to see how slow but steady land use changes can spell disaster for an isolated population of prairie chickens (Chadwick, 2002).

Wind Generators

In a recent publication titled: Ecology and Management of the Greater Prairie Chicken from the Oklahoma Cooperative Extension Services, Oklahoma State University (Bidwell, editor), concerns were raised about the impacts of wind generators on prairie chickens and grassland birds. There is no doubt that a large field of wind generators is going to have an impact simply because of the space they occupy. Other than the vertical structure, the impact would be similar to a plowed field where grassland habitat has been removed. In northwestern Minnesota southeast of Felton, there is a complex of three wind generators on the beach ridge. There are six booming grounds with a total of 144 cocks within 2.0 miles of this complex. One booming ground with 26 cocks is only 0.61 miles north of the towers. I have personally seen single birds, and small flocks of 20 prairie chickens, (some radio-marked) fly along side and between the towers and blades. When in agricultural production, the chickens fed in this field between the three towers. We have also had two radio-marked cocks from the nearest booming ground day loaf in the grass in the shadow of the towers.

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Attempts to reseed the area between the towers were initiated in 2002. That year, two hens raised broods within a quarter mile of the towers. During the 2003 breeding season we had two hens nest within 0.25 and 0.33 miles of the towers. Interestingly, since the fall of 2000 when the towers were put up, the population of prairie chickens in this area has increased 75%.

This wind generator complex is small and isolated. Other than the towers being an eyesore to some, the impacts on prairie chickens have yet to be seen. However, there are other wildlife related problems associated with wind generators and their economic returns have also been questioned. The expansion or further development of this field or other large fields in grassland occupied by chickens would likely impact the population as it would take up more grassland and become more intimidating. It is possible that rather than a large field of wind generators, a series of three smaller complexes scattered over the landscape could be placed to reduce impacts on grassland and grassland wildlife. What is true in Oklahoma concerning prairie chickens and wind generators may not be true in Minnesota. It would seem that the prairie chickens in this area have adjusted to these three towers and turning blades as long as the surrounding grasslands were not affected.

Dog Trials

Hicks (1992) studied the effects of dog-induced disturbances on sharp-tailed grouse in Manitoba and suggested that dog training activities have a negative impact on chick survival. However, the study design was weak because there were no marked birds used. The problem is thought to be that too many dogs are worked too often on hens with broods. Dog trainers prefer to train dogs, especially green dogs, on young birds as they are more numerous at this time of year and they hold well.

In northwestern Minnesota where we have worked extensively there is little dog training because much of the grassland is private. The Buena Vista on the other hand consists of large blocks of publicly owned land which is attractive to dog trainers because of the density of birds and the fact that trainers can work their dogs on the same grounds where the trials are held.

Since the 1960's, pointing dog and Brittany spaniel field trials have been conducted on the Buena Vista grasslands during September. The pointer trials are held annually and the Brittany trials every other year. We have no information indicating that the actual field trials have a negative impact on prairie chickens nor are we suggesting they do. However, there are concerns that training beforehand during the summer in preparation for the field trials could have an impact on young broods produced from re-nests. A few re-nesting hens (18%) do not hatch their eggs until July and some eggs hatch as late as July 15. This means that on August 1 when dog training begins on the Buena Vista, some broods will be only 2-4 weeks old. This August 1 date could be too early as dog trainers may be flushing and breaking up these young broods. The concern for the population here is that late broods could be impacted by dog training. And in a small isolated population, where survival and recruitment are especially important, any activities that could adversely impact the population should be examined.

We also flush broods at night for capture, recapture and radio-marking and have documented little mortality nor brood abandonment associated with our trapping activities in Wisconsin, Minnesota, and North Dakota. In broods we monitored during the period when dogs were being trained (broods with at least one radio-marked chick) we found no decline in brood size or mortality. It should be pointed out however that these radioed chicks were from first hatches and 6-10 weeks old. As a result, for these birds, the decline in brood sizes or loss of chicks occurred before we began trapping, before dog training commenced, and well before the dog trials were held.

At this time, there is no evidence that dog trials or dog training as they currently occur on the Buena Vista in Wisconsin have a negative impact on prairie chickens or chick survival. However because dog trainers prefer to work their dogs on broods there is potential for problems. It is common knowledge that most dog trainers know where broods are and they communicate the location to other trainers. If too many dogs are worked too often on the same broods problems will develop. The August 1 date allowing dog training should be reconsidered and moved back to August 15.

Habitat Model

GIS - Landscape Patterning

The WDNR with matching funds from STCP as a partner spent over seven years developing a GIS landscape data-base of greater prairie chicken habitat in central Wisconsin. The data-base contains booming ground locations and land use patterns within the prairie chicken range, but primarily for the Buena Vista and Leola. Portions of the database however lack information regarding land use on private land. It also does not contain single trees or small patches that are critical in evaluating the quantity and quality of open space and determining whether landscape habitat types are savannas or grassland. Finally, some of the booming ground locations are incorrectly located. A GIS database needs to be as accurate as possible and omissions and errors need to be corrected by field people familiar with the area and booming grounds. This has also been a concern with some of the GIS analysis that has been conducted in Minnesota (Whitmore 1996, Merrill et al. 1999, Anderson and Toepfer 1999).

One of the objectives of this project was to develop a habitat model for prairie chickens. Models are mathematical representations of biological or ecological systems. To be truly valuable and useful, habitat models need to be kept current to reflect habitat changes and population trends.

There have been several models generated for prairie chickens, most recently Merrill et al. (1999) and Neimuth (2000 and 2003). Both examined the habitat patterns within about a mile of a booming ground and compared habitat to random points. This type of model is not new. The original model and format was developed over 30 years ago on sharp-tailed grouse in Saskatchewan by Pepper (1972). He found that acreage of hayfields and ungrazed natural grass-shrub within each of the one-mile radii around dancing grounds were correlated with the number of males. However, he pointed out that if the area around a dancing ground lost suitable habitat, it might not subsequently be abandoned but instead would decline over two or more years. The presence of a prairie grouse lek along with the number of cocks present may or may not be an index to habitat quality and would depend on the population trends of that particular lek. In following, the number of cocks on any given booming ground location in any given year may be in decline due to habitat changes.

Niemuth (2000) conducted a one-year analysis of habitat in the central Wisconsin prairie chicken range and indeed at least seven of the booming grounds he used in Northern Range have since moved or no longer exist. Yet much of the grassland habitat especially the undisturbed wetland areas are still present. Now would be an ideal time to redo Neimuth (2000) using historical booming ground locations to see what has changed and why these grounds disappeared. Was it changes in habitat or something else?

The basic local habitat model for prairie chickens is still Hamerstrom et al. (1957). This model states: "total grass appears to be a rough index to habitat quality, densities increase with increasing amounts of permanent grassland, densest populations are associated with 55-60% or more grassland, and at the low end lingering populations at 10-15%."

Habitat models are valuable in the sense that from time to time they refocus our attention on the needs of a species. But everybody is looking for one magic bullet that will answer all our habitat questions when in most cases we already know the basic answers. With waterfowl it is wetlands and grass and with prairie chickens it is open space and lots of grassland. One concern is that Neimuth (2000) indicated the minimum area for management within an agricultural landscape should be about 7 square miles. It is a start, but still way too small as annual home ranges of some radio-marked birds are larger than this (11 square miles). The size of management areas has been discussed by many authors (Grange 1947, Ammann 1957, Kirsch 1974, Westemeier and Gough 1999) and today in hindsight, all are much much too small. The Buena Vista/Leola complex currently totals 173 square miles and Paul Olson 281 square miles and both have reduced genetic variability - the 7 square miles indicated above is too small for an isolated management area. At this time, Minnesota with its long and narrow range (Svedarsky et al. 1997) has maintained its genetic diversity through several bottlenecks and its range is approximately 3,000 square miles. In Minnesota we had a brood of four radio-marked chicks from one brood disperse over an area of over 1,000 square miles. Is 3,000 square miles large enough to maintain a long-term genetically viable greater prairie chicken population?

In Toepfer et al. (1990) we proposed a simple model based on 100 to 125 cocks that said the minimum area for a reintroduction release site was about 10 square miles with one-third of the area in undisturbed grassland habitat. At that time we were ignorant of genetics, the current genetic state of prairie chicken and the problems associated with isolated populations (Johnson et al. 2003). But today we understand that 100 cocks is just not enough, and that 10 square miles is much too small an area to maintain a prairie chicken population. Finally, models like all data are only of value if they are implemented; otherwise, they just become academic exercises.

The models created thus far are redundant and all indicate that grassland is the key habitat component for prairie chickens. All are based on the booming ground location and none have yet to incorporate any other aspects of prairie chicken ecology especially nesting, night roosting habitat, and survival, relative to landscape patterns. I assume that there will be many more prairie grouse models to come and all will indicate that prairie chickens are associated with open landscapes and undisturbed grassland. None have included yearly or long-term population trends nor changes in distribution or other aspects of prairie chicken ecology such as successful versus unsuccessful nests, night roosting areas, open space (treeless areas), survival of cocks, hens, and young of the year. Until these aspects of the prairie chicken are understood and included in the models, the models will be weak and will likely continue to prove again and again that prairie chicken populations require at least 20% of the landscape in grassland cover. What we need now is a model that will tell us what the minimum area is that is necessary to sustain a viable prairie chicken population. How do we increase the number of cocks on a booming ground from 4 to 10 to 20 or 40? And from a population perspective, do we even want booming grounds with 40 cocks? Maybe it would be better to have an understanding of how to establish four booming grounds with 10 cocks instead of one with 40.

