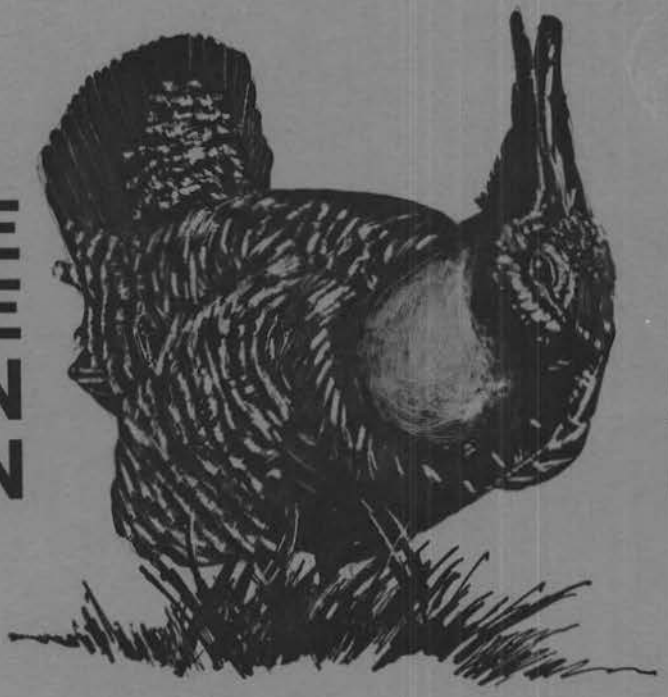
c.5

THE PRAIRIE CHICKEN IN WISCONSIN



HIGHLIGHTS OF A 22-YEAR STUDY OF COUNTS, BEHAVIOR, MOVEMENTS, TURNOVER AND HABITAT

1973

DEPARTMENT OF NATURAL RESOURCES
Madison, Wisconsin

Technical Bulletin No. 64

ABSTRACT

Booming ground surveys are reported for three prairie chicken areas in central Wisconsin for 22, 22, and 10 years respectively. The population trends shown have some bearing on cycle theory but neither strongly support nor deny it. Such surveys are useful indices of population trends and of habitat quality, both of which have strong management implications. For these reasons as well as for their research value, booming ground surveys will have increasing value in future years, and should be continued.

Among 2,264 copulations seen during 6,014 blind mornings in spring, most were between April 12 and May 25, with a strong peak between April 18 and 26 and a lower peak between May 7 and 13. Hens came to the booming grounds over a still longer period, and their presence showed a similar double-peaked pattern; their greatest numbers, however, came 1-6 (average 3.2) days before the major peak of copulations.

Breeding behavior of prairie chickens showed unexpected patterns. Some juvenile cocks held territories, including interior territories; 18 percent of copulations by color-banded known-age cocks were by juveniles and 30 percent by known-age hens were by juveniles. Juvenile cocks were as successful as adults (84 and 76%, respectively). More interior cocks copulated than exterior ones, but there was little if any difference in success rate.

Among 1,885 prairie chickens banded from 1950 through 1969, the analysis of 1,055 movements by cocks and 400 by hens showed: (1) immatures generally moved farther than adults and hens farther than cocks; (2) shortest moves were during the warmer months (although summer movements are unknown), longest were from one winter to another without intervening capture; (3) once established on a booming ground, cocks tended strongly to remain close to it year-long and a smaller proportion of hens did the same; (4) 95 percent of the moves of adult cocks and 93 percent of immatures were 5 miles or less, 83 percent of the moves of adult hens and 62 percent of immatures were within the same range; (5) 17 of 162 wing-tagged chicks were shot in autumn or retrapped in winter, and their movements were within normal limits of birds banded in the usual way. Banding data show strong interconnections between the Buena Vista Marsh and several outlying areas up to 25 miles away. We believe that this interchange gives strength to all colonies involved, and points to the need for management of additional colonies.

Composite dynamic life tables based on sight records of live birds on booming grounds show no significant difference at the 95 percent level in average annual mortality rate among immature cocks (52%), immature hens (59%), adult cocks (55%), and adult hens (51%); combining the sexes gives a rate of 54 percent for both immatures and adults. The population was hunted during one autumn. Average annual mortality rate for combined unshot cohorts was 52 percent. For the two shot cohorts average rate was 59 percent and 63 percent, respectively, but for the time interval which included the hunting season it was 79 percent and 66 percent, respectively. Hunting apparently increased mortality for that year by about 25 percent.

Cover type mapping on the 45,000-acre Portage County Management Area in 1953 and 1969 showed little change in total acreage of the individual types but a loss to intensified farming of about 5,000 acres along the northern and northeastern edges. A sample block of 6,714 acres within the Leola Marsh, mapped in 1941-42, 1947, 1956-57, and 1969, showed that grassland decreased from 47 percent in 1941 to 18 percent in 1969, while plowland increased from 29 percent to 64 percent; further losses are to be expected. Major losses on both areas are attributable primarily to the expansion of agrobusiness, which has profoundly affected not only prairie chickens but also the total environment. The prognosis for the Leola Marsh is bleak. By contrast, managed grassland reserves on the Portage County Management Area have secured a substantial population there.

Twenty-seven publications and two theses which have resulted from this study (1949-1971) are listed.

THE PRAIRIE CHICKEN IN WISCONSIN

Highlights of a 22-Year Study of Counts, Behavior, Movements, Turnover and Habitat

By
Frederick and Frances Hamerstrom

Technical Bulletin No. 64
DEPARTMENT OF NATURAL RESOURCES
Madison, Wisconsin
1973

CONTENTS

PREFACE

The Preservation of a Species

PAUL J. OLSON

"...The crux of the Prairie Chicken's problem is the crux and the thesis of all wildlife conservation. The thesis is this—wildlife abundance or scarcity is fundamentally a function of habitat suitability. This is a thesis seemingly simple and obvious, and yet it has taken a strangely long time to gain acceptance and is today still violently argued in some wildlife interest centers... The history of the Prairie Chicken after the time of human settlement is a particularly brilliant exposition of the habitat theory since it illustrates how a special kind of habitat encouraged first the dominance and later the recession of one species...

"In its finality the Chicken habitat shrank primarily to the Buena Vista Drainage district in Portage County. Here the land was good enough to maintain farming of the grassland type—resettlement followed by forest was not to be the picture. Here were some 50,000 acres of open land devoted to less intensive farming including the blue grass seed industry... Once again the accident of man's land use has set up a reasonable facsimile of Prairie Chicken habitat. Here the Chicken continued to thrive and here he is living today.

"The vise, then, is closed—but not tight. There are people in Wisconsin and elsewhere who insist that man shall never totally close the vise on any of our remaining species. There are those who believe that we can create in the future and on purpose that hospitable habitat which was created by accident in the past.

"Toward this end Wisconsin has a long and distinguished record in Prairie Chicken studies. Starting in 1928, a series of brilliant researchers have been working on the Wisconsin Prairie Chicken Investigation. Alfred Gross, Franklin Schmidt, Wallace Grange and Drs. Frederick and Frances Hamerstrom are some of the names. Because of this program it can be said that we know more about the life history, habits and requirements of the Prairie Chicken than of any other Wisconsin game bird.

"In 1957 came the publication of *A Guide to Prairie Chicken Management* by the Hamerstrom-Mattson research-management team. Here was a research-based plan of such excellence that it immediately received international acclaim as well as the award of the Wildlife Society as the distinguished and original contribution of 1957. This plan, along with the administrative policy relative to the Chicken which had been adopted by the Conservation Commission in 1953, forms the basis of a realistic Prairie Chicken program in Wisconsin.

"Unique in the Hamerstrom-Mattson plan is the idea of 'ecological patterning'—the notion of a scatter-pattern of grassland reserves integrated into the general farming community. These reserves are primarily to furnish nest-brood cover, long demonstrated as the weak link in the Prairie Chicken life chain. Summer food is found in the grain and clover fields of the farming community and winter food which is nearly adequate can easily be supplemented with food patches. Although winter cover is of some importance, Chickens with their snow burrowing habit can take a lot of winter. Space sufficient to fit the open-skies requirement of the bird is now present in reasonable amounts and is due to be increased as the plan works out. Bad weather, especially at the critical nesting time; the old enemy, brush, and the new enemy, billiard table clean grazing by the new beef industry—these are the real threats remaining.

"The Hamerstrom-Mattson plan, then, calls for acquisition of grassland reserves in the scatter pattern by private purchase followed by long term lease of these reserves to the Conservation Department. The Department would then 'manage' the lands largely by controlling the brush. The lease money would supply tax funds to the owners to pay the local community. Thus the plan would escape the stigma of being a parasite on an already strained economy.

"After a slow start, the acquisition program has recently snowballed. Several purchases of forty to sixty acres were made by private individuals as early as 1954, and these were followed by purchases under the leadership of the Wisconsin Conservation League and the Wisconsin Society for Ornithology. The tempo picked up markedly in 1959 with the formation of the Prairie Chicken Foundation, a tax exempt subsidiary of the Dane County Conservation League of Madison. After an investment of slightly more than $50,000 this organization now owns 1,641 acres. Early in 1961 a new and startlingly vigorous organization was formed–the Society of Tympanuchus Cupido Pinnatus–home-based largely in Milwaukee, and before last fall this organization had completed a 1,200-acre purchase. Altogether 3,283 acres have now [1962] been acquired, and plans continue for further acquisition.

"The response to the Prairie Chicken's dilemma in Wisconsin has been gratifying and widespread. The Prairie Chicken Foundation for example, has members in fifteen states, as wildlife people from many areas, catching the imagination of the plan, have given aid. This widespread interest, this generous spending, is testimony to the innate decency of sportsmen and nature groups once they understand the problem...

"In 1957 *A Guide to Prairie Chicken Management* was concluded with the statement, 'The Prairie Chicken can be saved in Wisconsin–but only if action is taken now'. Since 1957 much action has taken place but at the same time there is still a great deal to be done. That it will be done there is no doubt in the minds of 'Chicken people' who talk about the monument at Wyalusing State Park to the passing of the Passenger Pigeon, and who promise with high resolve that there will not be another such monument in Wisconsin".*

The total land acquired is now 10,806 acres (Fig. 1). Contributions have come from a large number of people, primarily through the Prairie Chicken Foundation (Madison) and the Society of Tympanuchus Cupido Pinnatus, Ltd. (Milwaukee).

The future of the Prairie Chicken is now assured, as nearly as one can make such a prediction in 1972! The Hamerstroms and the prairie grouse project have been instrumental both in setting up a management plan based on sound research, and in obtaining land on which to put it to work. Result: the preservation of a species!

*From: The prairie chicken, a symbol of our land as it used to be. Wis. Tales and Trails 3(1):26-30 (1962).

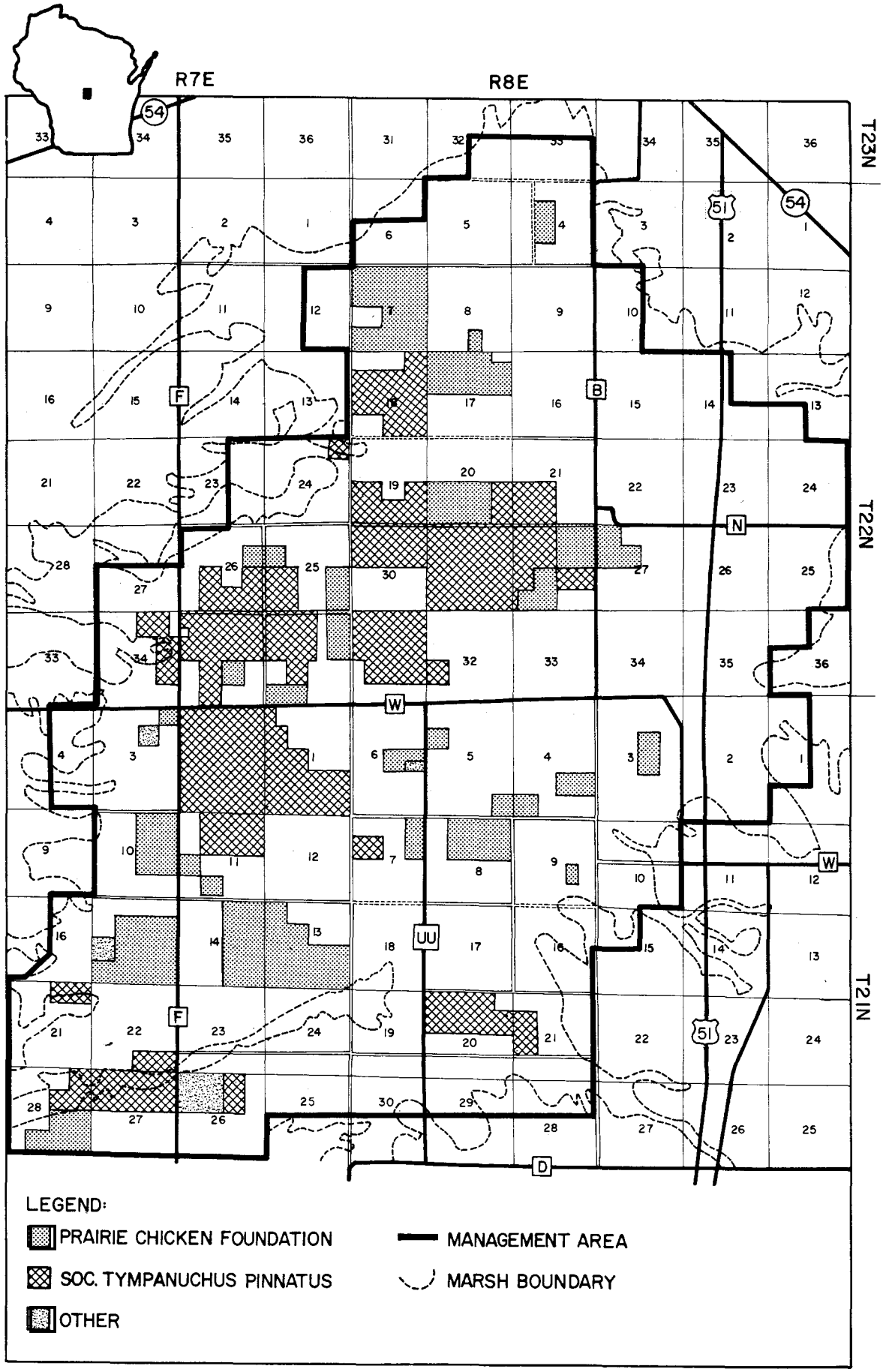


FIGURE 1. *Land privately purchased for prairie chickens on the Buena Vista Marsh, Portage County, through 1971.*

INTRODUCTION

Wisconsin has had an exceptionally long history of prairie grouse research. Begun under the Conservation Department in 1928, it has continued (despite occasional interruptions) to the present, sometimes in the hands of the Department of Natural Resources and sometimes under the auspices of the University of Wisconsin at Madison or at Stevens Point. The Department of Natural Resources' formal program of prairie grouse research ended in January of 1972; current work is being continued by the University of Wisconsin at Stevens Point.

When the program was begun in 1928, under the direction of Alfred O. Gross, the prairie chicken *(Tympanuchus cupido pinnatus)* and the sharp-tailed grouse *(Pedioecetes phasianellus campestris)* were important game birds in Wisconsin, and the program was originally pointed toward the management of huntable populations. It is an accurate reflection of recent changes in the world of grouse and men that during the years of our study the emphasis has been to save a species, the prairie chicken, that is being rapidly crowded toward extirpation by the pressures of modern society.

This report covers the highlights of our part in the Department of Natural Resources' program. It is an interim report. It stands between our Final Report for Wisconsin Pittman-Robertson projects W-13-R, W-79-R, and W-141-R and a more extensive and less technical book on the prairie chicken which we propose to write. The Final Report is limited to about a half dozen copies of extremely narrow distribution; the book is several years from publication. There seems considerable point, therefore, in a bulletin now to make available the technical material on which the later book will be partly based.

It is a condensed statement, almost in summary form, of the most important and still unpublished findings of our research on prairie chickens in Wisconsin from autumn 1949 through 1971 (plus some still earlier work): essentially the Final Report slightly modified. Several papers have already been published on parts of our research and their data will generally not be repeated here. Some are referred to in the text and all are listed in the Appendix in order to bring together a record of the whole study.

Because of the special purpose for which the Final Report was written and because we plan to expand on this material later, this bulletin does not follow standard format. Our purpose is simply to make the data available to others, and we have not followed the usual practice of reviewing the literature and relating our work to other findings.

This bulletin includes material on the prairie chicken part of our study—on population trends as shown by annual display ground counts, and on breeding behavior, movements, turnover, and changes in habitat over a long period of years.

BOOMING GROUND SURVEYS

METHODS

A few definitions are necessary, as follows:

1. Booming ground—a display ground used by two or more prairie chicken cocks. Exceptionally, a formerly well-established booming ground dwindles to one cock, but we still count it as a booming ground.

2. Regularly used display ground—a display ground to which the cocks come daily during the display season.

3. "Regulars"—the individual cocks that come daily to the regularly used grounds. Banding studies have shown that these are actually the same birds from day to day. The number of cocks on a display ground often varies slightly from day to day, so that it is sometimes impossible to express the number of "regulars" by a single figure: a range, as 6-8, is then necessary.

4. Highest count—in addition to the "regulars", visiting cocks sometimes appear for short periods. Sometimes they establish themselves, and become "regulars"; often they are thoroughly beaten and driven off.

5. Display ground of uncertain status—grounds whose status cannot be defined precisely. The uncertainties are of two sorts: (a) Definitely not in regular, daily use; (b) Found relatively late in the season, and we cannot be sure whether we overlooked them earlier or whether they really did not come into existence until later than the rest. All of these questionable grounds are relatively small in size. They may be composed of cocks that for some reason never settled down to the usual routine or were peculiarly late in doing so. It is possible that

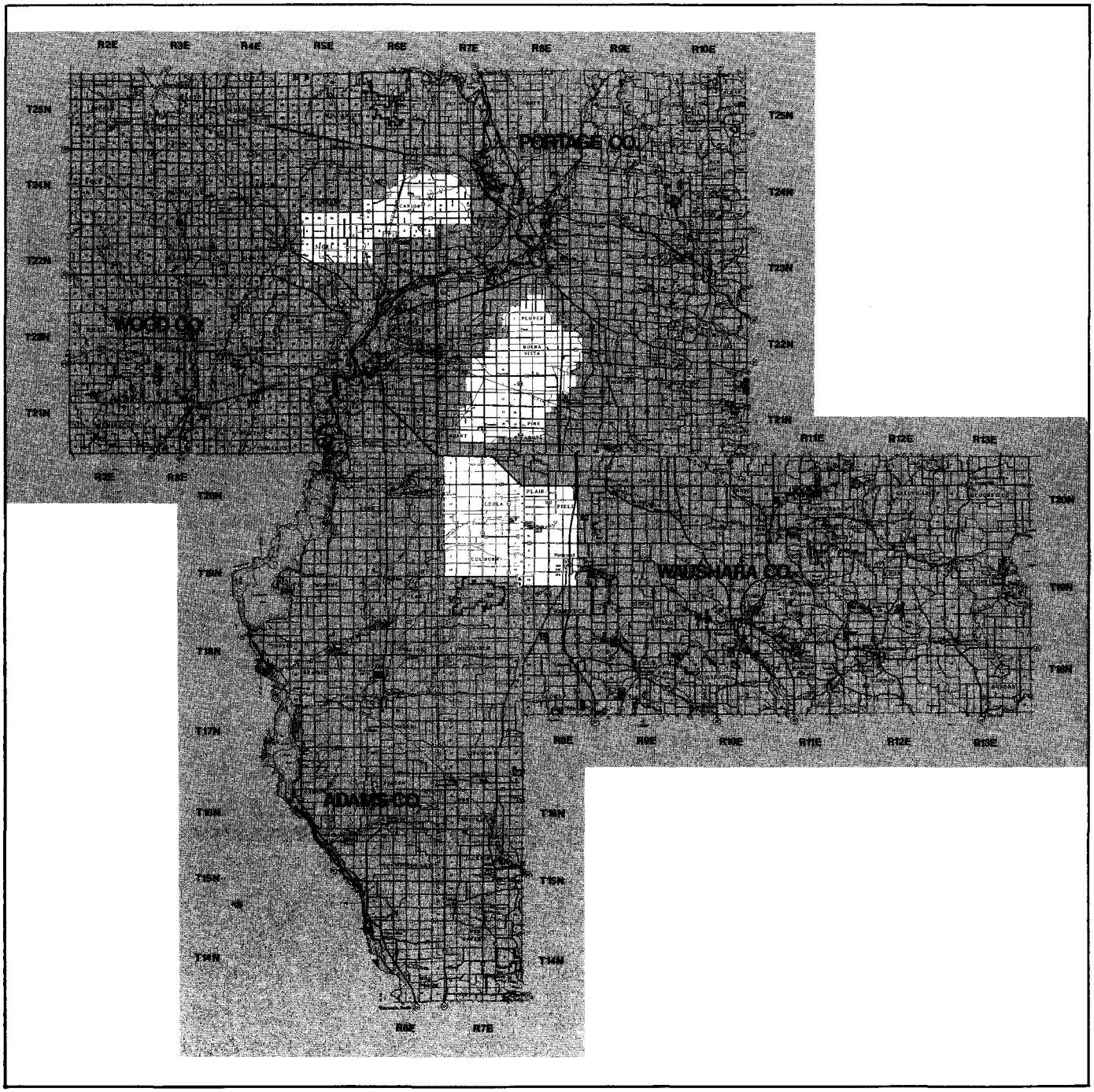


FIGURE 2. *Location of the three prairie chicken study areas.*

these cocks are duplicated in the "highest counts" on the regularly used display grounds, but they are almost certainly not included among the "regulars". We have found few such display grounds during most springs (often none), and we include them with the "regulars" for year-to-year comparisons.

6. Single territorial male—a single cock displaying daily at the same place apart from booming grounds.

7. Casual display—single cocks or small groups of cocks displaying apart from regularly used booming grounds, but never (or rarely) found at the same place again. Casual display sometimes occurs among feeding birds in late winter and when a cock chances to meet a hen or group of hens away from a display ground in spring, as examples. Casual display among prairie chickens may well involve cocks who do belong on a booming ground and who are putting on a brief show away from it. Casual and single territorial cocks are not included in our comparative counts.

The survey has two parts: finding the booming grounds and counting the cocks on the grounds. Clear and quiet mornings, with temperatures from 25-40 F, are best, although overcast but calm mornings are also good. Wind drastically cuts down the distance at which displaying birds can be heard, and snow cover hinders hearing. Activity is highest from about 45 minutes before sunrise to an hour or two later; it is both intensified and prolonged by the presence of hens, which are a strong stimulus. Since many spring mornings are windy throughout, and the wind often rises soon after sunrise even on mornings which are quiet earlier, windless mornings are especially valuable for searching. Counts can be made when conditions for listening are less suitable, but should not be delayed until so late in the morning that activity has dropped off to the point that some cocks have left the grounds.

We have found that the most efficient way to pinpoint booming grounds is to triangulate on the sound from known points along the roads and trails on our study areas. Booming can seem to be much closer than it really is, and triangulation prevents waste of time in what can be very like the pursuit of the will-o'-the wisp. Under good conditions, booming can easily be heard for 2 miles and sometimes 3 (the longest record we know of is 4 miles).

It has been our practice to search each area until all booming grounds have been found. This generally involved two complete searches, each made as nearly as possible as though we had never seen the area before in order to be sure that we did not overlook new grounds. We have occasionally not been able to be as thorough as we would have liked, because of unfavorable weather and shortage of time, but we are confident that we have never missed a major ground or enough small ones to seriously (more than 5%) distort the total count.

We believe that three good counts, in which the sexes are distinguished, are needed in order to arrive at the number of regulars. These counts should be made during the two to three week period of peak display; earlier and later counts may differ considerably. Sometimes three counts do not show a consistent number of cocks. This may occur because of disturbances caused by weather, because some counts may be made too late in the morning, etc., or because some display grounds do actually show considerable variation from day to day, rather than having a consistent number of regulars. When three counts do not show a consistent number of regulars, more counts are needed either to rule out the effect of temporary disturbances, or to establish as closely as practicable the limits of variation when the number of regulars is less consistent than usual.

Comparisons from one year to another are made on the basis of the total number of regulars on all booming grounds (including those of uncertain status) within the area. Although there is a high degree of consistency in the use of individual booming grounds from year-to-year, new grounds are apt to appear when the population rises and old grounds may drop out when the population falls. There are sometimes changes of this sort even when population changes are not large. Thus, the need for complete coverage of the area each year is plain. Hens are excluded from comparative counts because their numbers, as reflected by the day-to-day counts, vary so widely.

Counts on the Buena Vista Marsh (Portage County Management Area) were made by project personnel with a great deal of help from cooperative outside observers (reported in detail later) through 1969. Starting in 1967, students at the University of Wisconsin–Stevens Point, under the direction of Professor Raymond K. Anderson, made most of the observations on the northern third of the area and began to make part of the annual booming ground search. By 1969 the students were responsible for the entire search and continued to man the blinds and take counts in the northern third of the area, an arrangement which has continued through 1971. Our part in the spring work grew progressively smaller during this period, and was limited to about three weeks in 1969 and to about one in 1971. From 1950 through 1970 most of the counts on the Buena Vista Marsh have been made from blinds, the main exceptions being the grounds of uncertain status and some of the smallest regularly used grounds.

The Plainfield Area has been censused mainly by project personnel with occasional help—sometimes at critically important times—by men of the Game Management Division, particularly by L. Crawford, O. E. Mattson, B. Hubbard, and R. Beggs. Very little work has been done from blinds since the census was taken up by the Department in 1950. In our earlier work there, especially 1940-1943, we did a considerable amount of watching from blinds.

Following some earlier reconnaissance surveys by project personnel, R. L. Westemeier began a census west of Stevens Point in 1962 and 1963, a booming ground census which has been continued by students at the University of Wisconsin at Stevens Point, under the direction of R. K. Anderson. Annual counts involve a mixture of counts made from blinds and from a distance. Although not strictly a part of this project, we have been rather closely involved over the 10-year period and have been reporting the annual counts.

The positions of the three prairie chicken areas, in relation to one another, are shown in Figure 2.

FINDINGS

Buena Vista Marsh (Portage County Management Area)

Spring counts of cocks on booming grounds, 1950-1971, are shown in Table 1 and Figure 3. A few sharptail cocks and prairie chicken x sharptail hybrid cocks have been seen over the years, and are included in the table. Year-to-year comparisons, however, have been based on prairie chicken cocks only.

Boundaries of the area, and the position of booming grounds in the high population of 1950, are shown in Figure 4.

Plainfield Area

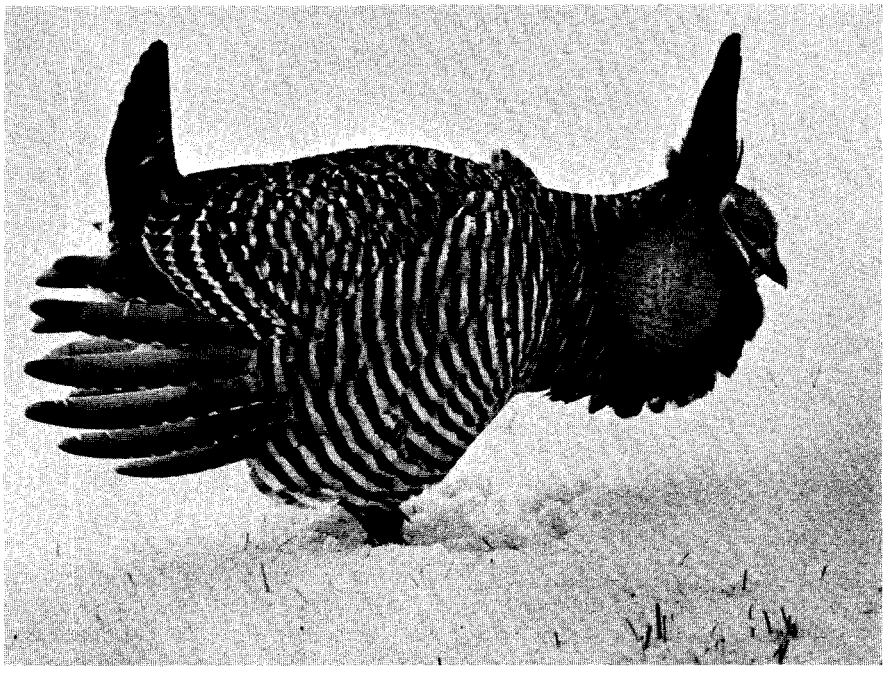
Spring counts of cocks on the Plainfield Area, 1950-1971, appear in Table 1 and Figure 3. Sharptail cocks and hybrids are also tabulated, as in the case of the Buena Vista Marsh. An earlier series of counts, 1939-1949, published previously, is shown in Figure 5. The position of booming grounds in the high population of 1950 is shown in Figure 6. The Leola Marsh is a critically important part of the Plainfield Area.

Area West of Stevens Point

Annual censuses have been made west of Stevens Point from 1962-1971. The survey area has grown smaller since Westemeier's original survey, and has varied somewhat in size especially during the early 1960's. Since 1965 it has been stabilized as the area shown in Figure 7; counts on the currently surveyed area from 1962-1971 are given in Table 2 and Figure 3. The population has consistently been in two colonies, the eastern Carson Township block and the western Sherry-Sigel Townships block, with a band of more intensively farmed country between.

Finally, it should be noted that display ground surveys have been reported in Pittman-Robertson quarterly and completion reports which have been issued in the publication *Wisconsin Wildlife Research* and as manuscript reports for the years 1958-59 through 1968-69. The counts therein were in many cases preliminary and are superseded by this report. The earlier reports do contain observations and interpretations in much greater detail than can be included here.

*Tables can be found at the end of each chapter.



Prairie chickens may begin their courtship activities while there is still snow on the ground

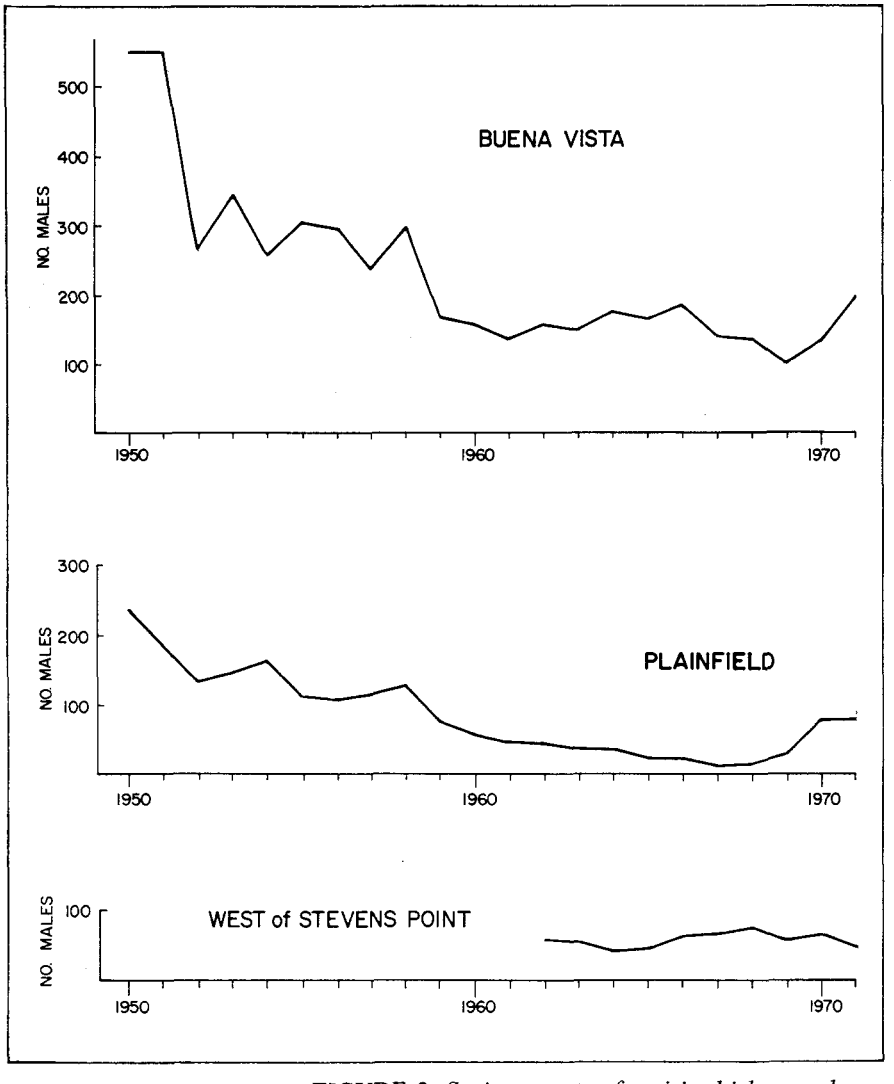


FIGURE 3. *Spring counts of prairie chicken cocks on booming grounds, 1950-1971.*

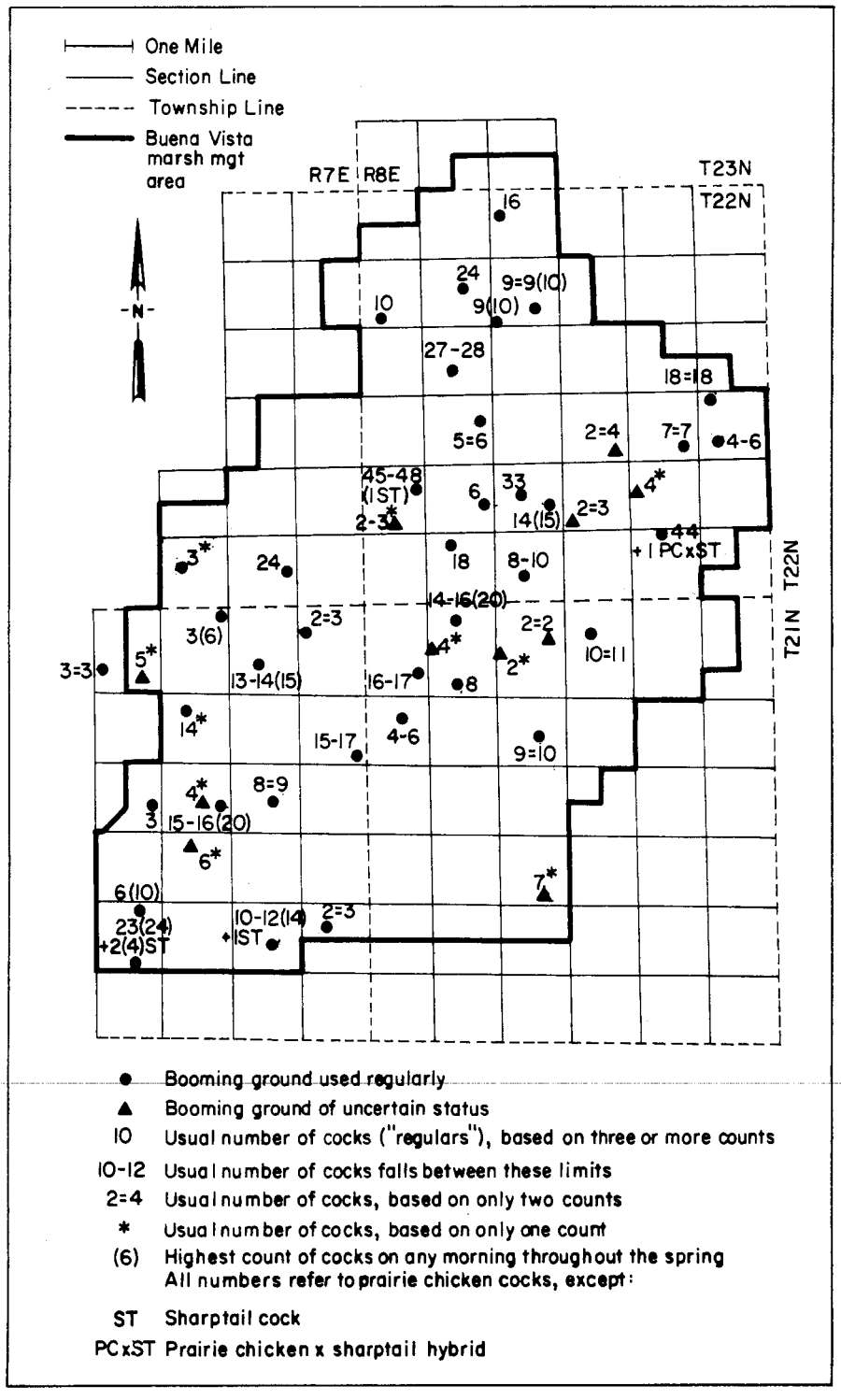


FIGURE 4. *Booming grounds on the Portage County Study Area, 1950. (From Hamerstrom et al., 1957).*

DISCUSSION

Display ground counts are primarily an index to population abundance, and as such have served their purpose well. There is no statistical proof that display ground counts do in fact represent the population because there is no single, positive means of accurately censusing chickens to use as a standard. Booming ground counts have paralleled other rough indices, such as brood counts, field trial counts, and general observations, and they have the advantage of giving a figure which can be arrived at in a consistent manner and used for comparison from year to year. We realize that a single year could be thrown off by accidents of weather or by atypical losses among a few of the largest grounds on an area.