Nebraska is the closest we still have to a natural viable population of prairie chickens and is where we need to go to obtain a better understanding of the true habitat and population dynamics of a prairie chicken population. If a practical model is to be developed, this is the place to start, not in the isolated populations in acquired range.

Pheasants

The establishment of the ring-necked pheasant (*Phasianus colchicus*)is often pointed to as one of the great success stories in wildlife management. However, the subject of the effects of the introduction of the pheasant on native wildlife is rarely addressed. Early on, Leopold (1931) voiced concern for the problems that exotics might create for native wildlife and Giles (1978) provided a long list of reasons why exotics should not be released.

Among the list are: they are an admission of defeat in managing native species, they are expensive, an evolutionary legacy will be lost and, do we have the right to change such legacies for future generations and the non-hunting public?

The exotic ring-necked pheasant has become a more popular game bird with the American sportsman than all the native prairie grouse combined. The reasons for this are that pheasants are easier to manage because they do not

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require as much habitat, they are easier to hunt and, they can be raised in large numbers in pens for release into the wild and for preserve hunting.

The impacts of pheasants on prairie chickens fall into four categories. First, pheasants are more aggressive and can be disruptive on booming grounds (Anderson 1969) and dominate prairie chickens in feeding areas (Sharp 1957). The second is possible transmission of diseases and parasites to prairie grouse that could become epidemic. This is of greatest concern where and when pen-reared pheasants are released into the wild in large numbers. The third is nest parasitism or the laying of eggs by hen pheasants in the nests of prairie chickens - pheasant eggs hatch at 23 days and prairie chicken's at 25. This means the pheasant eggs will hatch before those of the prairie chicken. Thus the prairie chicken will depart with the newly hatched pheasant chicks and leaving her un-hatched eggs behind. These effects have been discussed in detail by numerous authors (Vance and Westemeier 1979, Kimmel 1988, Westemeier et al. 1998). The incidence of nest parasitism by pheasants threatened the prairie chicken in Illinois to the point where pheasants were removed to reduce the threat (Westemeier 1988).

Many biologists have come to think nest parasitism by pheasants is unique to Illinois and that it is not a problem where grassland habitat is abundant and density of pheasants is low. In these cases some feel that pheasants and prairie grouse can coexist. However, Hagen et al. (2002) recently found pheasant eggs in 4% of 75 lesser prairie chicken (*Tympanuchus pallidicinctus*) nests. Pheasant eggs have also been found in a sharp-tailed grouse (*Tympanuchus phasianellus*) nest on the Fort Berthhold Indian Reservation in North Dakota (Toepfer unpubl. data).

Recent evidence from a prairie chicken reintroduction project in west-central Minnesota suggests that the rate of parasitism is much higher where pheasants are more prevalent. In this area, 37% of the prairie chicken nests (n = 19) we inspected had pheasant eggs in them. All of the pheasant eggs were removed from these nests and nesting success was 71%. Interestingly, none of four prairie chicken re-nests we located contained pheasant eggs. This was of course later in the season at a time when most hen pheasants had already hatched their eggs and were caring for broods. The presence of pheasant eggs in prairie chicken nests was also directly related to the number of crowing cock pheasants recorded in the spring further indicating that the incidence of nest parasitism is related to pheasant density.

In central Wisconsin, Minnesota and North Dakota ring-necked pheasants are not common within the prairie chicken's range. In Wisconsin, they are rare on Buena Vista and Leola but are more common on Paul Olson where we have observed pheasant hens with broods in the same night roosting areas as prairie chicken broods and adults. Cock pheasants have also been observed harassing and dominating chickens on booming grounds and in feeding areas during winter at Paul Olson. We found no pheasant eggs in the 370 prairie chicken nests we located in Wisconsin, nor in the 662 nests we found in western Minnesota.

However, there are efforts currently underway in northwestern Minnesota to increase pheasant numbers by translocating large numbers of South Dakota wild ring-necked pheasants into the southern end of the prairie chicken range (Wilkin County). In central Wisconsin efforts are ongoing to improve and add habitat for pheasants. If these projects increase the density of pheasants in grasslands occupied by prairie chickens they will likely increase nest parasitism. Such projects in prairie chicken areas should be discouraged as should efforts to re-establish prairie chickens in areas with high pheasant populations until we have a better understanding of the real effects of pheasants on prairie chickens.

Kimmel (1988) felt that nest parasitism by pheasants on prairie chickens was not a major factor where larger amounts of grassland are available. This may be true but we know very little about interactions of prairie grouse and pheasants. If we are going to have both prairie grouse and pheasants we will have to develop a much better understanding of the habitats and niche separation of these two species. In order to save prairie grouse we are going to have to understand how to manage grasslands (if possible) to keep pheasant densities low enough so they do not adversely affect prairie grouse and other grassland birds. It is my feeling that in order to save prairie grouse in North America, pheasant/prairie grouse interactions should be the number one research priority for upland birds.

The fourth impact is that an emphasis on pheasant management has taken funding away from native grassland species. If population distributions continue to shrink, the greater prairie chicken may soon follow the lesser prairie chicken and sage grouse (*Centrocercus urophasianus*) on their paths toward the endangered species list. If this happens, it will not speak well of wildlife management and the American sportsman. And, it would be the first time that a major game bird will have been given this status. Robel et al. (1970) indicated that at one time the greater prairie chicken was the number one game bird in the Great Plains.

The emphasis on pheasants by wildlife agencies and American sportsmen, while all but ignoring the native prairie grouse, could have far-reaching and drastic repercussions that may not sit well with the non-hunting public. This will be especially true if any of our native prairie grouse become federally listed endangered species. It behooves the American sportsman to not let this happen.

In 1989 I was asked to develop the first Native American Fish and Wildlife Program at Little Hoop Community College at Fort Totten, North Dakota. The College was asked to take over the Tribal Fish and Wildlife Program along with the Bison herd and subsequently put both under my direction. One of the very first items I had to deal with were students and tribal members who thought that their Tribal Wildlife Program should raise and release ring-necked pheasants to improve hunting. First, I was surprised, then curious until I came to understand that the Lakota were not aware of the fact that the pheasant was not native to North America. It's ironic, but in over 100 years the Lakota had become detached and unaware of their own wildlife heritage and instead had embraced our European heritage.

However, once the Lakota students understood that the pheasant was an exotic and realized the cost and ramifications of its establishment on native wildlife they convinced the Tribal Council that their Tribal Wildlife Program legacy should embrace prairie wildlife especially the sharp-tailed grouse. For those of us who are old enough to understand the politics, economics, and especially the history of wildlife management in North America - within this true story lies the future of the prairie as well as the prairie chicken and all prairie grouse in North America. For better or worse, like so many other exotics, the white man and the pheasant are here to stay.

Translocations

We have been involved in two translocation projects. The first one is in North Dakota at the North Dakota Game and Fish Prairie Chicken Management Area north of Grand Forks where there are over 34,000 acres of open grassland habitat; most of it enrolled in the Conservation Reserve Program or CRP.

The North Dakota project started in 1992 and the last major release was in 1998. This population has been increasing but did not start expanding until 2002. In 2003, there were 242 cocks on 24 booming grounds. However, sharp-tailed grouse are beginning to move in, and the greater prairie chicken booming grounds are now surrounded by sharptail dancing grounds. There were 203 sharptail cocks counted on 16 dancing grounds in 2003. The release methodology used in North Dakota (i.e., a summer release to initially establish booming grounds and then supplementation with the release of additional birds at established booming grounds) has reestablished a greater prairie chicken population. The status of the North Dakota reintroduced population is presented in Fig, 8.

We are now using the same methodology to establish a population at Lac qui Parle in southwestern Minnesota. This area has much less grassland habitat and much of the 10,000 - 12,000 acres is savanna. Thus far, we have succeeded in establishing seven booming grounds. However, this project is working but not as well as the North Dakota translocation project probably because the area has much less grassland habitat, more trees and woodland, and a high density of ring-necked pheasants.

We have also developed a summer release methodology to the point where we can get translocated greater prairie chickens to stay within 1-2 miles of the release site (Toepfer 1976, 1988, Toepfer et al 1990, Svedarsky et al. 2000). This is critical in establishing new booming grounds and will be important in introducing new birds and genes into existing populations. This same methodology was used to translocate birds to Illinois in 1992 and 1993 to increase genetic diversity. The addition of these birds from Minnesota and additional releases of birds