Thus we believe that booming ground counts are a useful index, especially in showing trends over a span of years. For example, booming ground counts clearly show the decline which has occurred on the Plainfield Area, from a strong population in 1940 (258 cocks) and 1950 (232 cocks) to almost complete extirpation by 1968 (12 cocks), followed by a not fully explainable increase (to about 77 cocks) in 1970 and 1971.

Booming ground counts are also an index of habitat quality. Where the grounds are few and far apart, and/or small in size, habitat tends to be poor—a clear warning that management is needed. The results of management, deliberate or inadvertent, and of habitat destruction are also reflected in changing booming ground counts. One cannot carry interpretation of this kind too far, however, as weather, hunting pressure, and the possible influence of the 10-year cycle (which we have not abandoned as a useful hypothesis) may also affect population changes.

On the Buena Vista Marsh management began in 1949 with a winter food patch program. Brush removal began in 1954, on 80 acres, and the tempo of land clearing has been gradually increased to the point that 3,000-4,000 acres were treated annually in the late 1960's and early 1970's.

While the Buena Vista management program has by now created new areas of good nest-brood cover, thus changing markedly the carrying capacity of the area, the disturbance involved—mowing, burning, grazing, spraying with herbicides—has surely had a depressing effect during the years of intensive land treatment. The changeover to a lower key maintenance program began in 1971, and disturbance of this sort will be much reduced in the future. The effective chicken-producing part of the Marsh has been cut by close to 5,000 acres during our study by the encroachment of intensive farming (mainly irrigation) around the edges, which of course reduces the carrying capacity. And a severe drought from about 1955 to 1965 has further complicated the picture.

The Sherry-Vesper and Carson blocks in the area west of Stevens Point are both so small that they can be unduly influenced by local changes. For example, the removal of one farm in the Carson block from the Soil

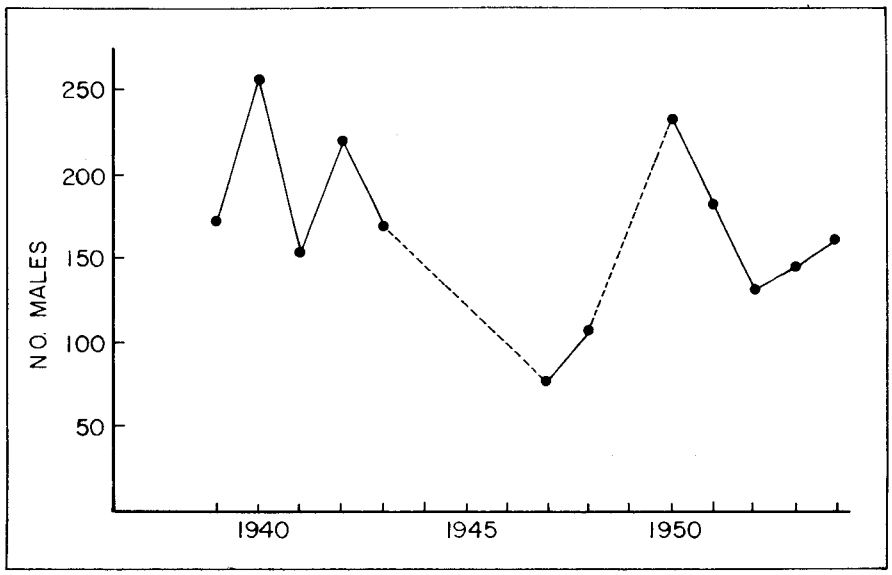


FIGURE 5. *Census of booming ground cocks, Plainfield Area, 1939-1954. (From Hamerstrom and Hamerstrom, 1955).*

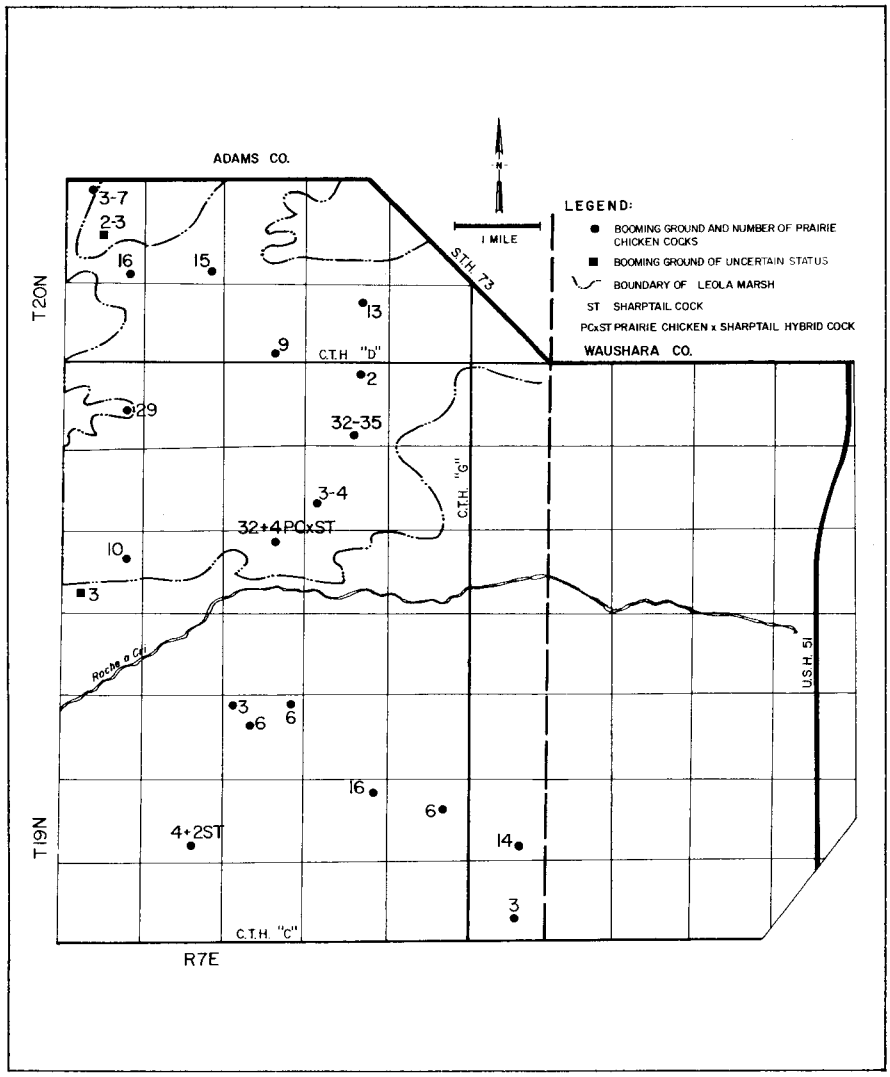


FIGURE 6. *Booming grounds on the Plainfield Area, 1950.*

Bank program wiped out a substantial part of the most productive habitat on the area. The near total destruction of chicken habitat on the Plainfield Area, reported elsewhere, has been by far the governing factor in determining chicken numbers there.

Our counts have limited usefulness in supporting or denying the 10-year cycle; nevertheless, there is a strong suggestion of it in these data. The contiguous Buena Vista Marsh and Plainfield Area were both at a pronounced high in 1950 and dropped off sharply thereafter, as anticipated. Our earlier records for the Plainfield Area show an even greater high in 1940 and a low in the mid-forties. The departure from cycle theory is, of course, the failure of the population to rise to a high in 1960 or 1961. Granted that habitat destruction on the Plainfield Area accounts for the general loss of birds there and that habitat on the Buena Vista Marsh was suffering from drought and the temporary disturbance of land treatment, it would seem that there should have been at least a token increase. Even the lack of a 1960 high is not completely damning, however, for Leopold* has described skipped cycles in both ruffed grouse and prairie chickens in the past. Finally, the upturn in the counts in 1970 and 1971, after 11 low years, comes at the time when a cyclic rise is to be expected. We cannot pretend that there is clear evidence for the 10-year cycle in these figures, but neither are we willing to say that prairie chickens are non-cyclic.

We recommend the continuation of the booming ground surveys on the Buena Vista Marsh, the Plainfield Area, and the area west of Stevens Point. Both practical and academic values are involved. The usefulness of such counts as indices of habitat condition, both to show where management is needed and to appraise the effects of management, have been shown. And from the point of view of population research, the counts on the Plainfield Area and the Buena Vista Marsh are among the longest series extant, with the added value they have with them (reported later) cover type maps to show in some detail the habitats in which these populations live. It is perhaps true that manage-

* Leopold, Aldo. 1931. Report on a game survey of the North Central States. Sporting Arms and Ammunitions Mfgrs. Inst., Madison, p. 155-156, 166-168.

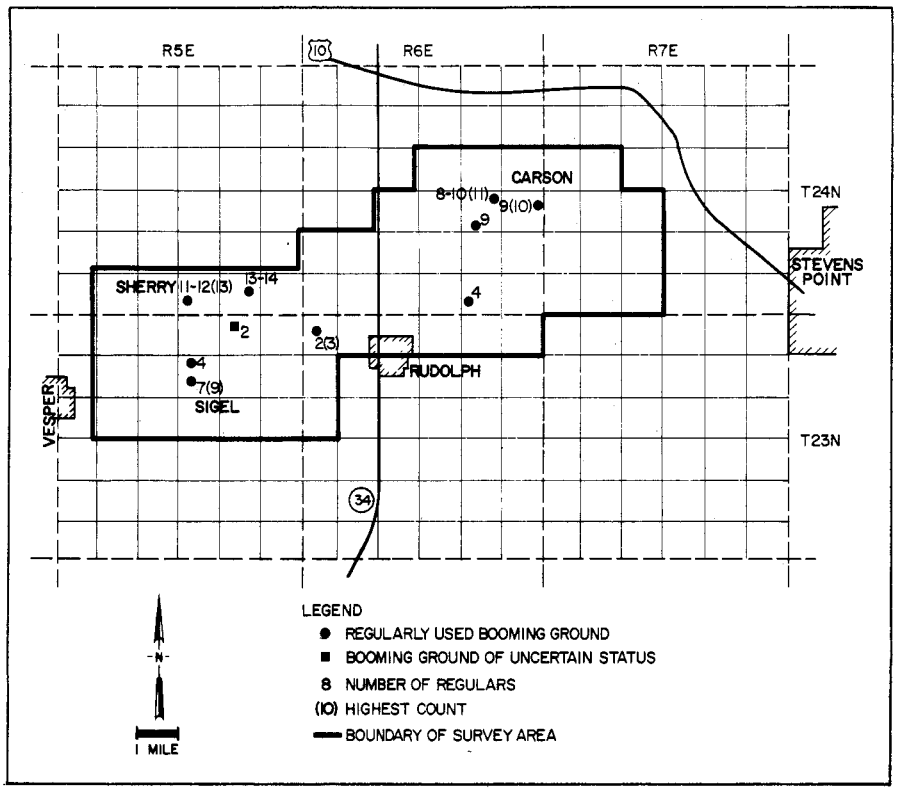


FIGURE 7. *Booming grounds on the area west of Stevens Point, 1968.*

ment's needs could be largely met with a rough, reconnaissance type of annual count. However, the difference in cost between that and a precise count would not be great, and the value of a continuing research count would be very great indeed. The contractual arrangement of the last few years with the University of Wisconsin at Stevens Point has been highly successful. Should the Department of Natural Resources find it inconvenient to continue the booming ground survey on the scale of past years, we strongly urge that the contract with the University be continued and strengthened as needed.

SUMMARY

This report tells how to find booming grounds, defines terms, and gives the reasons for basing year-to-year comparisons on counts of cocks only.

Annual counts are given as follows: on the Buena Vista Marsh, 1950-1971, on the Plainfield Area, 1950-1971, and on a two-part study area west of Stevens Point, 1962-1971.

We find that booming ground counts are useful as an index of population status and trends and as an index to habitat quality, both to show where management is needed and to appraise the effect of management under way. For these reasons we recommend that annual surveys be continued.

While neither strongly confirming nor denying the existence of the 10-year cycle, the data are at least suggestive that prairie chickens may indeed follow the cyclic pattern.

TABLE 1. Spring Counts of Prairie Chickens on Booming Grounds, 1950–1971.*

	Portage County Area				Plainfield Area			
	Chickens				Chickens			
Year	Range	Avg.	Sharptails	Hybrids	Range	Avg.	Sharptails	Hybrids
1950	537–563(588)	550	3(6)	1	227–236(242)	232	2	4(6)
1951	528–572(630)	550	5(10)	–	177–189	183	1	2
1952	255–275(324)	265	3	–	119–144(145)	132	2	–
1953	337–351(399)	344	2(3)	4(5)	139–152(159)	146	1	2
1954	242–270(296)	256	–	2(3)	155–169(171)	162	–	2
1955	293–316(348)	305	–	2	102–118(122)	110	–	–
1956	290–307(348)	299	1(2)	–	105–112(115)	109	–	–
1957	231–247(285)	239	–	1	109–118(122)	114	–	–
1958	288–306(345)	297	–	4(5)	123–129(133)	126	–	–
1959	164–173(216)	169	–	4(7)	71–73 (83)	72	–	–
1960	149–164(192)	157	–	6(9)	55–57 (58)	56	–	–
1961	131–138(161)	135	–	4–5(7)	45–46	46	–	–
1962	155–159(181)	157	–	3–4	43–45 (46)	44	–	–
1963	143–156(194)	150	–	–	35–38 (39)	37	–	–
1964	169–181(205)	175	–	–	36–39 (40)	38	–	–
1965	161–169(205)	165	–	–	19–22 (23)	21	–	–
1966	181–184(211)	183	–	–	18–22	20	–	–
1967	136–145(161)	141	–	–	10 (13)	10	–	–
1968	135–142(163)	139	–	–	12 (15)	12	–	–
1969	101–106(124)	104	–	–	27–28 (30)	28	–	–
1970	132–141(154)	137	–	–	77–78 (82)	78	–	–
1971	191–204(222)	198	–	–	74–79 (81)	77	–	–

*Counts are of the "regular" cocks (the number most consistently present), with the highest count in parenthesis.

TABLE 2. Summary of Annual Spring Booming Ground Counts-Area West of Stevens Point.*

Year	Carson Township	Sherry-Sigel Townships	Total
1962	26–29(33)	26–27(39)	52–56(72)
1963	24–25(31)	24–26(28)	48–51(59)
1964	17(18)	20–21(24)	37–38(42)
1965	13–14(15)	27–32(37)	40–46(52)
1966	28–31(31)	31–34(38)	59–65(69)
1967	32(36)	33–35(43)	65–67(79)
1968	30–32(34)	39–41(51)	69–73(85)
1969	25–26(34)	31–33(38)	56–59(72)
1970	22–23(25)	38–40(45)	60–63(70)
1971	12(21)	34–34(41)	46–47(62)

*One booming ground ("Highway P" in earlier P.R. reports, 5,3,2,1 cocks respectively) has been dropped from earlier tabulations because it lies outside the area regularly censused.

BREEDING BEHAVIOR

METHODS

Our studies of behavior were first a by-product of the more immediate need to study movements. We were in blinds on booming grounds for the purpose of identifying banded birds in order to learn where they had come from, how far they had travelled, and how long they lived. Rather than cause disturbance by leaving as soon as banded cocks had been checked, and in order to have the best chance to see hens (whose attendance is far less regular than the cocks'), we routinely stayed until activity for the morning (or afternoon) was over. This gave the initial foot in the door. Later, when we began to accumulate more and more histories of known individuals over a period of weeks and then of years, studies of behavior became important in their own right.

We watched behavior primarily on the Portage County Management Area. There have been 80-some booming grounds over the years, counting the small ones and those that disappeared; as many as 550 cocks have boomed on the area in one spring. For 15 years we banded and color marked birds in winter (described in the section "Movements") and so were able to watch known-age, marked individuals on the booming grounds.

We have watched from blinds in autumn, winter, and spring. We here report only on spring behavior, primarily April to mid-May but including also our less intense observations on the preliminaries in late March and the tapering off period as far as mid-June. The inclusive dates for this discussion are March 15 through June 17.

We have been given almost 7,000 man-mornings of help on booming grounds by cooperative observers who have been extremely useful in tracing banded birds and in recording behavior. Table 3 shows the number of observers each year and gives an idea of who these people were. Not only did some individuals spend several to many days helping us within a given spring, so that the number of man-mornings is always greater than the number of individuals, but some of them came back year after year and are thus counted more than once in the 21-year total of individuals. We have not sorted out these duplications, but can say that well over 5,000 individuals have come to help over the years. Many of them have thereby been made aware of the need for prairie chicken management and much of the money which has been raised for private land purchase has come from these very people.

The prairie chicken watch has also been popular among college and university classes in ornithology and ecology. The "Other Colleges" in Table 3 include: for Wisconsin—Milton, Ripon, University of Wisconsin at Oshkosh, at Platteville, and at Whitewater; Beloit, Lawrence, and Madison Area Technical College; and at greater distances the University of Minnesota and St. Olaf's, Iowa State University and Luther, University of Illinois and Wheaton, and the University of Colorado. Individual guests have come from most of the countries of western Europe and from as far as Australia. Departmental personnel have been mainly within the Research Bureau. We have used these

professional research people as shock troops for two days during the peak of the booming season for 20 years: J. B. Hale missed only one spring and R. A. Hunt two; H. A. Mathiak, D. R. Thompson, and E. E. Woehler came during 15 years or more.

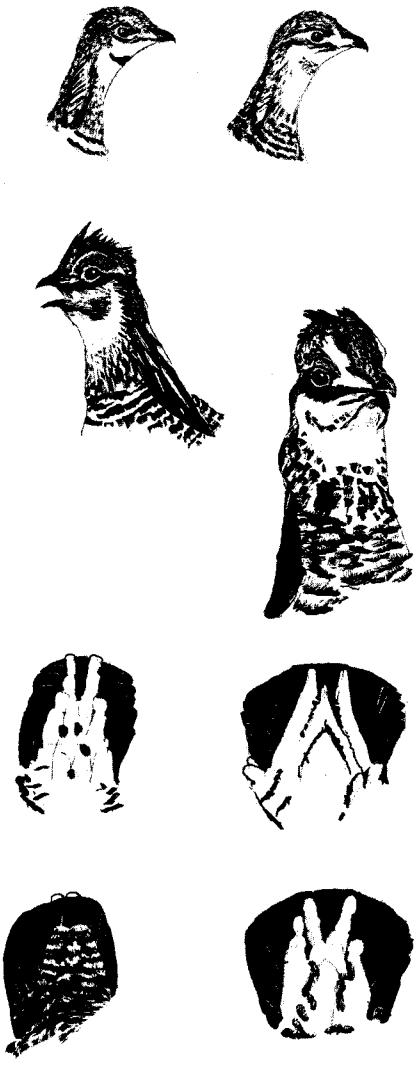
Several individuals have been remarkably faithful. George Socha (outside of his Departmental employment) has come for 7-10 days each spring since 1952; D. D. Berger has almost as long a record; E. W. Peartree helped for a day or two during 20 springs. J. T. Emlen, Jr., F. Greeley, J. J. Hickey, R. A. McCabe, H. C. and Nancy Mueller, and Jerry Vogelsang were especially helpful in the first years of the project. More recently, W. S. Brooks, P. Drake, R. Friday, J. Oar, F. Renn, and Drs. R. B. and Ruth L. Willey have been especially active.

This phase of the project, from 1950 through 1967, has been briefly described by R. A. McCabe.*

Because so many eyes have been available to us, we have been able to keep far closer watch over booming ground activity than would otherwise have been possible. During the first few years in particular, limitation of manpower forced us to concentrate on reading the bands of cocks. Except for one or two booming grounds that we watched more closely, once we had read the cocks we moved on to new grounds. Hens were given first priority whenever they appeared, for we knew the regular cocks would be there day after day. But we surely missed some hens that came to a certain ground before or after our observations there.

Prairie chickens choose short cover for display—a help in band reading. Many booming grounds were on meadows that were mowed or grazed in the course of normal farming operations. After the first few years we mowed other grounds deliberately, both as booming ground management and to make band reading easier.

We were able to cover the grounds more and more thoroughly as time went on, both because we had more observers and because there were fewer grounds to watch (only 16-23 in the 1960's). After 1955 we had a good check of bands on the cocks on all but a few of the smallest grounds. The



With practice, it is not difficult to recognize individuals by their faces, throats and by their undertail patterns.

critically important period of display is April 10-28 except in unusually late springs (Figs. 9 and 11). From 1956 through 1969 we kept a close watch on a number of major booming grounds on which we missed only 2-3 mornings, never more than 4, during this period each spring. Such grounds varied from a minimum of 3 in 1962 to a maximum of 11 in 1959, and averaged 7.3 per year. On a few grounds each spring we had even more intensive coverage, hardly missing a morning for weeks at a time. Figure 11 shows the distribution of 6,014 acceptable blind mornings during the springs of 1950 through 1969—i.e., useable records from individual booming grounds. Even though more than one observer may have been in a blind—often the case—their combined records constitute one blind morning.

The most valuable data come from the 10-year period 1956-1965. During this period we had an average of 7.2 booming grounds under close watch during the critical part of the spring, with observations continuing at nearly the same level to mid-May. Before 1956 we covered the area less thoroughly, and after 1965 we no longer had marked juveniles in the population since we had stopped banding. And after 1965, we sharply reduced the number of observers (Table 3) but concentrated them during the main display period, with fewer days in early May and thereafter.

A few bands escaped us even in the best years—for example, bands with numbers worn off and bands on hens and visiting cocks that were not present long enough to be identified. We estimate that during the years 1956 through 1970, when the last banded bird was seen, we identified 95 percent or more of the banded cocks and nearly as many of the hens; during the earlier years we were probably no more than 90 to 95 percent successful with the cocks and less so with the hens. Similarly, our knowledge of the numbers of unbanded as well as banded birds—especially hens—became increasingly detailed after the first few years, and attention to behavior was correspondingly intensified. Familiarity with the banded birds gave support to our conviction that we could indeed recognize unbanded individuals by distinctive markings, at least during a given spring.

Thus, we have data from a large study area, collected over a considerable period of years, and including substantial numbers of birds of known sex and age. These data have been useful not only as a population index and in studies of behavior, but are essential parts of our studies of movements and of mortality rates, discussed in later sections.

FINDINGS

Part of our material on display behavior has already been published (Hamerstrom and Hamerstrom, 1955, 1960); some further data are presented here.

Booming Grounds

The number and size of booming grounds varied roughly, but only roughly, with the total count of cocks (Table 4). The greatest numbers of booming grounds and of cocks on individual grounds occurred during the years of highest total counts and both fell off as the total count decreased. Booming grounds of uncertain status were always small: only 10 percent

* McCabe, R.A. 1970. Contributions of laymen to North American wildlife research. Trans. Internat. Cong. Game Biologists 8:202-224.

were larger than 5 cocks and the largest was 7. They too varied roughly in number as the total count varied, but the average size followed the total count even less closely than in the case of the stable grounds. Although booming grounds varied in number and size from year to year, there was too little consistency to permit the use of either size or number as a short-cut to an annual population estimate.

Hen Peaks

Once a booming ground is well organized, generally in early April, the number of regular cocks changes relatively little during the rest of the spring. Hens, however, show a very different pattern. Few are present in late March and early April, often none. Then more and more appear until their numbers build to a peak, most commonly about the third or early fourth week in April. There follows a drop in numbers, generally more rapid than the rise, to a low point during the first week in May. A second but much lower peak comes about mid-May, after which small numbers of hens straggle in into June and perhaps occasionally even later. We do not know how many of these latecomers are late nesters and how many are renesters, but a few have been banded birds which we had seen copulate earlier.

Hens are much less regular and predictable in their presence on a booming ground than cocks even within a given morning. Some arrive early and stay long; others are on for only a short time; a few may even go away and return. Sometimes the number builds to a maximum and then falls off in a regular manner with no returns or late arrivals to confuse matters, but often—especially during the peak—one cannot be certain of the precise number of individuals that came during the whole morning. By examining the times and directions of arrivals and departures (part of the daily note taking scheme), and with the help of bands and individual charcteristics, we could generally arrive at a reasonable approximation of the true figure. Such approximations are used along with accurate figures in the hen peak graphs which follow, but we are sure that the over-all picture is a true one.

Figure 8 shows the pattern of hen appearances from 1956 through 1965 (the period of our best data), with both an early year (1958) and a late year (1965) for comparison with the average. Hen peaks—here defined as at least 45 percent as many hens as cocks—have varied considerably in height (from 51-112% in 1956-1965 and 45-112% in 1956-1969), but have embraced a rather narrow time span

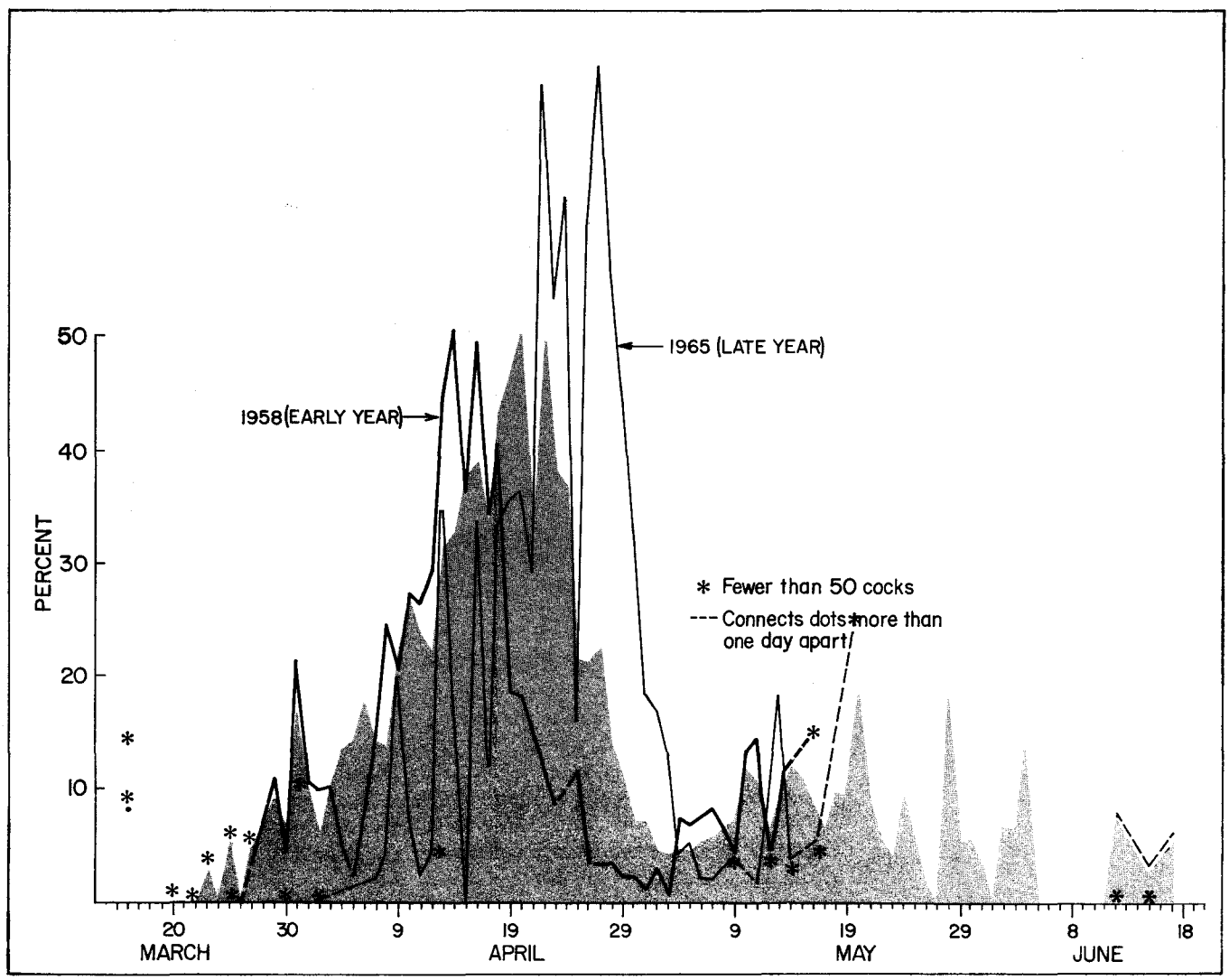


FIGURE 8. *Prairie chicken hens (as percent of the maximum number of cocks each morning) on booming grounds, 1956–1965.*

(Fig. 9). The day with the greatest number of hens of all—the peak day—has averaged April 18. The earliest peak day came on April 14 and the latest on April 27, with 93 percent between April 14 and 22. The peak day has fallen on April 20 more often than on any other day.

A year near to the normal, 1964, is shown in Figure 10. The figure illustrates several things: the number of booming grounds under observation each morning, the daily number of hens expressed as percent of the greatest number of cocks that day, and the number of copulations seen that morning. As in all years there were few observations after May 15, but the accumulated records of many years show that few hens appear and few copulations occur after that date.

Hen peaks have characteristically been interrupted rather than continuous (Figs. 8, 9 and 10), to such a degree that even the 10-year average of Figure 8 is not smooth. These irregularities were generally caused by weather. Prairie chicken activity is most intense on clear, still, and frosty mornings; the ideal temperature range is about 25-40 F. In Figure 10 the deep notch on April 17, 1964 represents a warm and windy morning (64 degrees, wind south at 15 mph), while April 21 was 40 degrees with intermittent hard rain and a 10 mph west wind. We have seen intense display and copulation on rainy mornings—and indeed three copulations were seen on April 21, 1964—but poor weather does discourage over-all activity and can stop it altogether.

Copulations

We have useable records of 2,264 copulations which have been seen on booming grounds during our study. The earliest was April 5 and the latest June 13; most have been between April 12 and May 24, with a strong peak between April 18 and 26, followed by a much lower and less definite peak between May 7 and 13 (Fig. 11). As might be expected, the shape of the graph of copulations is similar to that of hen peaks. However, when one compares hen peaks and copulation peaks year by year (Figs. 9 and 10), it is plain that the greatest number of copulations generally came a few days *after* the days on which most hens were reported: in the 14 years with adequate data (Fig. 9), copulation peaks came after hen peaks 11 times, on the same day 3 times, and

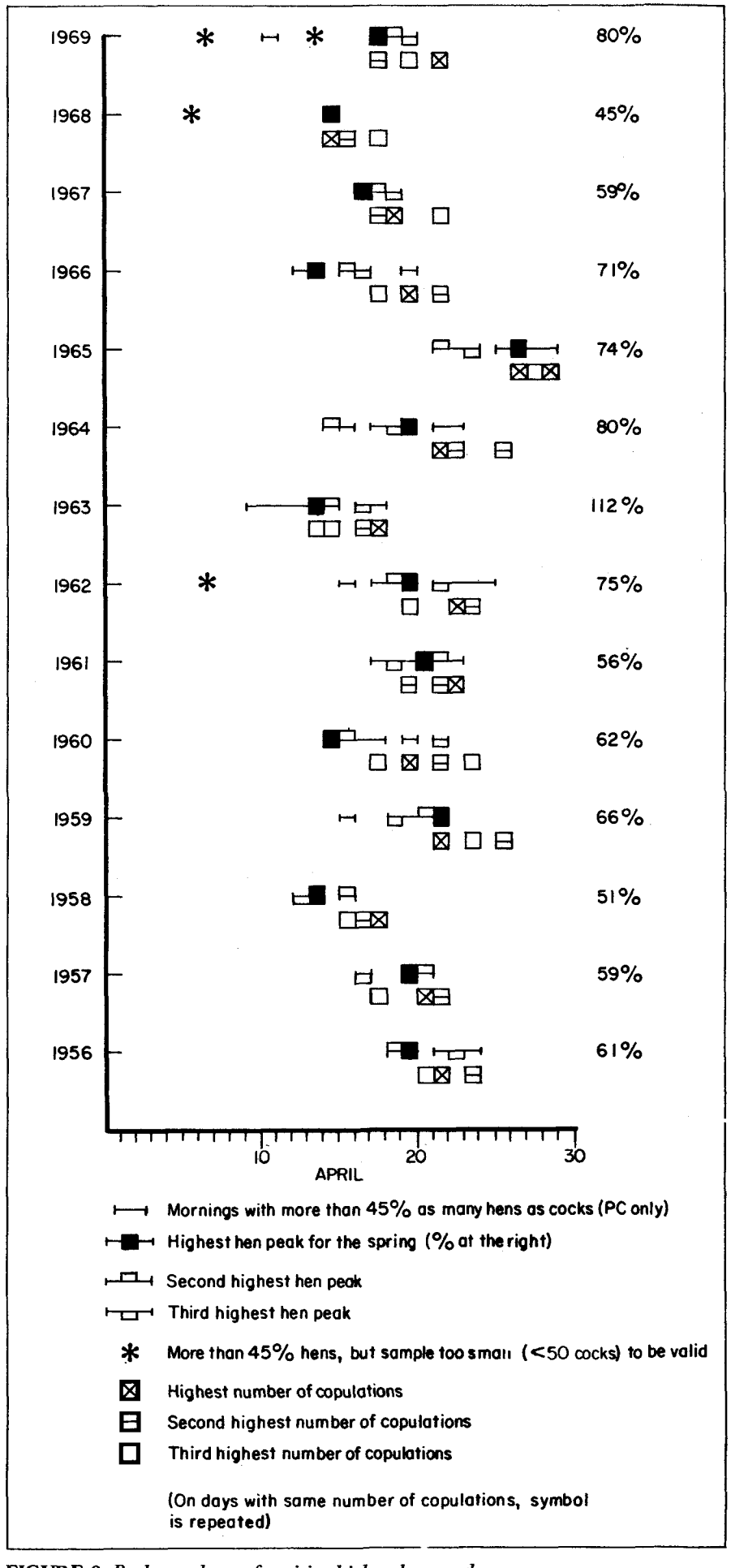


FIGURE 9. *Peak numbers of prairie chicken hens and copulations on booming grounds.*