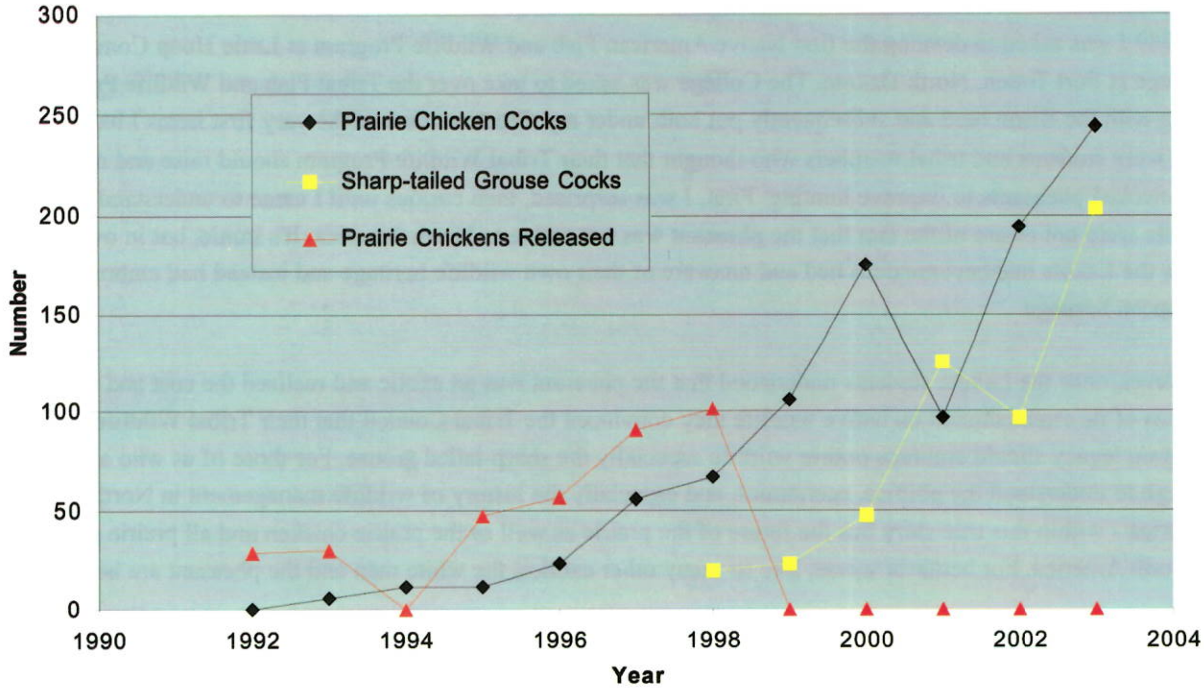

Figure 8. Prairie grouse population trends North Dakota Game and Fish Prairie Chicken Management Area, Grand Forks, North Dakota, 1992 - 2003.

In areas where the ranges of greater prairie chickens and sharp-tailed grouse overlap, hybridization between the two species occasionally occurs. Above is a displaying hybrid male greater prairie chicken x sharp-tailed grouse.

from Kansas and Nebraska to the Illinois population has apparently helped as the population increased from a low of 19 cocks (9 in Marion County and 10 in Jasper County) in 1992 to a high of 82 in 2003 (Scott Simpson, pers. comm.).

Snyder et al. (1999) in a recent review found that success of prairie grouse translocations was improved when a project was long-term, released more than 100 birds in the spring and used a soft release technique. This paper was written while PCG2B was developing the summer translocation methodology that successfully reestablished a prairie chicken population in North Dakota. The summer translocation can be considered a soft release technique.

We have now used the summer release methodology to establish small booming grounds in isolated patches of grassland habitat of just 1,000 acres in size. This approach should prove valuable in establishing booming grounds in the as yet to be developed habitat corridors between existing populations. We have now successfully released birds in late fall and had them localize with the birds established via summer releases. This creates yet another option for trapping and translocating birds to supplement these small re-established populations. Other than attempts to increase genetic diversity, the long-term goal of future greater prairie chicken translocations should be to connect existing populations and sub-populations not establish new isolated "zoo populations" or "museum populations" (Johnsgard 2002).

Management Recommendations

"Wherever one looks the answer is the same: to save prairie chickens grasslands must be preserved and managed for them. There are no substitutes". Hamerstrom et al. 1957

The contraction of the range that has occurred in Wisconsin is currently happening throughout the greater prairie chicken range. This contraction has been occurring for the past 100 years. The first to go was the Heath hen, and then the greater's in the eastern portion of the range and now the Attwater's prairie chicken. The response by wildlife management agencies to these declines was slow probably because a lack of interest by sportsmen in prairie chickens and greater interests in pheasants. Some states barely reacted to the decline of the chickens and some just took them for granted. But some states established core areas of permanent grassland reserves of high quality habitat and felt that if properly managed, they could maintain small isolated prairie chicken populations.

The fate of greater prairie chickens in Illinois, Texas, Missouri, Oklahoma, and North Dakota are in doubt today because of this core management philosophy that ignored the birds on the periphery of the range and concentrated management efforts in one or two major core areas (Westimeier and Gough 1999). This was done more by necessity and a lack of knowledge of the area requirements of a prairie chicken population. At this point in time we still do not know the minimum size necessary to sustain a viable greater prairie chicken population. However, we do know by the process of elimination that neither the Illinois population, the Buena Vista/Leola population nor the Paul Olson/Mead are large enough by themselves to sustain genetic variability comparable to prairie chicken populations with larger ranges. We should all now understand that to be successful, management would have to spread thousands of acres of grassland habitat over a landscape of several thousand square miles and maintain connectivity.

What is unfortunate is that this same core management philosophy was followed in Wisconsin despite the recommendations of Hamerstrom and Hamerstrom in 1973. The concentration of management efforts and land purchases on Buena Vista/Leola have contracted the range and ecologically and genetically isolated it from the rest of the range (Paul Olson, Mead, and the Outlying areas). Wisconsin's subpopulations have lost the connectivity that Hamerstrom and Hamerstrom warned us about in 1973. In order to succeed, greater prairie chicken and prairie grouse management both locally and nationally must become a range-wide endeavor.

In 1975, the WDNR prepared a management plan for STCP for the greater prairie chicken in Wisconsin. This plan needs to be revised and updated to reflect current conditions as they relate to changes in distribution, especially contraction of total range (50%) and contraction within the management areas as they relate to the loss of connectivity and the subsequent loss of genetic variability. Time is important so the plan should be given special status and should be treated as a Recovery Plan for Greater Prairie Chickens in Wisconsin. Most importantly, the plan and agency activities need to be examined to determine why certain portions of the 1995 version were not implemented. Unless these management problems are addressed and corrected, any future plan will fail.

Fifty years ago the Hamerstrom's recommended that: "One area, the best one should be permanently managed; management of other areas would also be desirable, but only in addition to the primary objective not in place of it". By the early 1970's, the core they spoke of had been established through land purchases and with the development of over 10,806 acres of grassland habitat on the Buena Vista and Leola. In 1973, 29 years ago, the Hamerstrom's further stated: "It is our urgent recommendation that the Carson-Sigel-Sherry area (now called Paul Olson) be put under management without further delay." They stated: "Banding data show strong interconnections between the Buena Vista Marsh (Portage County Management Area) and several outlying areas up to 25 miles away. We believe that this arrangement gives strength to each population and we reiterate our earlier recommendation that these outlying areas be put under management. Loss of the Carson-Sigel-Sherry Area would break the connection and leave Buena Vista isolated from Mead, a loss which would be more important than the mathematical number of birds in the Carson-Sigel-Sherry Area."

In 2003, we are now looking at declining populations in the unmanaged areas, range contraction statewide (50%) and on some of the management areas, a historicaland regional decline in chick survival, a lack of movement of birds between sub-populations, a loss of alleles and genetic diversity since 1951, and lower nesting success on the Buena Vista compared to other areas and private land.

All of these indicate that the immediate long-term outlook for the greater prairie chicken in Wisconsin is not good. Management practices will need to be initiated that will increase numbers and create movement between subpopulations. This means improving survival and reproduction on the management areas to increase numbers and encourage birds to move between subpopulations. This involves adding and creating more open space, cutting trees, improving food plots and reducing the amount of grassland disturbed each year to improve nesting success.

Research in Wisconsin by PCG2B indicates that the sub-populations are now ecologically and genetically isolated from each other and from other populations in the U.S. The subpopulations in Wisconsin (Buena Vista/Leola, Paul Olson/Mead and Outlying Areas) need to be connected with the development of corridors of permanent grassland reserves. The loss of alleles and low genetic diversity will have to be increased either by moving birds between subpopulations and/or by translocating birds from other states. The fact that all the subpopulaions have lost genetic variability and are the lowest in the United States means that genetic variability will probably not be improved much by moving birds within the state. The loss of genetic variability will have to be addressed by bringing birds in from another state, probably Minnesota or Nebraska.

On the landscape level the only real hope for the long-term existence of a self-sustaining, **genetically** viable greater prairie chicken population in Wisconsin is to bring in birds or connect to the Illinois, Minnesota or Iowa populations. This could involve the development of a grassland corridor to connect with the Glacial Habitat Restoration Area (31 miles) (Gatti et al 1994) or through Necedah National Wildlife Refuge and Sandhill Wildlife Area to the southern grassland complex (100 miles) being developed near Dodgeville. However, the potential of these areas for prairie chickens is greatly compromised by the presence of and current management emphasis on the ring-necked pheasant. The southern complex is only 225 and 250 miles from the Illinois and Iowa populations.

Whether these concepts are undertaken and accomplished remains to be seen. In the interim however it is now critical in 2003-04 that the WDNR and other land management agencies initiate management activities to improve the quality of existing grassland habitat and increase the amount of grassland and open space on the Paul Olson, Mead, Dewey and Outlying Areas for greater prairie chickens and other grassland species. The best recommendation I can make is to repeat the recommendation that Hamerstrom and Hamerstrom made in 1973, "we reiterate our earlier recommendation that these outlying areas be put under management".

The WDNR without delay must begin to manage greater prairie chickens in Wisconsin on a range-wide basis. This means abandoning the core management philosophy that has focused management activities and land purchases on the Buena Vista and Leola. It also will require a team approach involving numerous individuals and groups, private, state and federal. And to be successful, it absolutely must involve the expertise and input of all WDNR personnel especially the managers within the greater prairie chicken range. To continue the present management scheme will eventually create a "zoo population" that will probably lead to extirpation.

'The overall concept is very simple - reestablish connectivity between the Buena Vista and Paul Olson and add as much grassland habitat as possible within a mile of existing and historical booming grounds within the 2,077 square mile Wisconsin prairie chicken range as of 1990. A scatter pattern of grassland reserves (Hamerstrom et al. 1957) of at least 30,000 acres scattered through the Paul Olson, Mead and Outlying Areas will be the minimum amount of grassland habitat necessary to maintain a viable greater prairie chicken population in Wisconsin. The corridor will require 1,500 to 2,000 arces of grassland habitat.

The first step will be to establish grassland corridors between the Buena Vista and Paul Olson and Mead and the Northern Range within the next five years. At the same time it will be necessary to create a large island complex of grassland reserves within, surrounding and between Paul Olson, Mead and the Northern Range within the next 10 years. This number is a projection based on a model using the number of booming grounds and a ratio of 425 acres of permanent grassland cover per booming ground in 1989 on the Buena Vista. The year 1989 was chosen because of the wide distribution of booming grounds on Paul Olson/the Mead and the Northern Range.
The plan should establish minimum acquisition acreage goals as shown in Table 4.

Flexibility in purchasing or otherwise securing land will be key. Managers in prairie chicken areas should not be limited as they have in the past by unrealistic goals and property boundaries. A project boundary line should be drawn around the 1990 prairie chicken range and any land within a mile of an existing booming ground or historical booming ground should be targeted for purchase or other permanent protective form of acquisition until the total acreage goal is reached. If land goals cannot be met at Paul Olson or Mead, the allocation should be shifted to the Northern Range.

Table 4. Minimum acquisition acreage goals for greater prairie chickens in Wisconsin.

Area	Acres
Buena Vista	0
Leola	0
Buena Vista Corridor	2,125
Paul Olson	9,775
Mead	9.775
Northern Range	9,350
Total	**31,025**

The addition of suitable grassland habitat near and extending from existing prairie chicken populations will increase prairie chicken numbers whether on a local or national level. The Conservation Reserve Program started in 1986 has established grassland cover on over 34 million acres of agricultural land with highly erodible soils. Over 148,260 acres of CRP grasslands were added within the greater prairie chicken range in northwestern Minnesota by 1989 and much more has been added since. This represents at least two-thirds of grassland reserves in this region. The response was predictable and the population has increased and expanded into the new habitat. Likewise wherever CRP grasslands have been added within or adjacent to existing prairie chicken range, prairie chickens have increased their numbers or expanded the range. This has occurred in Kansas, Nebraska, Colorado, Minnesota, South and North Dakota.

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Minnesota is the real prairie chicken success story in the U.S. This fall they will be having their first hunting season since 1942. However, make no mistake. Minnesota's huntable population is the result of the addition of a scatter pattern of over 148,000 acres of CRP grassland reserves distributed throughout the northwestern range. Like its predecessor Soil Bank, which also benefited prairie chickens and grassland birds, CRP will likely be modified or eliminated when the price of grain and soybeans reaches a certain point. Minnesota will have to be vigilant and now accept the responsibility to maintain this population and be involved early on in the planning of where these existing grasslands will be maintained. The key will be to maintain connectivity within its permanent grassland reserves and with adjacent states. Minnesota also needs to continue efforts to connect the current populations with North Dakota and South Dakota to maintain genetic security.

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Graduate Student Projects and Masters Theses

Johnson, J. A. 2003. Greater prairie chicken genetics. Ph.D. dissertation. University of Wisconsin, Milwaukee, Wisconsin, USA.

Lor, S. K. (In Progress). A habitat model for American bitterns. University of Missouri, Columbia, Missouri, USA.

Laney, T. L. 2003. Ecology of the American bittern (Botaurus lentiginosus) in the prairie pothole region of west central Minnesota. M.S. thesis. University of Missouri, Columbia, Missouri, USA.

Halfmann, D. H. 2001. Natal dispersal of greater prairie chickens in Wisconsin. M.S. thesis. College of Natural Resources, University of Wisconsin, Stevens Point, Wisconsin, USA.

Bellinger, R. 2001. Loss of genetic variation in greater prairie chickens following a population bottleneck in Wisconsin, USA. M.S. thesis. University of Wisconsin, Milwaukee, Wisconsin, USA.

Azure, D. A. 1998. Aspects of American bittern ecology in northwest Minnesota. M.S.. thesis. St. Cloud State University, St. Cloud, Minnesota, USA.

Keenlance, P. W. 1998. Reproductive ecology of greater prairie chickens in central Wisconsin. M.S. thesis. College of Natural Resources, University of Wisconsin, Stevens Point, Wisconsin, USA.

Golner, D. P. 1997. Analysis of habitat selection by female greater prairie chickens in central Wisconsin. M.S. thesis. University of Wisconsin, Stevens Point, Wisconsin, USA.

Rosenquist, E. L. 1996. Winter aspects of prairie chicken ecology in northwest Minnesota. M.S. thesis. St. Cloud State University, St. Cloud, Minnesota, USA.

Wilmore, S. L. 1996. Analysis of greater prairie chicken open space requirements using a geographic information system. M.S. thesis. St. Cloud State University, St. Cloud, Minnesota, USA.

Brininger, W. L. Jr. 1996. The ecology of the American bittern in northwest Minnesota. M.S. thesis. St. Cloud State University, St. Cloud, Minnesota, USA.

Presentations

Johnson, J. A., J. E. Toepfer and P.O. Dunn. 2003. The effects of habitat fragmentation on levels of genetic variability in populations of greater prairie chickens over a fifty-year period. Society for Conservation Biology. June 28-July 2, Duluth, Minnesota.

Johnson, J. A. and P. O. Dunn. 2003. Genetic signature of the extinct Heath Hen. American Ornithologists' Union Annual Meeting. August 6-9, Champaign-Urbana, Illinois.

Palkovacs, E. P., A. J. Oppenheimer, E. Galdyshev, J. E. Toepfer, G. Amato and A. Caccone. 2003. Phylogeography of the greater prairie chicken including the extinct heath hen: implications for conservation and management. Meeting of the Society for Conservation Biology. June 28-July 2. Duluth, Minnesota.

Johnson, J. A. and P. O. Dunn. 2002. Conservation genetics of the greater prairie chicken. Society for the Study of Evolution. June 28-July 2, Urbana, Illinois.

Johnson, J. A. and P. O. Dunn. 2002. Population genetics of the greater prairie chicken. North American Ornithological Conference. Sept. 24-28, New Orleans, Louisiana.

Huschle, G., J. E. Toepfer and D. C. Douglas. 2002. Migration and wintering areas of American Bitterns form northcentral United States as determined by satellite and VHF telemetry, 1998-2001. American Ornithological Union Annual Meeting. New Orleans, Louisiana.

Toepfer, J. E. and L. M. Mechlin. 2002. Prairie chicken and sharp-tailed grouse translocations: past, present and future. The Wildlife Society 9th Annual Conference. Bismarck, North Dakota.

Johnson, J. A. 2001. Range-wide survey of levels of genetic variability among fragmented populations of greater prairie chicken. American Ornithologists' Union Annual Meeting. August 15-18, Seattle, Washington.

Johnson, J. A., Bellinger, R., J. Toepfer, and P. O. Dunn. 2001. Levels of genetic variability among fragmented populations of greater prairie chickens. Prairie Grouse Technical Council Conference. Nov 5-8, Woodward, Oklahoma.

Halfmann, D. H., J. E. Toepfer and M. W. Blondin. 2001. Natal dispersal of juvenile prairie chickens in Wisconsin. 24th Prairie Grouse Technical Council Conference. Woodward, Oklahoma.

Halfmann, D. H., J. E. Toepfer and M. Blondin. 2001. Natal dispersal of juvenile prairie chickens in Wisconsin. 63rd Midwest Fish and Wildlife Conference. Des Moines, Iowa.

Johnson, J., R. Bellinger, P. Dunn, and J. Toepfer. 2001. Loss of genetic variation following a population bottleneck in Wisconsin. 24th Prairie Grouse Technical Council Conference. Woodward, Oklahoma.

Septon, G. A. 2001. The history of the Society of Tympanuchus Cupido Pinnatus, Ltd. 24th Prairie Grouse Technical Council Conference. Woodward, Oklahoma.

Toepfer, J. E. 2001. Prairie chickens & grasslands: 2000 and beyond. Wisconsin Society of Ornithology, 62nd Annual Convention. Stevens Point, Wisconsin.

Toepfer, J. E. 2001. Translocating prairie grouse: the making of an endangered species. 24th Prairie Grouse Technical Council Conference. Woodward, Oklahoma.

Toepfer, J. E. 2001. Prairie chickens & grasslands: 2000 and beyond. 24th Prairie Grouse Technical Council Conference. Woodward, Oklahoma.

Toepfer, J. E., 2000. Translocating prairie grouse - what have we learned? 62nd Midwest Fish and Wildlife Conference. Minneapolis, Minnesota.

Toepfer, J. E. 1999. Prairie chickens & grasslands: 2000 and beyond. 23rd Prairie Grouse Technical Council Conference. Gimli, Manitobia, Canada.

VanDoren, D. 1999. Nest site characteristics influencing prairie chicken nesting success in central Wisconsin. 23rd Prairie Grouse Technical Council Comference. Gimli, Manitoba, Canada.