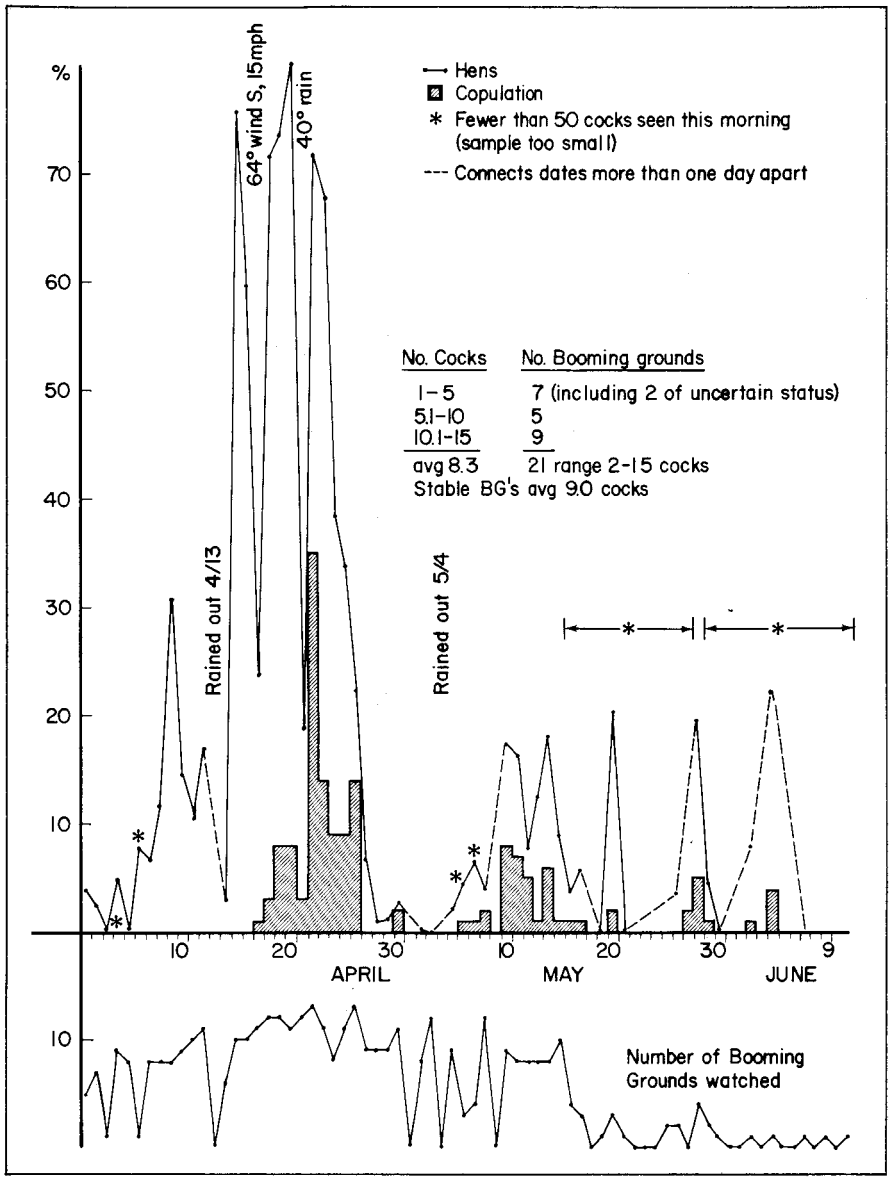
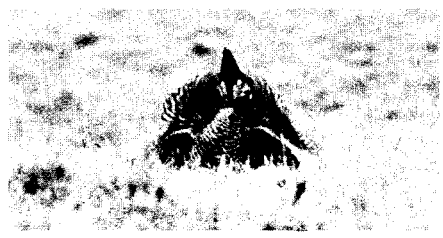
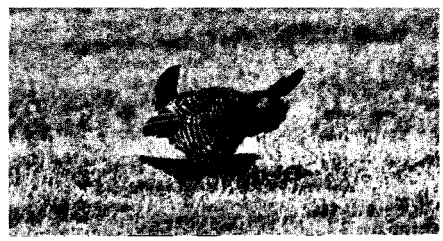


FIGURE 10. *Prairie chicken hens (as percent of maximum number of cocks each morning) and copulations (actual number seen each morning) on booming grounds in a "normal" spring, 1964.*

Inviting hen...



... and normal copulation.



"Weirdo" cock mounts hen and stands or actually booms on her back.

never before the hen peak. The lag varied from 1-6 days and averaged 3.2.

Eight hundred of these copulations were by color-marked known-age birds—549 by banded cocks with unbanded hens, 169 by banded hens with unbanded cocks, and 82 in which both birds were banded. Details as to the number and success of copulations by juveniles as compared with adults are given in Tables 5 and 6. Copulations by interior as opposed to exterior cocks are shown in Table 7.

The foregoing deals with normal copulations, during which the hen invited and the cock mounted squarely. We have also seen what we have to come to call—for lack of a better term—"multiple weirdos": repeated, strangely ineffectual attempts which were occasionally successful after many tries but generally not. Occasional imperfect attempts have simply been classed as attempts and not as copulations; it is the persistent repetition (more than 5) combined with the unusual nature of these attempts that has lead us to give them a special name. Sometimes a hen invites, allows the cock to mount, then seems unable to turn her tail properly; the cock dismounts, the hen invites, and the whole procedure is repeated many times. Or the cock, having mounted a receptive hen, seems not to know what to do next and booms back and forth along her back and rump. We have seen as many as 37 consecutive ineffectual attempts. In all, we have seen 309 such attempts, of which only 8 (2.6%) appeared to be successful. Figure 12 shows the distribution of their occurrence, which tended to peak shortly before the secondary peak of normal copulations.

DISCUSSION

With so many helpers, it is fair to question the accuracy of the data. After the first few years, cooperators were briefed each evening so that they knew what kinds of information we wanted and how to record it. At a debriefing session over coffee immediately after their return from the booming grounds, we went over their notes with them to make sure we understood, and they summarized their notes on a form which we provided (Fig. 13). Original notes and summaries were left with us for future use. We have culled the material that we consider unuseable; there is surprizingly little.

In addition, we had a number of built-in controls: (1) After the first

few days each spring, we had (but the observer did not) an increasingly detailed knowledge of the cocks on each booming ground under regular observation, and of the number of hens coming each day. Major discrepancies rarely occurred, but were immediately apparent when they did. (2) We also knew the band numbers and color combinations of the regular cocks and their territorial positions, and could use reports of the known birds as a measure of the accuracy of reports of something new. (3) Since most birds, including hens, were present for more than one day, we generally had more than one report on which to base identification. (4) Similarly, behavior generally showed patterns which developed over a period of days rather than changing abruptly, and our day-to-day study of the records of each ground gave us a good basis for evaluating each new morning's notes. (5) Finally, we arranged the schedule (normally 10-12 people per morning, scheduled months in advance) so as to have a leavening of capable observers who could be assigned to the grounds where particularly close attention was needed.

We are confident that our presence had little effect on the birds. Observers were told how to behave in the blind, almost always arrived before the birds, and were told how long to stay and not to leave so long as a hen was present; exceptions were noted and evaluated. We rarely trapped on booming grounds (see "Movements"); such mornings and other experimental operations were generally excluded from the notes on behavior. Major disturbances thus were rare, and affected grounds were allowed to "cool" for 2-3 days afterward.

We have tested the results in two ways. Figure 14 presents the number of copulations seen during all years 1950-1969 with those seen during only the years of best data, 1956-1965. We compared these curves to see whether the ragged shape of the all-years curve might be an artifact due to the fewer and more scattered mornings of watching in the earlier years. The best-years and all-years curves are in fact closely similar. Some difference in details is to be expected, since copulation peaks have occurred at slightly different times in different years and the all-years curve includes years which are excluded from the best years. In Figure 15 we have compared the reports of copulations seen by all observers 1950-1969 with

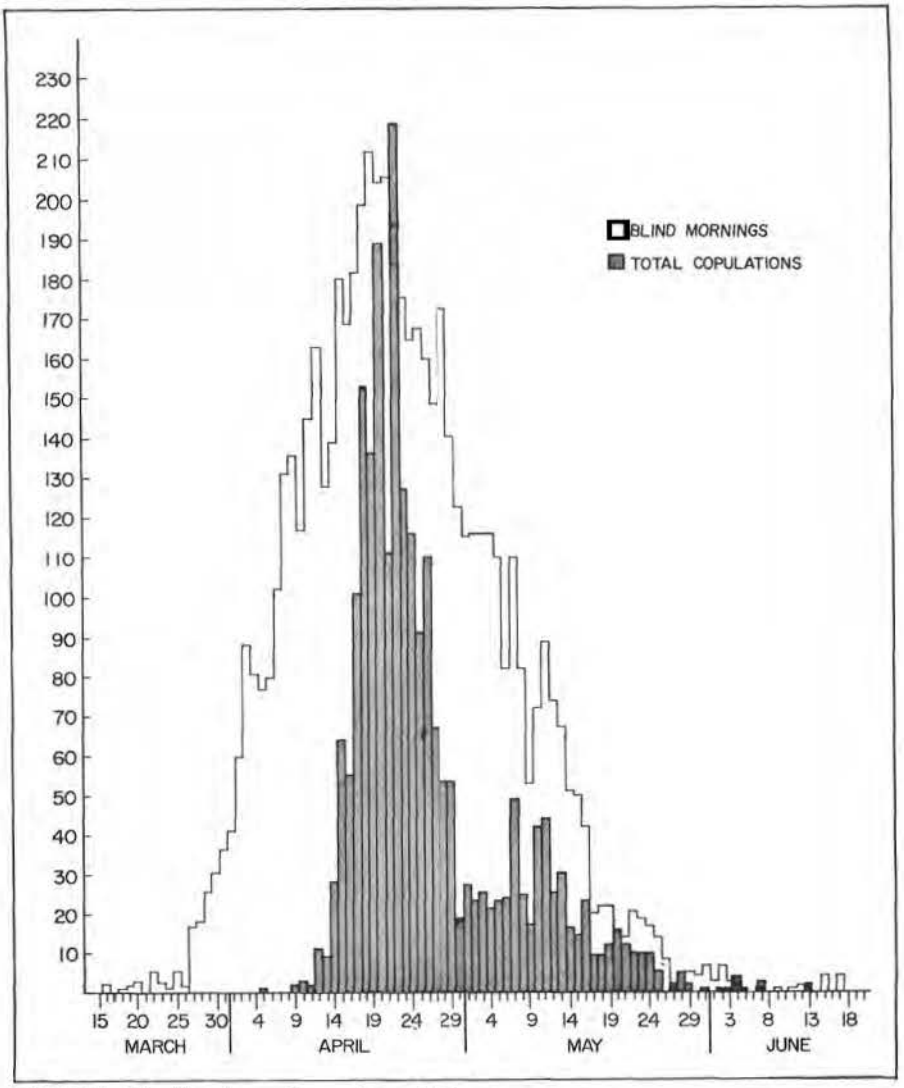
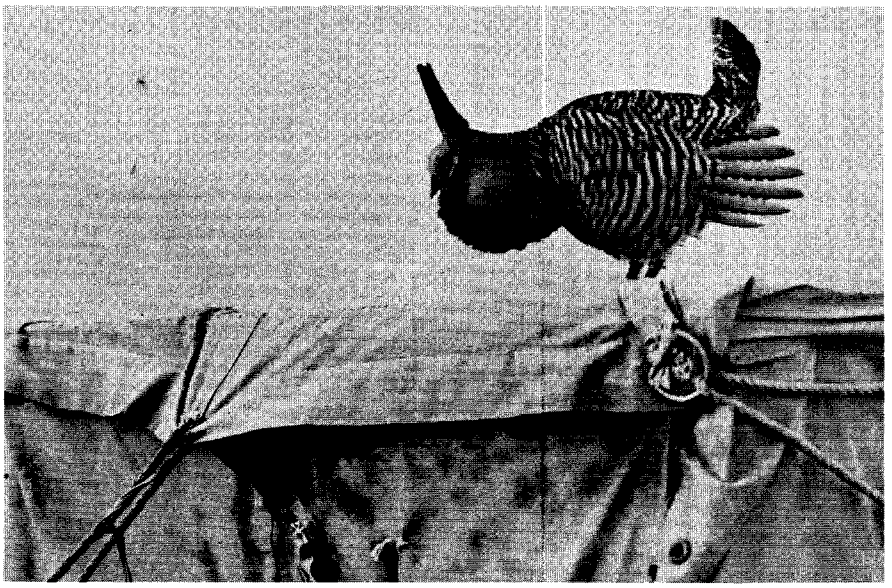


FIGURE 11. *Total number of copulations seen on booming grounds, 1950-1969.*

Cooperators check in immediately after returning from a morning in the blind.



Chickens don't pay much attention to the blind– and sometimes boom on top of it.

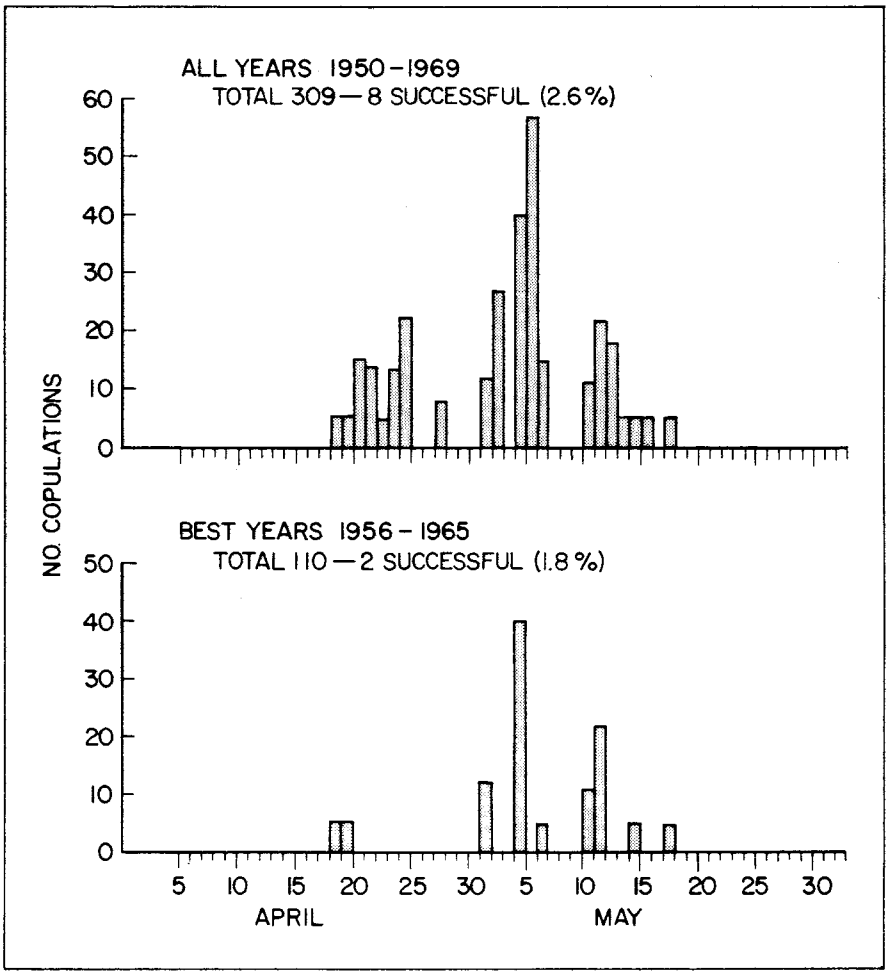


FIGURE 12. *"Multiple weirdos"–repeated aberrant attempts at copulation.*

those seen by the best observers (project members, other professionals, graduate students, repeaters of known capability, etc). Here again the two curves are very similar although not identical. The high proportion of records by "best observers" after mid-May comes from the fact that we did not schedule miscellaneous observers late in the season; the late records are fewer in number than in mid-season, but most were made by members of the staff and a few other skilled observers.

Altogether, we conclude that the data are generally sound. While it is unquestionably true that some errors have escaped us and are included, we believe that such errors as there may be cannot appreciably distort the over-all picture, and that the broad picture which emerges is far more valuable than a more intensive study of narrow focus. Actually, we have both, for we have accumulated over the years a number of case histories of particular grounds which were very closely watched by trained people.

Our information on breeding success leads to several unorthodox ideas. In 506 copulations by banded cocks of known age, 82 percent were by adults, and 18 percent by juveniles. This substantial percentage of mating by juveniles suggests that the old, pretty well agreed-to idea that in lekking grouse young birds are very much held down or even entirely excluded from reproduction is not so among prairie chickens. Our data for hens do not fit the idea that juveniles are excluded from breeding either. Of 204 copulations by banded known-age hens, 30 percent were by juveniles.

Copulation success was high and was about the same for both age groups. Of 516 copulations by adult cocks of which the success or failure was known (judged as well as we could by several criteria), 76 percent were successful, while 84 percent were successful among 74 by juvenile cocks. We suspect that the difference between the two is not significant. The figures for known-age hens are similar: of 175 copulations by adults, 78 percent were successful; and of 56 copulations by juveniles, 82 percent were successful. The young hens, also, are doing as well as the old ones.

The question of social rank order and its importance among cocks on the booming ground has attracted much attention. It is plainly impossible to set up a linear order of dominance among a group of birds that do not all have free access to one another. The territorial spacing on a booming ground of even moderate size means that many cocks never come into direct contact. It is fair to say that interior cocks must be more aggressive than exterior cocks, but how does one define an interior cock?

We thought it was easy, but after we had spent months working with maps of territories, made over the years, we discovered that it is not so very easy after all. We settled upon the criteria that: (a) any cock entirely surrounded by other cocks is an interior cock, and (b) any cock whose territory is not surrounded on all sides, and who can thus escape from a fight without trespassing on another's territory, is an exterior cock (Fig. 16).

Differences in dominance may well exist among interior cocks, but we have found no satisfactory way to find them. The usual approach of counting and measuring seems inadequate, largely because the score given to any one cock is influenced by the actions and reactions of his neighbors, all different, and no two cocks have the same set of neighbors. A straight tally of fights won means little, for the cock who has just won a boundary dispute and who has followed into the other's territory will almost surely be turned on and driven out: who was the winner? Ritualization is an enormous complication. Once territorial boundaries have been established, booming as ritual fighting greatly reduces actual contact. Changes in dominance do sometimes occur—a cock enlarges his territory at the expense of his neighbors, or another is crowded off to the edge—but to try to establish an order of dominance among stable interior cocks has seemed to us unfruitful.

As between the two classes, interior vs. exterior, our figures support the commonly accepted idea of dominance, at least in part. It is by no means true that only interior cocks copulated. However, we have seen about twice as many copulations by interior (especially among the older ones) as by exterior cocks, although there have been more exterior than interior cocks in total. Large booming grounds may have several interior cocks, but small grounds have none at all.

It is striking, however, that there has been little if any difference in the success of copulations as between interior and exterior cocks. For all ages combined, there were 381 copulations by interior cocks, of which 76 percent were successful, and 174 by exterior cocks of which 80 percent were successful. Considering juvenile cocks alone, 87 percent of 24 copulations by interior birds were successful, and 81 percent of 48 copulations by exterior birds were successful.

Our findings on breeding habits have caused a number of our earlier notions to tumble. If grouse researchers are to build theoretical population models that include the representation of age classes on display grounds and the parts that the various age classes play in reproduction, we really need to know whether or not young birds are actually excluded from breeding. From what we have seen, young prairie chickens are not.

Pred:

WISCONSIN CONSERVATION DEPARTMENT
Madison 1, Wisconsin

R&P-3

BOOMING GROUND SURVEY

Name of Booming Ground ..... Date .....

Observers ..... Weather .....
Arrival time of observers ..... Arrival (or return) time of birds .....
Did you beat the birds to the booming ground? ..... Left blind at .....

COCKS ONLY: Highest count: Chicken cocks ..... Sharptail cocks ..... Hybrid cocks .....
No. present most of AM (PM): Chicken cocks ..... Sharptail cocks ..... Hybrid cocks .....

HENS: It is often hard to know how many *individual* hens there were during the AM as they may keep moving in and out, but certain limits can be set. (HENS ONLY):
Chickens - There were at most ..... At least ..... Probable number of individuals .....
Sharptails - There were at most ..... At least ..... Probable number of individuals .....

COPULATIONS: Total number ..... How many were interrupted? ..... Not interrupted ..... How many do you think were successful? ..... How many were in *outermost* ring of territories (edge territories)? ..... Interior territories? ..... Unknown? ..... Did any banded cocks copulate? ..... Banded hens? ..... Which ones, and how many times each? Give this information opposite band numbers, below.

BANDS: Total number of banded birds on booming grounds - chickens cocks ..... chicken hens ..... sharptail cocks ..... sharptail hens ..... hybrids ..... How many birds were unbanded (both legs checked) - cocks? ..... hens? .....

BAND RECORD: *IMPORTANT:* BE SURE TO NOTICE AND RECORD WHICH LEG (Right or Left) EACH BAND IS ON. Read the numbers on the colored bands if you can; if not, describe what bands you see and which leg they are on anyway. When there are two bands on one leg, read only the number on the *upper* band. List bands for each bird separately, for example:

Sex	Left Leg	Right Leg	No. Cops	No. of Unbanded Cocks	No. of Unbanded Hens	No. Not Checked or?	
						Cocks	Hens
Cock	Black 86	Yellow 14 over red	2	8	4	2	3
Hen	Green 37	Alum	1				

The following colors are in use, singly or in combinations: white, yellow, red or pink (not necessary to distinguish between these two), green, black, purple (spiral bands) yellow-blue-yellow (spiral bands, 2 yellows with a blue between; record as "YBY"); some are plain uncolored aluminum.

MAP: It will be a great help to the next person coming to this ground, and to us in keeping track of booming ground behavior, if you can make a rough sketch showing the relative positions of the cocks on the booming ground. Indicate all banded cocks, and their numbers; those that you can be sure are not banded, and those that you could not check for bands. Please show also which cocks copulated, if any. Indicate north, the position of the blind, and the approximate scale.

REV. 2-44

FIGURE 13. *Booming ground summary sheet.*

SUMMARY

From 6,014 blind mornings of observation in spring we learned that:

The size and number of individual booming grounds varied only roughly with changes in the total annual count of cocks.

The number of hens on booming grounds progressed from few or none in early spring to a major peak (more than 45 percent as many as the cocks present) in the third or early fourth week of April, followed by a second but much lower peak about mid-May, with few hens seen thereafter. Major peaks lasted 1-10 days, averaging 6.7; the single day of the highest count averaged April 18, and the proportion of hens varied from 45-112 percent of the number of cocks.

Among 2,264 copulations which have been seen on booming grounds, most have been between April 12 and May 24, with a strong peak between April 18 and 26 and a lower peak between May 7 and 13. The major peak of copulations lagged 1-6 days

(average 3.2 days) behind the major peak of hen numbers.

Contrary to general belief, young birds are not excluded from reproduction. Some juvenile cocks hold territories, including interior territories; 18 percent of the copulations by known-age cocks were by juveniles and 30 percent of those by known-age hens were by juveniles. Success rate was as high among juveniles (cocks 84 and hens 82%) as among adults (cocks 76 and hens 78%).

More copulations have occurred among interior than exterior cocks, but there has been little if any difference in success rate (76 and 80%, respectively).

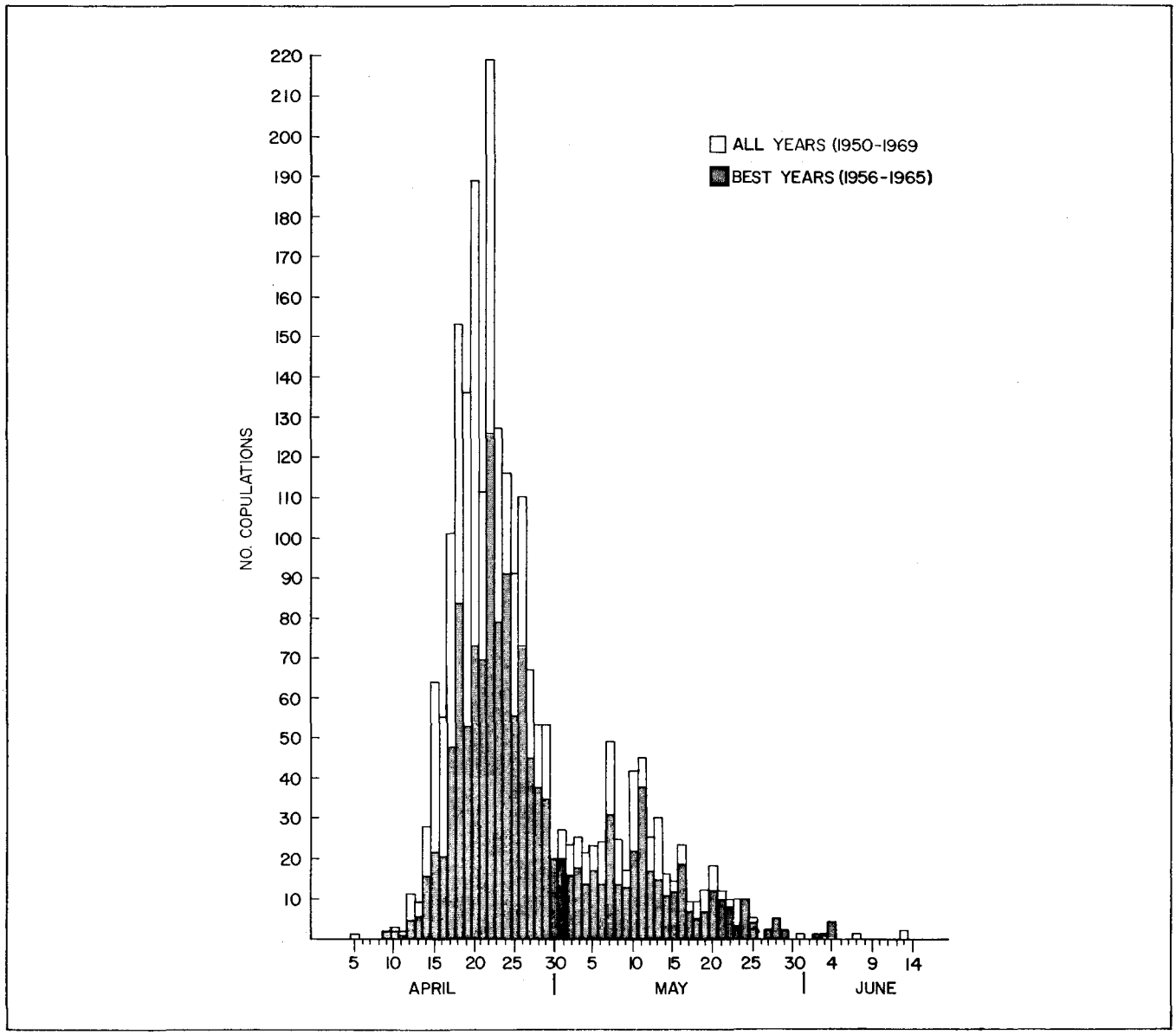


FIGURE 14. *Copulations seen during the springs of 1950-1969 compared with the years of best data, 1956-1965.*

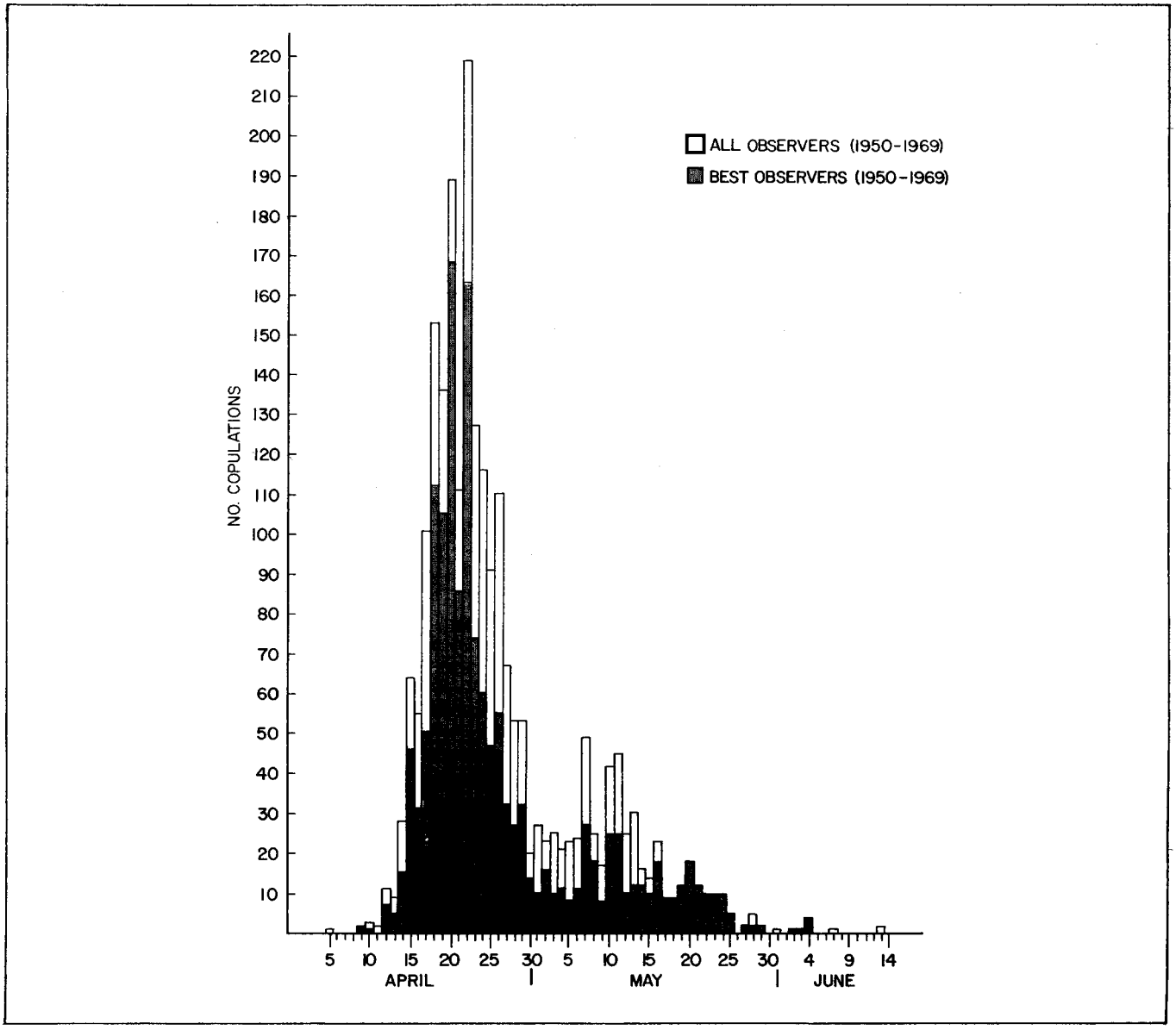
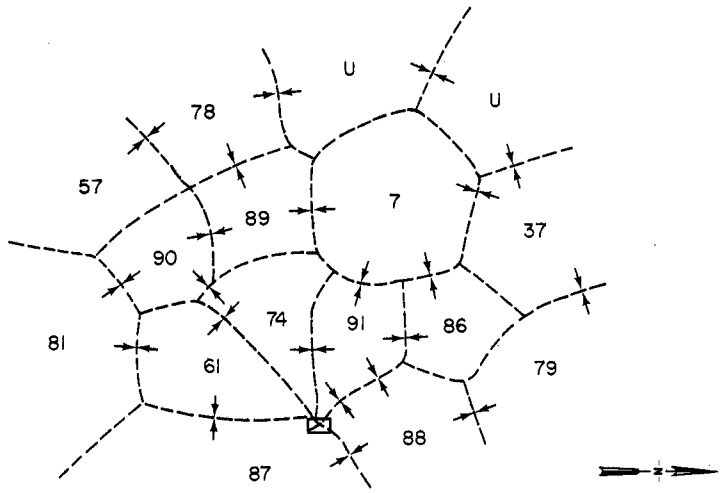


FIGURE 15. *Copulations seen by all observers compared with those seen by the best observers (1950-1969).*



BAND	AGE (yrs)	No. COPULATIONS
7	2	0
37	≤ 4	2
*57	2	0
61	2	0
74	≤ 4	0
78	1	1
79	≤ 2	0
81	1	0
86	1	0
87	≤ 2	0
88	1	0
89	≤ 2	0
90	1	0
91	≤ 2	8
	Territory unknown	5
	Total copulations	16

* Present only a few days
≤ At least; bird was adult when banded
U Unbanded
Major fighting/sparring point (not all included)
Blind

All birds were banded in winter, none on the booming ground in spring.

FIGURE 16. *SERR booming ground, 1964, showing interior (fully closed in) vs. exterior (open to the rear) territories. The age and copulations of banded cocks are tabulated. Territory boundaries are estimated rather than measured, hence no scale is given. Composite of several maps. (For a careful map of the same booming ground in 1966, when only one of these banded cocks remained, see Figure 93, p. 368 in Hjorth Ingemar, 1970. Reproductive behaviour in Tetraonidae. Viltrevy 7(4). Cock F = our 81.)*

TABLE 3. Number of Observers Participating in Display Ground Observations in Spring.

Year	Univ. Wis.– Madison	Univ. Wis.– Stevens Pt.	Other Colleges	Wis. Soc.* For Ornith.	Other Bird Clubs	High Schools	PC** Foundation	Society[1] Tymp. Cup. Pin.	Misc.	Wis. Dept. Nat. Res.	Total Individuals	Total Man AM's
1950	34	–	–	–	–	–	–	–	27	21	82	104
1951	60	24	–	–	–	–	–	–	17	19	120	177
1952	43	16	–	41	8	–	–	–	23	19	150	188
1953	47	17	–	30	13	–	–	–	68	13	188	225
1954	60	22	–	40	6	–	–	–	103	16	247	281
1955	82	40	–	19	12	–	–	–	99	19	271	345
1956	71	45	–	28	25	–	–	–	135	14	318	376
1957	59	45	29	21	18	–	–	–	154	13	355	450
1958	51	51	57	22	–	57	–	–	81	19	338	410
1959	47	82	48	27	28	40	10	–	78	20	380	451
1960	73	58	61	13	45	22	14	–	106	19	411	476
1961	58	67	34	31	10	43	28	18	72	15	376	442
1962	63	39	30	17	6	23	16	53	40	15	302	338
1963	63	55	35	23	2	10	12	105	78	15	399	453
1964	89	34	41	24	7	3	10	76	87	19	390	452
1965	72	23	86	15	–	7	13	39	81	19	355	417
1966	70	40	53	25	–	3	19	8	64	14	296	340
1967	59	1	63	26	–	–	13	17	59	17	255	278
1968	46	5	32	12	–	–	6	18	80	10	209	226
1969	48	–	34	22	6	–	2	23	55	11	201	224
1970	9	–	37	–	–	–	–	17	55	1	119	127
Totals	1,204	664	640	436	186	208	143	374	1,562	328	5,762	6,780

*Wisconsin Society for Ornithology.