Wiedenfeld, D., D. Wolfe, J. E. Toepfer, L. Mechlin, R. Applegate and S. Sherod. 1999. Survey for reticuloendotheliosis viruses in wild populations of greater and lesser prairie chickens. 23rd Prairie Grouse Technical Council Conference. Gimli, Manitoba, Canada

Svedarsky, W. D., J. E. Toepfer and F. Kollman. 1998. CRP opportunities for prairie grouse in Minnesota. 22nd Prairie Grouse Technical Council Conference, College Station, Texas.

Toepfer, J. E. 1998. Prairie chickens & grasslands: 2000 and beyond. 22nd Prairie Grouse Technical Council Conference. College Station, Texas.

Beringer, P. W. and J. E. Toepfer. 1996. Movements, habitat use and survival of translocated greater prairie chickens in North Dakota. 21st Prairie Grouse Technical Council Conference, Dickinson, North Dakota.

Rosenquist, E. L. and J. E. Toepfer. 1995. A preliminary report on the winter ecology of the greater prairie chicken in northwest Minnesota. (Abstract). Pages 15-16 in J. Kobriger, editor. Proceedings 21st Prairie Grouse Technical Council Conference, Dickinson, North Dakota.

Publications

Svedarsky, W. D., J. E. Toepfer, R. L. Westemeier and R. J. Robel. (Accepted). Effects of management on grassland birds: greater prairie chicken. Grassland Ecosystem Initiative, Northern Prairie Wildlife Research Center, U.S. Geological Survey, Biological Resource Division, Jamestown, North Dakota.

Johnson, J. A., J. E. Toepfer and P. A. Dunn. (Accepted) Contrasting patterns of mitochondrial and mircosatellite population structure in fragmented populations of greater prairie chickens. Molecular Ecology.

Bellinger, R. M., J. Johnson, J. Toepfer and P. Dunn. 2003. Loss of genetic variation in greater prairie chickens following a population bottleneck in Wisconsin, USA. Conservation Biology 17:717-724.

Huschle, G., J. E. Toepfer, W. L. Brininger and D. A. Azure. 2002. Trapping and handling American bitterns. Waterbirds 25:505-508.

Wiedenfeldt, D. A., J. E. Toepfer, D. Wolfe, L. M. Mechlin, R. D. Applegate, and S. Sherrod. 2002. REV in greater prairie chickens. Wilson Bulletin 114:142-144.

Svedarsky, W. D., R. L. Westemeier, R. J. Robel, S. Gough, and J. E. Toepfer. 2000. Status and management of greater prairie chicken Tympanuchus cupido pinnatus in North America. Wildlife Biology 6:277-284.

Azure, D. A., D.E. Naugle, J. E. Toepfer, G. Huschle, and R. Crawford. 2000. Sexing American bitterns using morphometric characteristics. Can. J. Field Nat. 114:307-310.

Azure, D. A., W. L. Brininger, J. E. Toepfer, G. Huschle and R. Crawford. 2000. Renesting in the American bittern. Wilson Bulletin 112:271-273.

Anderson, R. K. and J. E. Toepfer. 1999. History, status and management of the greater prairie chicken in Wisconsin. Pages 39-58. in W. D. Svedarsky, R. H. Hier, and N. J. Silvy, editors. The greater prairie chicken: a national look. Minnesota Agricultural Research Station, University of Minnesota, St. Paul Minnesota.

Svedarsky, W. D., T. J. Wolfe, and J. E. Toepfer. 1999. Status and management of the greater prairie chicken in Minnesota. Pages 25-58. in W. D. Svedarsky, R. H. Hier, and N. J. Silvy, editors. The greater prairie chicken: a national look. Minnesota Agricultural Research Station, University of Minnesota, St. Paul Minnesota.

Svedarsky, W. D., T. J. Wolfe and J. E. Toepfer. 1997. The greater prairie chicken in Minnesota. Minnesota Department of Natural Resources. Wildlife Report 11. 55pp.

Toepfer, J. E. 1996. Movements of prairie chickens. Pages 42-48. in Svedarsky, W. D. and G. L. Van Amburg. Integrated management of the greater prairie chicken and livestock on the Sheyenne National Grasslands. Northwest Experiment Station, University of Minnesota, Crookston, Minnesota. 243 pages.

Literature Cited

Ammann, G. A. 1957. The prairie grouse of Michigan. Federal Aid in Wildlife Research Project, Michigan 5-R, 37R, and 70-R. Game Division, Michigan Department of Conservation, Lansing, Michigan. 200 pages.

Amstrup, S. C. 1980. A radio-collar for game birds. Journal of Wildlife Management 44:214.

Anderson, R. K. 1969. Mating and inter-specific behavior of greater prairie chickens. Ph.D. dissertation. University Wisconsin, Madison, WI. 188 pages.

Anderson, R. K. and J. E. Toepfer 1994. Greater prairie chicken in Wisconson. Pages 49-94 in Wisconsin Grouse Symposium Proceedings, Madison, Wisconsin.

Anderson, R. K. and J. E. Toepfer. 1999. History, status and management of the greater prairie chicken in Wisconsin. Pages 39-58 in W. D. Svedarsky, R. H. Hier, and N. J. Silvy, editors. The greater prairie chicken: a national look. Agricultural Experiment Station, University of Minnesota, St. Paul, Minnesota. Miscellaneous Publication 99-1999.

Baker, M. F. 1953. Prairie chickens of Kansas. State Biological Survey of Kansas, Lawrence, Kansas. Miscellaneous Publication Number 5. 68 pages.

Bellinger, R. 2001. Loss of genetic variation in greater prairie chickens following a population bottleneck in Wisconsin. M.S. thesis. University of Wisconsin, Milwaukee, Wisconsin.

Bellinger, R., J. Johnson, J. Toepfer and P. Dunn. 2003. Loss of genetic variation in greater prairie-chickens following a population bottleneck in Wisconsin. Conservation Biology 17: 717-724.

Berger, D., F. Hamerstrom and F. N. Hamerstrom, Jr. 1962. The effect of raptors on prairie chickens on booming grounds. Journal of Wildlife Management 27:778.

Beringer, P. S. 1995. Movements, habitat use, and survival of translocated greater prairie chickens in North Dakota. M. S. Thesis. University of Wisconsin, Stevens Point, WI. 77 pages.

Bogenschutz, T. R., D. E. Hubbard and A. P. Leif. 1995. Corn and sorghum as a winter food source for ring-necked pheasants. Journal of Wildlife Management 59:776-784.

Bouzat, J. L., H. A. Lewin, and K. N. Page. 1998a. The ghost of genetic diversity past: historical DNA analysis of the greater prairie-chicken. The American Naturalist 152-1-6.

Bouzat, J. L., H. H. Cheng, H. A. Lewin, R. L. Westemeier, J. D. Brawn and K. N. Page. 1998b. Genetic evaluation of a demographic bottleneck in the greater prairie-chicken (Tympanuchus cupido). Conservation Biology 12:836-843.

Buck, J. A., LW. Brewer, M. J. Hooper, G. P. Cobb, and R. J. Kendall. 1996. Monitoring great horned owls for pesticide exposure in south-central Iowa. Journal of Wildlife Management 60:321-331.

Bumann, G. R. and D. f. Stauffer. 2002. Scavenging of ruffed grouse in the Appalachians: influences and implications. Wildlife Society Bulletin 30:853.

Caldwell, J. A. 1980. Primary shaft measurements in relation to age of sharp-tailed grouse. Journal of Wildlife Management 44:202.

Chadwick, Douglas H. 2002. Down to a handful. Pages 49-61 in National Geographic Magazine. Vol. 201, #3.

Deeley, G. M. 1980. Pesticide drift and its effect on cholinesterase levels of birds in non-target areas in the Buena Vista Marsh. M.S. thesis. University Wisconsin Stevens Point, Wisconsin. USA.

Dumke, R. T. and C. M. Pils. 1973. Mortality of radio-tagged pheasants on the Waterloo Wildlife Area. Wisconsin Department Natural Resources Technical. Bulletin 72. 52pages.

Fairbrother, A., R. S. Bennett and J. K. Bennett. 1989. Sequential sampling of plasma cholinesterase in mallards (Anas platyrhynchos) as an indicator of exposure to cholinesterase inhibitors. Environ. Toxicol. Chem., 12:673.

Gervais, J. A., D. K. Rosenberg, D. M. Fry, L. Trulio and K. K. Sturm. 2000. Burrowing owls and agricultural pesticides: evaluation of residues and risks for three populations in California, USA Environ. Toxicol. Chem. 19:337.

Giles, R. H. 1978. Wildlife Management.W. H. Freeman. 416 pages.

Grange, W. B. 1948. Wisconsin grouse problems. Wisconsin Conservation Department, Madison, Wisconsin. Publication No. 328-A. 318 pages.

Gratson, M. W. 1988. Spatial patterns, movements, and cover selection by Sharp-tailed Grouse. Pages 158-192 in A. T. Bergerud and M. W. Gratson, editors. Adaptive strategies and population ecology of northern grouse. University of Minnesota Press, Minneapolis, Minnesota.

Hagen, C. A., B. E. Jamison, R. J. Robel, and R. D. Applegate. 2002. Ring-necked pheasant parasitism of lesser prairie chicken nests in Kansas. Wilson Bulletin 114:522.

Halfmann, D. H. 2002. Natal dispersal of greater prairie chickens in Wisconsin. M.S. thesis, College of Natural Resources, University of Wisconsin, Stevens Point, Wisconsin.

Hamerstrom, F. N., Jr., and F. Hamerstrom. 1973. The prairie chicken in Wisconsin - highlights of a 22-year study of counts, behavior, movements, turnover, and habitat. Wisconsin Department of Natural Resources, Madison, Wisconsin. Technical Bulletin 64. 52 pages.