**Prairie Chicken Foundation.

[1]Society of Tympanuchus Cupido Pinnatus.

TABLE 4. Number and Size of Booming Grounds on the Buena Vista Marsh, 1950–1971.

		All Booming Grounds													Stable Booming Grounds				Grounds of Uncertain Status**			
			Number of Cocks												Number of Cocks				Number of Cocks			
Year	Total Cocks*	No. of Booming Grounds	1–5	5.1–10	10.1–15	15.1–20	20.1–25	25.1–30	30.1–35	35.1–40	40.1–45	Avg.	Min.	Max.	No.	Avg.	Min.	Max.	No.	Avg.	Min.	Max.
1950	550	48	16	13	6	6	3	1	1		2	11.5	2	45	38	13.5	2.5	45	10	3.7	2	7
1951	550	52	15	15	11	7	1	1	2			10.6	1	34	43	12.0	1.5	34	9	3.9	1	8.5
1952	265	40	19	16	3	2						6.6	1.5	16.5	35	7.2	2	16.5	5	2.8	1.5	4
1953	344	42	16	14	5	6	1					8.2	2	22.5	35	9.2	2	22.5	7	3.2	2	5.5
1954	256	29	7	13	6	3						8.8	1	18	27	9.3	1	18	2	2	1	3
1955	305	37	12	12	10	3						8.2	1	18.5	34	8.8	1	18.5	3	2.2	1.5	2.5
1956	299	35	11	12	7	4	1					8.5	1	20.5	32	9.2	1	20.5	3	1.3	1	2
1957	239	32	12	10	9	1						7.5	1	17.5	27	8.6	2	17.5	5	1.3	1	2
1958	297	31	9	7	9	5	1					9.6	1	22.5	27	10.3	1	22.5	4	4.5	2	7
1959	169	27	11	11	5							6.2	1	14.5	23	7.2	2	14.5	4	1	1	1
1960	157	22	7	11	3	1						7.1	1	16.5	18	8.2	3	16.5	4	2.1	1	3
1961	135	18	8	6	4							7.5	2	14	18	7.5	2	14	0	–	–	–
1962	157	22	9	10	2	1						7.1	1	16	20	7.5	2	16	2	3.5	1	6
1963	150	23	9	10	4							6.5	1	12.5	19	7.6	2	12.5	4	1.2	1	2
1964	175	21	7	5	9							8.3	2	15	19	9.0	2	15	2	2	2	2
1965	165	23	9	8	5	1						7.2	1	19	17	9.1	4	19	6	1.8	1	4
1966	183	21	7	5	7	2						8.7	1	19.5	18	9.9	4	19.5	3	1.7	1	2
1967	141	16	3	7	3	3						8.8	2	16.5	15	9.2	2	16.5	1	2	2	2
1968	139	18	8	6	2	1	1					7.7	1	21.5	16	8.3	1	21.5	2	2.5	1	4
1969	104	16	7	7	1	1						6.4	1	16	16	6.4	1	16	0	–	–	–
1970	137	17	9	3	2	2	1					8.0	1	21.5	13	10.0	4.5	21.5	4	1.6	1	2.5
1971	198	21	8	7	2	1	2	1				9.4	1	30	19	10.3	2	30	2	1	1	1

*See Table 1 "Spring Counts of Prairie Chickens on Booming Grounds".

**All smaller than 5.1 except:
1950–2 (6 and 7 cocks)
1951–2 (6.5 and 8.5 cocks)
1953–1 (5.5 cocks)
1958–2 (6 and 7 cocks)
1962–1 (6 cocks)

TABLE 5. Number of Copulations Among Adults and Juveniles*

Sex	Adults: No. of Copulations	Adults: Percent	Juveniles: No. of Copulations	Juveniles: Percent	Total Copulations
Cocks	416	82	90	18	506
Hens	142	70	62	30	204

TABLE 6. Success of Copulations Among Adults and Juveniles*

Sex	Adults: No. of Copulations	Adults: Percent Success	Juveniles: No. of Copulations	Juveniles: Percent Success	Total Copulations
Cocks	516	76	74	84	590
Hens	175	78	56	82	233

TABLE 7. Success of Copulations Among Cocks on Interior and Exterior Territories*

Position	Adults: No. of Copulations	Adults: Percent Success	Juveniles: No. of Copulations	Juveniles: Percent Success	All Ages: No. of Copulations	All Ages: Percent Success
Interior	357	75	24	87	381	76
Exterior	126	80	48	81	174	80

*The totals in Tables 5-7 differ because:

(a) Table 5 includes only years in which both young and adults were seen, in order to compare the relative incidence of copulation. This excludes copulations by adults in years when no young had been banded but such copulations do appear in Table 6.

(b) Success was not always known, so some copulations are germaine to Table 5 but not to Table 6.

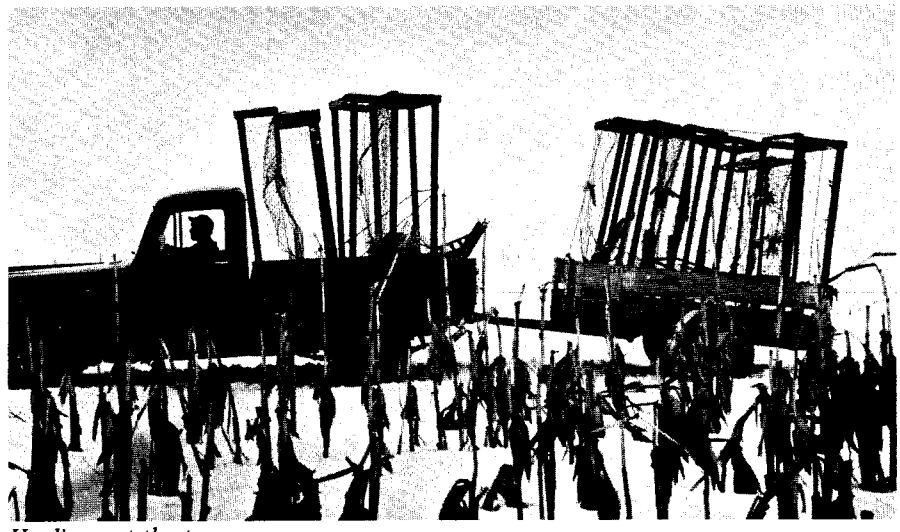
(c) Territorial position was not always clearly interior or exterior; such copulations are excluded from Table 7.

MOVEMENTS

METHODS

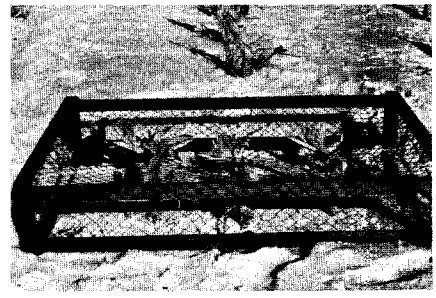
A total of 1,885 free-living wild prairie chickens, 23 sharptails, and 21 prairie chicken–sharptail hybrids were trapped and banded on the Portage County Management Area from 1950 through 1969. We trapped mainly in winter, when snow decreased the amount of food available and made our bait more attractive. The last trapping winter was 1964-65. We did very little spring trapping in order to avoid disturbance, but did trap 11 cocks (and retrapped a few others to replace color bands) on booming grounds. Booming ground traps and procedures are described in Anderson and Hamerstrom (1967). Retrapping in winter gave information on movements from one feeding place to another during the winter in which the bird was first caught, and from one winter to a later one. By watching birds from blinds on booming grounds in spring, using binoculars and 20-power spotting scopes, color-banded birds were traced from winter feeding places to the display grounds. Hunter kills during the open seasons of 1950 through 1953 showed where banded birds were in autumn; in many cases these birds had earlier histories of winter movements or movements to the booming grounds as well. We have a few recoveries of a miscellaneous nature, such as banded birds found dead, or color-banded birds recognized at times other than spring, including a few seen on booming grounds in autumn and winter.

Although we tried many types of traps, the one which was generally most successful was a funnel trap about 6 feet long by 4 feet wide by 12-18 inches high, with a broad and low funnel rather than a high and narrow one at each end. O. E. Mattson (unpubl.) devised a highly successful trap called the "rat trap" because it was powered by rat trap springs. The trap was essentially a spring-loaded bownet, triggered at the half-sprung position and completely open in front when set. The rat trap differs from the conventional bownet in the vertical position of the bow when set, and in having a three-dimensional holding compartment when sprung, rather than having the sprung net flat to the ground. During the last several years of the project we had particularly good results with a 40-foot by 40-foot drop net, slightly modified from one described by Jacobs (1958)*.

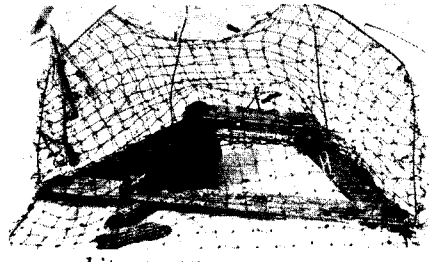


Hauling out the traps.

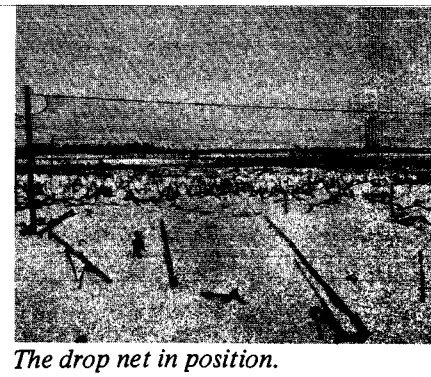
The rat trap and its designer, O. E. Mattson, . . .



Broad funnel trap, used most commonly.



. . . and its quarry.



The drop net in position.

* Jacobs, Karl F. 1958. A drop net trapping technique for greater prairie chickens. Proc. Okla. Acad. Sci. 38:154-157.

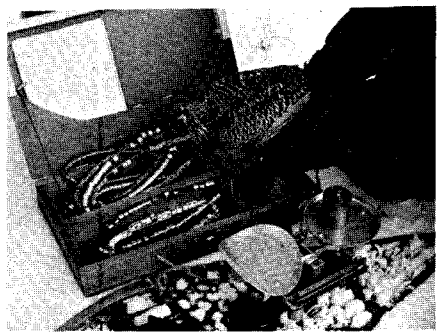
Tip-tops, bob-wires, Figure S, falling-door traps and a number of others also caught some birds. In the winter of 1950-51 we tried unusually large traps (up to 16 feet long by 24 feet wide by 4 feet high) made by hanging seine from wires strung between steel fence posts. One side or two ends were raised to form entrance doors, and the doors were dropped by means of trip wires operated from a blind. These traps were moderately successful, but not as effective as anticipated. The cannon-projected net was tried on a small scale in the winter of 1950-51 and again in 1951-52. Although about 20 birds were caught in this way, this trap has many disadvantages for winter use: The net itself often freezes down; it is apt to get damp and not throw well; the angle of the mortars must be adjusted within close limits, which is difficult with deep snow; we had to operate the net from a blind (entered before sunrise) and often the birds did not come to the bait at all.

Raptors are often attracted to a trapping station. After some early losses, we developed an effective system of protection, described in Berger and Hamerstrom (1962).

We used state-issued aluminum bands for the permanent serial number of each bird, plus colored aluminum bands and numbered, colored plastic bands to give several color combinations with numbers large enough to be read with spotting scopes and binoculars. Details are given in Hamerstrom and Mattson (1964).

Birds were sexed and aged by standard techniques when caught. After mid-March of 1951 virtually all were weighed to the nearest half gram. During two winters, the first and the last, we unfortunately had to discard the age determinations by two assistants, so that in these two years there are an unduly large number of birds which must be recorded as "age unknown". There are some birds of uncertain age scattered through the years, because the bursa of Fabricius becomes less and less reliable as an indicator of age as winter progresses, and the wing primary tips are sometimes so frayed as to be unreadable.

Numbered fingerling tags, clipped across the leading edge of the propatagium, have been useful in marking a limited number of summer-caught chicks too small to carry a leg band. The chicks were marked before leaving the nest, or were caught by running down broods. A small net was sometimes thrown over young birds hiding in the grass. We did not try to catch young chicks in baited traps.



Trapped birds are weighed, sexed, aged and banded, and then released.

During each of the open seasons of the grouse population high of 1950, 1951, and 1952, most of the research section, other members of the Game Division, and a number of students helped the project to make hunter checks, especially on the opening weekend. We had checkers in all of the best prairie chicken and sharptail areas for at least the opening weekend each year, and continued to make checks on a much restricted scale throughout each season. On no area, however, was it practicable to check every hunter, even on the opening weekend. The most intensive check was on the Portage County Area in 1951, the only year it was open to hunting, when we had 18 checkers in the field during the first two days. By far the greatest number of band recoveries resulted from this check, although a few others were mailed in or picked up by checkers elsewhere.

Practically every banded bird that was reported as shot was ultimately traced to the 40 in which it was shot, either in conversation with the hunter in the field or through correspondence. Except for a few hunters whose names or addresses were inadvertently not taken, every hunter was sent a report about his bird giving the date and place of banding and all recoveries up to the time the bird was shot.

A short article on the banding program, with photographs of some of the equipment and techniques, has been published (Hamerstrom, Frederick and Frances, 1967).

FINDINGS

Table 8 summarizes the total of birds banded. Table 9 gives the details of each year's banding by season, species, sex, and age. If one is to use trapping as a sampling method for sex and age composition, the retraps should also be included for they, too, are part of the trapped sample. Table 10 therefore, includes new bandings and retraps, which raises the proportion of adults.

Some losses are inevitable in banding game birds: Table 11 shows all birds accidentally killed plus those removed alive for experimental purposes.

Our study area was hunted only once during our program, and few of our birds were shot off the area. One of the major sources of recoveries in the usual game bird banding study was thus largely denied us. Conversely, we searched out banded birds by means of sight observations of color bands, mainly on booming grounds, to a greater than usual extent. Sight records and retraps gave us several fixes on many of our birds, so that the usual banded-to-shot type of analysis simply does not fit. We settled on the scheme of measuring and counting movements rather than birds: each time a bird was recorded after moving to another place, that movement was tallied as though it were the only record for that bird.

We divided the movements on a seasonal basis to show what seem to be the most important aspects of the data: movements within winter (banding winter or a later one); from one winter to another, with no intervening record; from winter to spring (in virtually all cases to the booming grounds); the reverse movement from spring to winter, with no intervening record. Autumn material came mainly from shot birds and four found dead; for those birds which were not seen again before they were shot, we tabulated distances between winter and fall. Some were seen on booming grounds before they were shot, and their last movement was recorded as from spring to fall. The above groups of movements were placed in subsections of Table 12 so that seasonal

comparisons are more apparent. Within each subsection the number of individuals is shown, but as the same birds often appear in different parts of the table, one cannot add the subsections to find a grand total. The grand total of movements, however, seems to be a valid approach to the question of how far prairie chickens move. In the material presented here, there are 1,055 movements by cocks and 400 by hens.

Since those cocks that are established on booming grounds spend so much of their lives there—through 10 or more weeks in spring, irregularly but persistently in autumn, and occasionally in winter—we have shown in Table 13 the farthest record from the "home" booming ground for the 588 cocks for which we have such records. Hens seem less tightly attached to one booming ground than cocks, but 59 hens have shown enough attachment that a similar measurement has been made for them (Table 13). For both sexes the distances shown are from the home booming ground to the farthest point at which we knew them whether or not they ever moved directly between the two points.

Wing-tagging is summarized in Table 14.

DISCUSSION

Trapping Mortality

Among the birds killed, the greatest loss was to predators while the birds were cornered in traps, 33 in all, but such losses were dramatically reduced after we devised, in 1959-60, the protective system already mentioned (see "Methods"). Trap injuries, the next largest category, also may have been partly caused by predator harassment that we were unaware of. Some of the birds that died during handling were definitely injured while in the trap and were so tallied, while others may have been. Some were apparently suffocated while in the burlap bags in which we carried them from the traps; some showed symptoms of hypoglycemic shock; at least two were diagnosed as heart failure by Dr. George Fisher of the State Diagnostic Laboratory in Madison. In total, however, the 70 deaths charged against trapping and banding amount to but 3.6 percent of the birds banded and an even smaller percentage of the total captures (new banding plus repeats and returns).

Sex and Age Composition

Even excluding all years with a sample of less than 100 birds (Table 10), the percentage of cocks varied from 53 percent to 89 percent. We doubt that the true sex ratio in the population varied as widely as this, or averaged as strongly to cocks as these figures suggest. Similarly, we found little logical relationship between the variations in the proportions of immatures and the booming ground counts reported under "Booming Ground Surveys". For the present, at least, we question the value of sex and age ratios derived from trapping as valid samples of the population.

Seasonal Movements

Table 15 facilitates comparison among the several groups of movements by putting them all on a percentage scale—the percent of movements within 2 miles, 3 miles, 5 miles (which includes most), and more than 5 miles. Overall and in most seasonal movements, immatures moved farther than adults and hens farther than cocks. These differences were least pronounced in winter moves—both within winters and from one winter to another. The most conservative group, the adult males, moved the shortest distances of all from spring to autumn, during the warm part of the year when food and cover are most available. Ninety-three percent of cocks shot or found dead in autumn were within 3 miles of the booming ground on which they had spent the spring and 83 percent were within 2 miles; in fact, about a third of them were within a half mile. Cocks tended strongly to winter close to their booming grounds: 92 percent were within 3 miles and 74 percent were within 2 miles. Hens, however, moved more widely in search of winter food. We take this to mean that the cocks have a stronger attachment to the booming ground than hens, and will tolerate less favorable conditions than the hens will in order to stay close by.

Thus, the longest moves are generally by the birds least attached to booming grounds: hens, young birds and adults with no known booming ground records.