Hamerstrom, F. N., Jr., F. Hopkins and A. J. Rinzel. 1941. An experimental study of browse as winter diet for prairie chickens. Wilson Bulletin 53:185-195.

Hamerstrom, F. N., Jr., O. E. Mattson, and F. Hamerstrom. 1957. A guide to prairie chicken management. Wisconsin Conservation Department, Madison, Wisconsin. Technical Wildlife Bulletin Number 15.128 pages.

Hayne, D. W. 1949. Calculation of size of home range. Journal of Mammalogy 30:1.

Heezen, K. L. and J. R. Tester. 1967. Evaluation of radio-tracking by triangulation with special reference to deer movements. Journal of Wildlife Management 31:124.

Hicks, D. L. 1992. The effects of dog training on sharp-tailed grouse in Manitoba. M.S Thesis. Natural Resource Institute, University of Manitoba, Canada. 144 pages.

Higgins, K. F., L. M. Kirsch, H. F. Duebbert, A. T. Klett, J. T. Lokemoen, H. W. Miller, and A. D. Kruse. 1977. Construction and operation of cable-chain drag for nest searches. United States Fish and Wildlife Service Leaflet 512.

Hooper, M. J., P.J. Detrich, C. P. Weisskopf, and B. W. Wilson 1989. Organophosphorous insecticide exposure in hawks inhabiting orchards during winter dormant spraying. Bull. Environ. Contam. Toxicol. 42:651-659.

Horak, G. J. 1985. Kansas prairie chickens. Wildlife Bulletin No. 3. Kansas Fish and Game Commission. Pratt, Kansas. 65 pages.

Johnsgard, P. A. 2002. Grassland grouse and their conservation. Smithsonian Institution. Washington, D.C.

Keir, J. R. 1999. Prairie chicken management in Wisconsin: an agency perspective. Pages 59-62 in W. D. Svedarsky, R. H. Hier, and N. J. Silvy, editors. The greater prairie chicken: a national look. Agricultural Experiment Station, University of Minnesota, St. Paul, Minnesota. Miscellaneous Publication 99-1999: 81-98.

Keir, J. R. 2003. Spring booming ground census report for central Wisconsin. WDNR report.

Kenward, R. 1977. Predation on released pheasants by goshawk in central Sweden. Viltrevy 10:81.

Kimmel, R. O. 1988. Potential impacts of ring-necked pheasants on other game birds. Pages 253-266. in D.L. Hallett, W. R. Edwards and G. V. Burger (eds.), Pheasants: Symposium of Wildlife Problems on Agricultural Lands. North Central Section of the Wildlife Soc., Bloomington, IN. 345pages.

Kirsch, L. M. 1974. Habitat management considerations for prairie chickens. Wildlife Society Bulletin 2:124.

Kerstern, D. B. 1998. The effect of T-2 mycotoxin on adult bobwhite quail (Colinus virginianus). M.S. thesis. University of Tennessee, Knoxville, TN. 94 pages.

Lande, R. 1998.Anthropogenic, ecological and genetic factors in extinction and conservation. Research in Population Ecology 40: 259-269.

Ligon, J. S. 1951. Prairie chickens, highways and power lines. The Conservationist, News and Views of the State Department of Game and Fish. NM.

Leopold, A. 1931. Report on a game survey of the North Central States. Sporting Arms and Ammunition Manufacturers Institute, Madison, WI USA. 299 pages.

Loesch, C. R. and R. M. Kaminski. 1989. Winter body weight patterns of female mallards fed agricultural seeds. Journal of Wildlife Management 53:1081-1087.

Meng, H. 1971. The Swedish goshawk trap. Journal of Wildlife Management 35:832.

Merrill, M. D., K. A. Chapman, K. A. Poiani, and B. Winter. 1999. Land-use patterns surrounding greater prairie chicken leks in northwestern Minnesota. Journal of Wildlife Management 63:189-198.

Mineau, P. 1991. Cholinesterase-Inhibiting Insecticides: Their impact on wildlife and the environment. Elsvier Science Publishers, Amsterdam.

Morgan, B. B. and F. N. Hamerstrom, Jr. 1941. Notes on the endoparasitism of Wisconsin pinnated and sharp-tailed grouse. Journal of Wildlife Management 5:194.

Morrow, M. E., R. S. Adamick, J. D. Friday and L. B. McKinney. 1996. Factors affecting Attwater's prairie-chicken decline on Attwater's National Wildlife Refuge. Wildlife Society Bulletin. 24:593-601.

Moss, R., A. Watson and R. Parr. 1975. Maternal nutrition and breeding success in red grouse. Journal Animal Ecology 44:223.

Newell, J. A. 1987. Nesting and brood-rearing ecology of the greater prairie chicken in the Sheyenne National Grasslands, North Dakota. M.S. thesis. Montana State University, Bozeman, Montana. 111 pages.

Niemuth, N. D. 2000. Land use and vegetation associated with greater prairie-chicken leks in an agricultural landscape. Journal Wildlife Management 64:278.

Niemuth, N. D. 2003. Identifying landscape for greater prairie chicken translocations using habitat models and GIS: a case study. Wildlife Society Bulletin 31:145.

Pepper, G. W. 1972. The ecology of sharp-tailed grouse during spring and summer in the aspen parklands of Saskatchewan. Saskatchewan Department of Natural Resources Wildlife Report One. 56 pages.

Peterson, L. 1979. Ecology of great horned owls and red-tailed hawks in southeastern Wisconsin. Wisconsin Department of Natural Resources Technical Bulletin 111. 63 pages.

Potts, G. R. 1980. The effects of modern agriculture, nest predation and game management on the population ecology of partidges. Pages 1-79, in A. Macfadyen, editor. Advances in Ecological Research, Vol. II. Academy Press, NY.

Prose, B. L. 1985. Habitat suitability index models: greater prairie (Multiple Levels of Resolution). USDI, U. S. Fish and Wildlife Service, Fort Collins, CO. 33 pages.

Rands, W. R. W., and T. Paulhayward. 1987. Survival and chick production of hand-reared gray partridges in the wild. Wildlife Society Bulletin 15:456.

Riley, T. Z., W. R. Clark, D. E. Ewing and P. A. Vohs. 1998. Survival of ring-necked pheasant chicks during brood rearing. Journal of Wildlife Management 62:36.

Reed, D.H. and R. Frankham. 2003. Correlation between fitness and genetic diversity. Conservation Biology 17: 230-237.

Robbins, S. D. Jr. 1991. Wisconsin birdlife, population & distribution - past & present. The University of Wisconsin Press. Madison, Wisconsin.

Robel, R. J. 1970. Possible role of behavior in regulating greater prairie chicken populations. Journal of Wildlife Management 34:306-312.

Robel, R. J., and M. Arruda. 1986. Energetics and weight changes of northern bobwhites fed six different foods. Journal of Wildlife Management 50:236-238.

Robel, R. J., A. Dayton, and K. E. Kemp. 1979. Comparative Energetics of bobwhites on six different foods. Journal of Wildlife Management 43:987-992.

Rosenquist, E. L. 1996. Winter aspects of prairie chicken ecology in northwest Minnesota. M.S. thesis. St. Cloud State University, St. Cloud, Minnesota. 72 pages.

Rosenquist, E. L. and J. E. Toepfer. 1995. A preliminary report on the winter ecology of the greater prairie chicken in northwest Minnesota. (Abstract). Pages 15-16 in J. Kobriger, editor. Proceedings 21st Prairie Grouse Technical Council Conference. North Dakota Game and Fish Department, Dickinson, North Dakota.

Rubin, C. S. 1994. Survival, movments, and habitat use of female greater prairie chickens translocated from Minnesota to Illinois. M.S thesis. University of Illinois, USA 44 pages.

Rusch, D. H. and L. B. Keith. 1971. Seasonal and annual trends in numbers of Alberta ruffed grouse. Journal of Wildlife Management 35:803.

Schmidt, F. J. W. 1936. Winter food of the sharp-tailed grouse and pinnated grouse in Wisconsin. Wilson Bulletin 48:186-203.

Schorger, A. W. 1944. The prairie chicken and sharp-tailed grouse in early Wisconsin. Transactions Academy Science, Arts and Letters 35:1.

Sharp, W. M. 1957. Social and range dominance in gallinaceous birds, pheasants and prairie grouse. Journal of Wildlife Management 21:242.

Silvy, N. J., C. P. Griffin, M. A. Lockwood, M. E. Morrow, and M. J. Peterson. 1999. The Attwater's prairie chicken - a lesson in conservation biology research. Pages 153-162 in W. D. Svedarsky, R. H. Hier, and N. J. Silvy, editors. The greater prairie chicken: a national look. Agricultural Experiment Station, University of Minnesota, St. Paul, Minnesota. Miscellaneous Publication 99-1999: 153-162.

Sisson, L. 1976. The sharp-tailed grouse in Nebraska. Nebraska Game and Parks Commission. Lincoln, Nebraska, 88 pages.

Smith, G. J. 1987. Pesticide use and toxicology in relation to wildlife: orgranophosphorous and carbamate compounds. U.S. Fish and Wildlife. Service Resource. Publication 170.

Snyder, J. W., E. C. Pelren and J. A. Crawford. 1999. Translocation histories of prairie grouse in the United States. Wildlife Society Bulletin 27:428.

Svedarsky, W. D. 1979. Spring and summer ecology of female greater prairie chickens in northwestern Minnesota. Ph.D. dissertation. University of North Dakota, Grand Forks, North Dakota. 166 pages.

Svedarsky, W. D., M. Kuchenreuther, G. J. Cuomo, P. Buesseler, H. Moechnig and A. Singh. 2002. A landowner's guide to prairie management in Minnesota. Northwest Research and Outreach Center, University of Minnesota, Crookston, Minnesota.

Svedarsky, W. D., R. L. Westemeier, R. J. Robel, S. Gough, and J. E. Toepfer. 2000. Status and management of the greater prairie chicken in North America. Wildlife Biology.6:277-284.

Svedarsky, W. D., T. J. Wolfe, and J. E. Toepfer. 1997. The greater prairie chicken in Minnesota. Minnesota Department Natural Resources Report 11, St. Paul, MN.19 pages.

Svedarsky, W. D., T. J. Wolfe, and J. E. Toepfer. 1999. Status and management of the greater prairie chicken in Minnesota. Pages 25-38. in W. D. Svedarsky, R. H. Hier, and N. J. Silvy, editors. The greater prairie chicken: a national look. Agricultural Experiment Station, University of Minnesota, St. Paul, Minnesota. Miscellaneous Publication 99-1999: 81-98.

Templeton, A. R, R. J. Robertson, J. Brisson, and J. Strasburg, 2001. Disrupting evolutionary processes: the effect of habitat fragmentation on collared lizards in the Missouri Ozarks. Proceedings of the National Academy of Sciences, USA. 98: 5426-5432.

Thirgood, S. J. and S. M. Redpath. 1999. Numerical and functional responses of generalist predators: hen harriers and peregrine falcons on Scottish grouse moors. Journal of Animal Ecology, September. Pages 879-892.

Toepfer, J. E. 1976. Movements and behavior of transplanted radio-tagged prairie chickens in central Wisconsin. M.S. thesis. University of Wisconsin-Stevens Point, Stevens Point, Wisconsin.

Toepfer, J. E. 1988. The ecology of the greater prairie chicken as related to reintroductions. Ph.D. dissertation. Montana State University, Bozeman, Montana. 533 pages.

Toepfer, J. E., R. L. Eng, and R. K. Anderson. 1990. Translocating prairie grouse - what have we learned? North American Wildlife and Natural Resources Conference 55: 569-579.

Toepfer, J. E. and R. A. Crete. 1978. Migration of radio-tagged greater sandhill cranes from Minnesota and Wisconsin. Pages 159-173 in Proceedings 1978 Crane Workshop. J. C. Lewis, editor.

Toepfer, J. E. and R. E. Eng. 1988. Winter ecology of the greater prairie chicken on the Sheyenne National Grasslands, North Dakota. Pages 32-48 in A. J. Bjugstad, technical coordinator. Prairie chickens on the Sheyenne National Grasslands. U.S.D.A. Forest Service. General Technical Report Rm -159. 73 pages.

Toepfer, J. E., R. L. Eng, and R. K. Anderson. 1990. Translocating prairie grouse - what have we learned? North American Wildlife and Natural Resources Conference 55: 569-579.

Toepfer, J. E., J. A. Newell, and J. Monarch. 1988. A method for trapping prairie grouse hens on display grounds. Pages 21-23. in A. J. Bjugstad, editor. Prairie chickens on the Sheyenne National Grasslands. U.S. For. Gen Serv. Tech. Rep. RM-159.

Trudeau, S. and G. Sans Cartier. 2000. Biochemical methods to determine cholinesterase activity in wildlife exposed to pesticides. Technical Report Series No. 338. Canadian Wildlife Service, Headquarters, Hull Quebec, Canada.

Vance, D. R. and R. L. Westemeier. 1979. Interactions of pheasants and prairie chickens in Illinois. Wildlife Society Bulletin 7:221.

Warner, R. E., P. C. Mankiin, L. M. David and S. L. Etter. 1999. Declining survival of ring-necked pheasant chicks in Illinois during the late 1900s. Journal of Wildlife Management 63:705.

Westemeier, R. L. 1971. The history and ecology of prairie chickens in central Wisconsin. College of Agriculture and Life Sciences, University of Wisconsin, Madison, Wisconsin. Research Bulletin No. 281. 63 pages.

Westemeier, R. L. 1988. Development of prairie pasture demonstration areas, Phase II. Illinois Natural History Survey Final Report (White paper). 22 pages, 10 tables.

Westemeier, R. L., J. E. Buhnerkempe, W. R. Edwards, J. D. Brawn, and S. A. Simpson. 1998. Parasitism of greater prairie chicken nests by ring-necked pheasants. Journal of Wildlife Management 62:854-863.

Westemeier, R. L. and S. Gough. 1999. National outlook and conservation needs for greater prairie chickens. Pages 169-187 in W. D. Svedarsky, R. H. Hier, and N. J. Silvy, editors. The greater prairie chicken: a national look. Agricultural Experiment Station, University of Minnesota, St. Paul, Minnesota. Miscellaneous Publication 99-1999.

Wilmore, S. L. 1996. Analysis of greater prairie chicken open space requirements using a geographic information system. M. S. thesis. St. Cloud State University, St. Cloud, Minnesota, USA.

Wisconsin DNR. 1993. A survey of land uses within the prairie chicken range of Wisconsin 1990-1991. Publication JGWM-14993.

Wright, S. 1969. Genetics and the Evolution of Population: The Theory of Gene Frequencies. University of Chicago Press, Chicago.

The mission of STCP is to save the prairie chicken from extinction, indeed "extinction is forever" but so then is the job of preventing it.

ERRATA

December 15, 2003

PRAIRIE CHICKENS GRASSLANDS: 2000 & BEYOND

Page ix: Figure 1. Range maps and contraction Page 55 based on Aldrich (1963).
Page ix: Walchezk to Walczak; Lynn McDaniel to Len; Brian Peterson to Prince.
Page 8: originated from Minnesota (32) to originated from Minnesota (140).
Page 13: Paul Olson 62 should be 76 square miles.
Page 16: Toepfer and Newell (1987) to Toepfer (1988) and Newell (1987).
Page 17: Bellinger (2000) should be (2001).
Page 17, 22: Bergurud and Gratson (1988) (1986) both should be (1990).
Page 24: Golner (1993) should be (1997).
Page 24: Halvorson and Anderson (1980) Halvorsen (1981) Halvorsen and Anderson (1983).
Page 24: Sample (1997) to Sample and Mossman (1997)
Page 40: pheasants regularly change to pheasants occasionally.
Page 50: Grange (1947) should be (1948).
Page 50: Paul Olson (281 square miles) to Paul Olson/Mead and between.
Page 51: Westemeier (1988) should also be (1998b)
Page 56: 1975 should be 1995.
Page 57: Gatti et al. (1997) should be (1994).
Page 58: Table 4 under Mead 9.775 change to 9,775.

Scientific names need to be italicized; sharp-tailed grouse (Tympanuchus phasianellus); ring-necked pheasant (Phasianus colchicus).

Add to Literature Cited

Aldrich, J. W. 1963. Geographic orientation of American Tetraonidae. Journal of Wildlife Management 27:529-545.

Ammann, G. A. 1944. Determining the age of pinnated and sharp-tailed grouse. Journal of Wildlife Management 8:170-171.

Bergurud, A. T. and M. W. Gratson. 1990. Prairie chicken biology and conservation. Final Report. World Wildlife Fund, Canada. University Victoria, British Columbia, Canada.

Frankham, R., J. D. Ballou, and D.A. Briscoe. 2002. Introduction to Conservation Genetics. Cambridge University Press, Cambridge, UK.

Gatti, R. C., D. W. Sample, E. J. Barth, A. Crossley, S. W. Miller and T. L. Peterson. 1994. Integrated grassland bird habitat restoration in Wisconsin using GIS habitat modeling. Transactions North American Wildlife and Natural Resource Conference 59:309-316.

Golner, D. P. 1997. Analysis of habitat selection by female greater chickens in central Wisconsin. M. S. thesis. University Wisconsin Stevens Point, Wisconsin. USA

Gross, A. O. 1930. Progress report of the Wisconsin prairie chicken investigation. Wisconsin Conservation Commission. Madison, Wisconsin.

Halvorsen, H. H. 1981. An evaluation of grassland management practices for wildlife in central Wisconsin. M. S. thesis. University Wisconsin, Stevens Point Wisconsin.

Halvorsen, H. H., and R. K. Anderson. 1983. Evaluation of grassland management for wildlife in central Wisconsin. Pages 267-297 in C. L. Kucera, editor. Proceedings of 7th North American Prairie Conference. Southwest Missouri State University, Springfield, Missouri, USA.

Holevet, R. 1990. Kelley's Slough Wildlife Management Plan. North American Waterfowl Plan Project. U.S. Fish and Wildlife Service, Devils Lake, North Dakota.

Johnson, J. A., J. E. Toepfer and P. A. Dunn. 2003. Contrasting patterns of mitochondrial and microsatellite structure in fragmented populations of greater prairie chickens. Molecular Ecology 12:3335-3347.

Jorge, D. G., J. P. Jorgenson, and T. A. Messmer. 1976. A management plan for the prairie chicken management area, Grand Forks Co., North Dakota. University of North Dakota. Institute for Ecological Studies. Research Report 17.

Management Recommendations

"Wherever one looks the answer is the same: to save prairie chickens grasslands must be preserved and managed for them. There are no substitutes". Hamerstrom et al. 1957

The contraction of the range that has occurred in Wisconsin is currently happening throughout the greater prairie chicken range. This contraction has been occurring for the past 100 years. The first to go was the Heath hen, and then the greater's in the eastern portion of the range and now the Attwater's prairie chicken. The response by wildlife management agencies to these declines was slow probably because a lack of interest by sportsmen in prairie chickens and greater interests in pheasants. Some states barely reacted to the decline of the chickens and some just took them for granted. But some states established core areas of permanent grassland reserves of high quality habitat and felt that if properly managed, they could maintain small isolated prairie chicken populations.

The fate of greater prairie chickens in Illinois, Texas, Missouri, Oklahoma, and North Dakota are in doubt today because of this core management philosophy that ignored the birds on the periphery of the range and concentrated management efforts in one or two major core areas (Westimeier and Gough 1999). This was done more by necessity and a lack of knowledge of the area requirements of a prairie chicken population. At this point in time we still do not know the minimum size necessary to sustain a viable greater prairie chicken population. However, we do know by the process of elimination that neither the Illinois population, the Buena Vista/Leola population nor the Paul Olson/Mead are large enough by themselves to sustain genetic variability comparable to prairie chicken populations with larger ranges. We should all now understand that to be successful, management would have to spread thousands of acres of grassland habitat over a landscape of several thousand square miles and maintain connectivity.

What is unfortunate is that this same core management philosophy was followed in Wisconsin despite the recommendations of Hamerstrom and Hamerstrom in 1973. The concentration of management efforts and land purchases on Buena Vista/Leola have contracted the range and ecologically and genetically isolated it from the rest of the range (Paul Olson, Mead, and the Outlying areas). Wisconsin's subpopulations have lost the connectivity that Hamerstrom and Hamerstrom warned us about in 1973. In order to succeed, greater prairie chicken and prairie grouse management both locally and nationally must become a range-wide endeavor.

In 1975, the WDNR prepared a management plan for STCP for the greater prairie chicken in Wisconsin. This plan needs to be revised and updated to reflect current conditions as they relate to changes in distribution, especially contraction of total range (50%) and contraction within the management areas as they relate to the loss of connectivity and the subsequent loss of genetic variability. Time is important so the plan should be given special status and should be treated as a Recovery Plan for Greater Prairie Chickens in Wisconsin. Most importantly, the plan and agency activities need to be examined to determine why certain portions of the 1995 version were not implemented. Unless these management problems are addressed and corrected, any future plan will fail.

Fifty years ago the Hamerstrom's recommended that: "One area, the best one should be permanently managed; management of other areas would also be desirable, but only in addition to the primary objective not in place of it". By the early 1970's, the core they spoke of had been established through land purchases and with the development of over 10,806 acres of grassland habitat on the Buena Vista and Leola. In 1973, 29 years ago, the Hamerstrom's further stated: "It is our urgent recommendation that the Carson-Sigel-Sherry area (now called Paul Olson) be put under management without further delay." They stated: "Banding data show strong interconnections between the Buena Vista Marsh (Portage County Management Area) and several outlying areas up to 25 miles away. We believe that this arrangement gives strength to each population and we reiterate our earlier recommendation that these outlying areas be put under management. Loss of the Carson-Sigel-Sherry Area would break the connection and leave Buena Vista isolated from Mead, a loss which would be more important than the mathematical number of birds in the Carson-Sigel-Sherry Area."

In 2003, we are now looking at declining populations in the unmanaged areas, range contraction statewide (50%) and on some of the management areas, a historicaland regional decline in chick survival, a lack of movement of birds between sub-populations, a loss of alleles and genetic diversity since 1951, and lower nesting success on the Buena Vista compared to other areas and private land.

All of these indicate that the immediate long-term outlook for the greater prairie chicken in Wisconsin is not good. Management practices will need to be initiated that will increase numbers and create movement between subpopulations. This means improving survival and reproduction on the management areas to increase numbers and encourage birds to move between subpopulations. This involves adding and creating more open space, cutting trees, improving food plots and reducing the amount of grassland disturbed each year to improve nesting success.

Research in Wisconsin by PCG2B indicates that the sub-populations are now ecologically and genetically isolated from each other and from other populations in the U.S. The subpopulations in Wisconsin (Buena Vista/Leola, Paul Olson/Mead and Outlying Areas) need to be connected with the development of corridors of permanent grassland reserves. The loss of alleles and low genetic diversity will have to be increased either by moving birds between subpopulations and/or by translocating birds from other states. The fact that all the subpopulaions have lost genetic variability and are the lowest in the United States means that genetic variability will probably not be improved much by moving birds within the state. The loss of genetic variability will have to be addressed by bringing birds in from another state, probably Minnesota or Nebraska.

On the landscape level the only real hope for the long-term existence of a self-sustaining, **genetically** viable greater prairie chicken population in Wisconsin is to bring in birds or connect to the Illinois, Minnesota or Iowa populations. This could involve the development of a grassland corridor to connect with the Glacial Habitat Restoration Area (31 miles) (Gatti et al 1994) or through Necedah National Wildlife Refuge and Sandhill Wildlife Area to the southern grassland complex (100 miles) being developed near Dodgeville. However, the potential of these areas for prairie chickens is greatly compromised by the presence of and current management emphasis on the ring-necked pheasant. The southern complex is only 225 and 250 miles from the Illinois and Iowa populations.

Whether these concepts are undertaken and accomplished remains to be seen. In the interim however it is now critical in 2003-04 that the WDNR and other land management agencies initiate management activities to improve the quality of existing grassland habitat and increase the amount of grassland and open space on the Paul Olson, Mead, Dewey and Outlying Areas for greater prairie chickens and other grassland species. The best recommendation I can make is to repeat the recommendation that Hamerstrom and Hamerstrom made in 1973, "we reiterate our earlier recommendation that these outlying areas be put under management".

The WDNR without delay must begin to manage greater prairie chickens in Wisconsin on a range-wide basis. This means abandoning the core management philosophy that has focused management activities and land purchases on the Buena Vista and Leola. It also will require a team approach involving numerous individuals and groups, private, state and federal. And to be successful, it absolutely must involve the expertise and input of all WDNR personnel especially the managers within the greater prairie chicken range. To continue the present management scheme will eventually create a "zoo population" that will probably lead to extirpation.

The overall concept is very simple - reestablish connectivity between the Buena Vista and Paul Olson and add as much grassland habitat as possible within a mile of existing and historical booming grounds within the 2,077 square mile Wisconsin prairie chicken range as of 1990. A scatter pattern of grassland reserves (Hamerstrom et al. 1957) of at least 30,000 acres scattered through the Paul Olson, Mead and Outlying Areas will be the minimum amount of grassland habitat necessary to maintain a viable greater prairie chicken population in Wisconsin. The corridor will require 1,500 to 2,000 arces of grassland habitat.

The first step will be to establish grassland corridors between the Buena Vista and Paul Olson and Mead and the Northern Range within the next five years. At the same time it will be necessary to create a large island complex of grassland reserves within, surrounding and between Paul Olson, Mead and the Northern Range within the next 10 years. This number is a projection based on a model using the number of booming grounds and a ratio of 425 acres of permanent grassland cover per booming ground in 1989 on the Buena Vista. The year 1989 was chosen because of the wide distribution of booming grounds on Paul Olson/the Mead and the Northern Range.
The plan should establish minimum acquisition acreage goals as shown in Table 4.

Flexibility in purchasing or otherwise securing land will be key. Managers in prairie chicken areas should not be limited as they have in the past by unrealistic goals and property boundaries. A project boundary line should be drawn around the 1990 prairie chicken range and any land within a mile of an existing booming ground or historical booming ground should be targeted for purchase or other permanent protective form of acquisition until the total acreage goal is reached. If land goals cannot be met at Paul Olson or Mead, the allocation should be shifted to the Northern Range.

Table 4. Minimum acquisition acreage goals for greater prairie chickens in Wisconsin.

Area	Acres
Buena Vista	0
Leola	0
Buena Vista Corridor	2,125
Paul Olson	9,775
Mead	9.775
Northern Range	9,350
Total	**31,025**

The addition of suitable grassland habitat near and extending from existing prairie chicken populations will increase prairie chicken numbers whether on a local or national level. The Conservation Reserve Program started in 1986 has established grassland cover on over 34 million acres of agricultural land with highly erodible soils. Over 148,260 acres of CRP grasslands were added within the greater prairie chicken range in northwestern Minnesota by 1989 and much more has been added since. This represents at least two-thirds of grassland reserves in this region. The response was predictable and the population has increased and expanded into the new habitat. Likewise wherever CRP grasslands have been added within or adjacent to existing prairie chicken range, prairie chickens have increased their numbers or expanded the range. This has occurred in Kansas, Nebraska, Colorado, Minnesota, South and North Dakota.

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Minnesota is the real prairie chicken success story in the U.S. This fall they will be having their first hunting season since 1942. However, make no mistake. Minnesota's huntable population is the result of the addition of a scatter pattern of over 148,000 acres of CRP grassland reserves distributed throughout the northwestern range. Like its predecessor Soil Bank, which also benefited prairie chickens and grassland birds, CRP will likely be modified or eliminated when the price of grain and soybeans reaches a certain point. Minnesota will have to be vigilant and now accept the responsibility to maintain this population and be involved early on in the planning of where these existing grasslands will be maintained. The key will be to maintain connectivity within its permanent grassland reserves and with adjacent states. Minnesota also needs to continue efforts to connect the current populations with North Dakota and South Dakota to maintain genetic security.