Returns from Prairie Chickens Wing-Tagged as Chicks

Except for a very few cocks that were caught on booming grounds, our band returns came from birds that were first caught in winter. It is entirely possible that before they were banded, these birds may have made long and important moves of which we know nothing. We have, therefore, wing-tagged 162 chicks too small to carry leg bands, in an attempt to learn something of movements during the time after hatching and before winter trapping. Seventeen of these birds have subsequently been recovered, nine during the hunting season of 1951 (the first autumn after tagging) and the others in the course of trapping, when they were leg banded.

Of the shot birds, none moved far from the place where it was tagged. Six were within three quarters of a mile (2 cocks, 2 hens, 2 sex?), and three were between one and two miles away (1 cock, 1 hen, 1 sex?).

Three of the birds came from one brood of seven chicks about two and a half weeks old, of which six were tagged. When they were shot at about 13 weeks of age, two cocks were taken in the same 40, about a half mile from the tagging point; the third (sex?) was slightly more than a quarter mile from the tagging place.

Two others (1 cock, 1 sex?) were tagged in the same nest, part of a brood of 9 successfully hatched and tagged, and shot at 73 days in the same 40, a mile and three quarters from the nest.

Two more were from a second nest containing nine hatched eggs. Six chicks were caught and tagged 10 feet from the nest, but as two were found dead at the spot the next day, only four got away. The two which were shot were both hens 74 days old. One was slightly more than a half mile from the nest, the other about a mile and a quarter.

One (sex?) was tagged in still another nest (1 of a brood of 4) and was shot at 56 days at a distance of three quarters of a mile.

The ninth, a hen, was tagged as a single when about three and a half weeks old and was shot at about fourteen and a half weeks just under a half mile away.

Eight of the wing-tagged birds were later winter trapped and banded, all but two cocks during the first winter after tagging. Two hens were tagged after leaving the nest, one at about two weeks and the other at about four weeks. They had moved 3.3 and 7.8 miles respectively when trapped in winter. The rest were tagged while still in the nest. They were recaptured at the following distances, and all were immatures except as noted: one hen, 3.3 miles; one adult cock, 0.2 miles; two cocks, 1.2 and 1.3 miles; one cock 3.4 miles; and one adult cock, 4.6 miles.

These movements were well within the normal limits of the birds banded in the usual way; even in this samll sample the hens showed the longer movements. Although the sample is too small to be definitive, there is nothing here to suggest that there were major movements between hatching and the first winter. All winter retraps (5 cocks, 3 hens) were found still later on booming grounds on the Marsh; they are included with the main body of winter-to-spring movements in Table 12.

It is highly interesting that so many of the 35 chicks tagged in 1951 survived until autumn. This suggests both a high survival of young, and since nine were shot, a heavy harvest of the year's production.

The movement studies lead to several suggestions:

1. The range of movements shown by these data has important implications for management. Although prairie chickens are capable of long movements—they were said to migrate as regularly as the Canada goose in the late 1800's (Cooke, 1888)*—it is plain that present populations in Wisconsin are highly localized. Movements on the Buena Vista Marsh, our best remaining area, were on a far smaller scale than was at first suspected. With most of the known activities of the birds within a range of 2 to 3 miles, and almost all of them within 5 miles, it follows that management practices should also be close together so that all of the annual requirements of the birds can be met within small compass. This was the basis for our recommendations for food and cover development in the guide to prairie chicken management (Hamerstrom, Mattson, and Hamerstrom, 1957. We believe that the additional data on movements reinforce our earlier conclusion and recommendation.

2. Further data also strengthen the conclusion that booming grounds are the year-long center of activities for the established cocks. The case is not so clear for hens, but here again the connection is tighter than at first supposed. It follows that management practices, such as food patches and nest-brood cover development, could best be oriented in relationship to booming grounds—either to support existing ones or to encourage new ones—rather than placed at random.

3. As the result of banding, it was well established that current populations on the Buena Vista Marsh (Portage County Management Area), the Leola Marsh (part of the Plainfield Area), the Carson-Sigel-Sherry Area west of Stevens Point, and Mead Wildlife Area are all interconnected (Fig. 17). We discussed this in earlier Completion Reports (in particular, Wisconsin Wildlife Research, 1953, 11(4):33-52) and Westemeier (1971) published on it, using our data with permission. Since the time of Westemeier's analysis (made about 1963) and our earlier report, we have had a few more band returns from the Carson-Sigel-Sherry Area and considerably more from the Leola Marsh.

The Buena Vista Marsh and the Mead Wildlife Area have prairie chicken management now in progress. The two areas are 16 miles apart at their closest points, about 25 miles center to center. Although exchange of chickens between them was demonstrated, such movements were well beyond the normal. Half way between lies the Carson-Sigel-Sherry Area, *not* under management and with a declining population. We believe that the maintenance of this midway population is extremely important to the well being of the entire Wisconsin prairie chicken population. If the middle portion is lost, the two ends of the chain—Buena Vista-Leola and Mead—will quite possibly become isolated and especially the Mead thereby weakened.

It is our urgent recommendation that the Carson-Sigel-Sherry Area be put under management without further delay.

4. As a sidelight, banding data showed why it is so difficult (we find it impracticable) to census prairie chickens by counting winter flocks. Flocks or parts of flocks are shown by band recoveries to shift from one feeding place to another during the winter, often enough to be confusing. Sometimes more than one flock feeds in one field but at different times of day. We found what seemed to be a "morning flock" and an "afternoon flock". Except for banding, it could have been assumed that the same flock was feeding twice a day—which actually is the usual situation. At several stations with what seemed a fairly constant number of birds day after day, we banded considerably more birds than we ever saw at once.

SUMMARY

From 1950 through 1969 we banded and released 1,885 prairie chickens, 23 sharptails, and 21 hybrids on the Portage County Management Area. Broad-funnel traps, "rat traps", and drop nets caught the most birds. Trapping mortality was 3.5 percent of the birds trapped; loss to predators was considerably reduced after we developed a system for protecting our trapping stations.

Analysis of 1,055 movements by cocks and 400 by hens shows that immatures generally moved farther than adults, and hens farther than cocks. Shortest moves were during the warm season, from spring to fall. We know nothing of movements during summer, however. Longest moves were those from one winter to another without intervening capture. Once established on a booming ground, cocks tended strongly to remain close to it year-long; a smaller proportion of hens did the same thing.

Altogether, most movements were rather short: 95 percent of adult and 93 percent of immature cocks were 5 miles or less, 83 percent of adult and 62 percent of immature hens were within the same range.

We wing-tagged 162 chicks at the nest or shortly after leaving it; 17 were recovered either through hunting (9) or winter trapping. Their movements were well within the normal limits of birds banded in the usual way.

Implications for management of food and cover have been discussed in *A Guide to Prairie Chicken Management.* The more extensive data here reported support our earlier conclusions.

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-Leola isolated from Mead, a loss which would be more important than the mathematical number of birds in the Carson-Sigel-Sherry Area.

* Cooke, W. W. 1888. Report on bird migration in the Mississippi valley in the years 1884 and 1885. U. S. Dep. Agric., Div. Econ. Ornith., Bull. 2; ed. and rev. by C. H. Merriam.

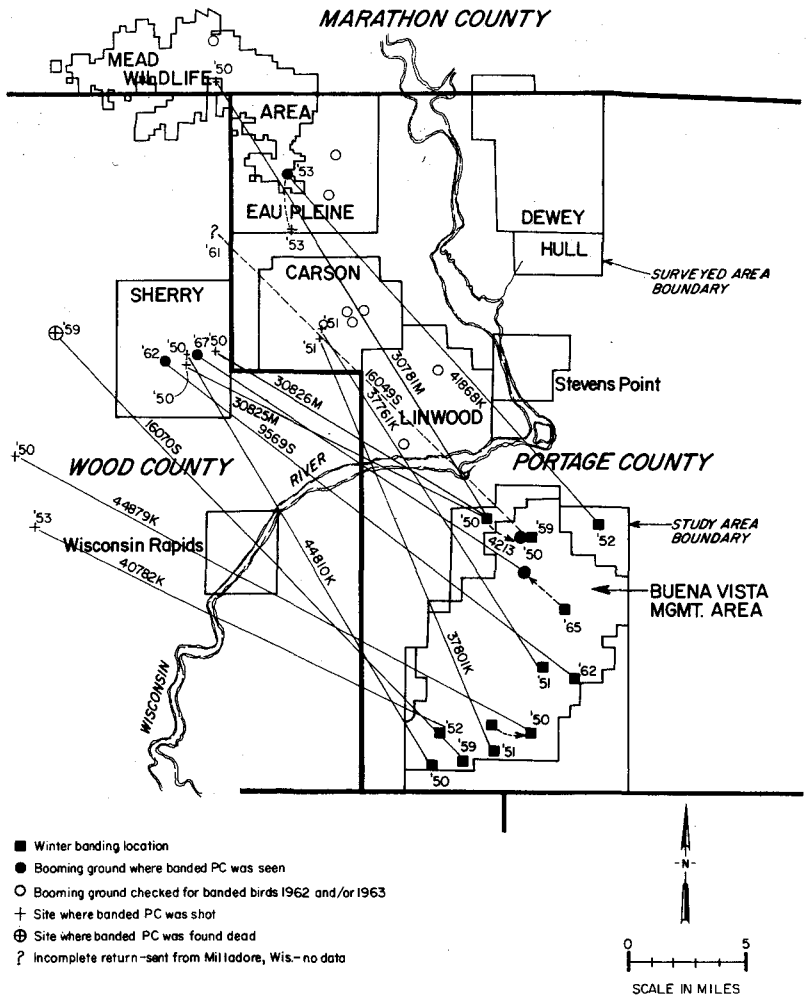


FIGURE 17. *Prairie chicken movements from the Buena Vista Marsh to the Northwest Outlying Range since 1950. (Adapted from Westemeier, 1969).*

TABLE 8. Banding Summary, 1950–1969*

		Prairie Chickens					Sharptails	Hybrids	All Species
		Fall	Winter	Booming Grounds	Summer	Total	Winter	Winter	All Seasons
Males	Ad	1	384	2	–	387	2	5	394
	Im	10	686	1	–	697	9	10	716
	?	–	87	8	–	95	–	1	96
	Total	11	1,157	11	–	1,179	11	16	1,206
Females	Ad	2	247	–	1	250	3	1	254
	Im	2	392	–	–	394	8	4	406
	?	–	62	–	–	62	1	–	63
	Total	4	701	–	1	706	12	5	723
Grand Total		15	1,858	11	1	1,885	23	21	1,929

*Table includes only birds that were banded and released alive; trap deaths, sack deaths, experimental removals, etc., at the time of first capture are not included here. However, birds that died or were removed at a subsequent capture, after yielding data on at least one more, are included. All but 7 (special-purpose cocks, banded on booming grounds in 1966 and 1969) were caught between 1949–50 and 1964–65.

TABLE 9. Birds Banded and Their Sex and Age Composition 1950–1969.

Year	Prairie Chicken						Sharptail						Prairie Chicken x Sharptail					
	Males			Females			Males			Females			Males			Females		
	Ad	Im	?	Ad	Im	?	Ad	Im	?	Ad	Im	?	Ad	Im	?	Ad	Im	?
1949–50	28	82	50	30	66	42	–	2	–	–	4	1	–	–	1	–	–	–
1950–51	60	78	8	29	31	4	1	3	–	–	1	–	–	–	–	1	1	–
1951–52	35	45	1	18	52	1	–	1	–	–	–	–	–	–	–	–	–	–
1952–53	43	137	1	36	73	–	–	1	–	1	2	–	1	5	–	–	1	–
1953–54	2	17	–	4	7	–	–	1	–	–	–	–	–	–	–	–	1	–
1955–56	52	81	2	20	36	1	1	–	–	–	–	–	–	–	–	–	–	–
1956–57	4	15	–	3	10	–	–	1	–	–	–	–	–	–	–	–	–	–
1957–58	9	27	–	4	4	–	–	–	–	–	–	–	1	1	–	–	–	–
1958–59	53	37	–	42	39	–	–	–	–	–	–	–	1	2	–	–	–	–
1959–60	2	2	–	2	–	–	–	–	–	2	–	–	–	1	–	–	–	–
1960–61	10	20	–	2	1	–	–	–	–	–	–	–	1	–	–	–	–	–
1961–62	23	35	–	25	28	–	–	–	–	–	1	–	1	1	–	–	1	–
1962–63	34	57	1	28	34	1	–	–	–	–	–	–	–	–	–	–	–	–
1963–64	9	26	3	3	10	2	–	–	–	–	–	–	–	–	–	–	–	–
1964–65	23	37	23	4	3	11	–	–	–	–	–	–	–	–	–	–	–	–
1966	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1969	–	1	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
TOTAL																		
Fall	1	10	–	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
Winter	384	686	87	247	392	62	2	9	–	3	8	1	5	10	1	1	4	–
Booming Ground	2	1	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Summer	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–

TABLE 10. Composition of Winter-trapped Samples of Prairie Chickens.

Banding Year	No. Birds	Males	Females	Ad*	Im	Males		Females	
						Ad	Im	Ad	Im
1949–50	206	53	47	28	72	14	40	14	32
1950–51	221	69	31	51	49	33	35	17	14
1951–52	167	54	46	42	58	28	27	14	31
1952–53	323	63	37	35	65	20	42	15	23
1953–54	31	61	39	23	77	–	–	–	–
1955–56	192	71	29	39	61	29	42	10	19
1956–57	39	64	36	36	64	–	–	–	–
1957–58	47	81	19	34	66	–	–	–	–
1958–59	187	56	44	59	41	36	20	23	21
1959–60	5	80	20	60	40	–	–	–	–
1960–61	35	91	9	40	60	–	–	–	–
1961–62	116	53	47	46	54	23	30	22	24
1962–63	175	59	41	48	52	27	33	21	19
1963–64	70	68	32	49	51	–	–	–	–
1964–65	103	89	11	61	39	53	36	8	3

*Age estimated at time of banding.

TABLE 11. Trapping Deaths and Experimental Removals.

Year	Deaths Due to Trapping				Type of Trapping Death				Band History			Experimental Removals (Live Birds)	Deaths Plus Removals
	PC	ST	Hyb	Total	Trap Injury	Killed in Trap by Predator	Died During Handling	Misc.	Unbanded	Banded Earlier This Winter	Banded in Earlier Winter		
1949–50	7	–	–	7	1	3	3	–	7	–	–	1[w]	8
1950–51	6	2	1	9	2	5	1	1[a]	5	2	2	6[x]	15
1951–52	2	1	–	3	1	–	1	1[b]	2	–	1	2[y]	5
1952–53	4	–	–	4	1	1	2	–	4	–	–	–	4
1953–54	1	–	–	1	–	–	1	–	1	–	–	–	1
1955[c]	1	–	–	1	1	–	–	–	–	–	1	–	1
1955–56	8	–	1	9	2	6	1	–	6	1	2	–	9
1956–57	2	–	–	2	1	–	1	–	1	–	1	–	2
1958–59[d]	14	–	–	14	–	13	1	–	9	1	4	–	14
1959–60	–	–	–	–	–	–	–	–	–	–	–	2[y]	2
1960–61	2	–	–	2	1	–	1	–	2	–	–	–	2
1961–62	4	–	–	4	2	1	1	–	3	–	1	–	4
1962–63	1	–	1	2	1	–	1	–	1	–	1	–	2
1963–64	4	–	–	4	1	–	3	–	2	–	2	–	4
1964–65	8	–	–	8	4	4	–	–	3	4	1	–	8
Total	64	3	3	70	18	33	17	2	46[e]	8	16	11	81

PC=Prairie Chicken ST=Sharptail Hyb=Prairie Chicken x Sharptail hybrid

[a]Wing broken in handling.

[b]Struck fence and killed on release (not included in total of birds banded)

[c]No winter trapping 1954–55; one cock netted and accidentally killed on booming ground in spring.

[d]No deaths or removals in 1957–58.

[e]8 birds died after bands were put on but are not counted as banded birds since they were not successfully released; they are included here as unbanded.

[w]To Poynette for pathological examination (negative).

[x]4 to Prof. Wolfe, Univ. Wis.; 2 for trial breeding.

[y]For trial breeding.

TABLE 12. Movements of Banded Prairie Chickens (Miles)

	0-1		1.1-2		2.1-3		3.1-4		4.1-5		5.1-6		6.1-7		7.1-8		8.1-9		9.1-10		10.1-15		15.1-20		20.1-25		25.1-30		No. of Moves		No. of Individuals	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Within Winter																																
Im	1	2	19	12	23	12	10	4	4	–	2	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	60	31	58	27
Ad	–	1	15	2	5	4	4	1	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	26	8	24	7
Age?	–	–	5	4	4	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	6	10	6
Total	1	3	39	18	32	18	15	5	5	–	3	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	96	45	92	40
Winter to Winter																																
Ads**	3	1	5	10	3	2	2	1	1	3[a]	1	1	1	–	1[a]	1	–	2[a]	–	–	–	–	–	–	–	–	–	–	17	21	17	19
Winter to Spring																																
To 1st Spring*																																
Im	78	3	99	16	95	14	45	20	26	13	14	23	9	7	1	15	1	4	1	4	–	6	–	–	–	–	–	–	369	125	369	125
Ad	99	9	103	20	59	29	24	14	6	15	4	4	1	2	–	2	1	1	–	–	–	1	–	–	–	1	–	–	297	98	230	86
Age?	7	–	13	3	21	2	8	4	2	2	–	2	–	2	–	1	–	–	–	–	–	–	–	–	–	–	–	–	51	16	51	16
To 2nd Spring**	6	2	7	5	8	4	4	11	3	3	3	1	3	3	–	3	–	–	–	1	–	2	–	–	1	–	–	–	35	35	35	33
To 3rd + later**	1	–	4	1	2	2	–	1	1	1	–	1	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	10	7	10	7
Totals	191	14	226	45	185	51	81	50	38	34	21	31	14	15	2	21	2	5	1	5	–	9	–	–	1	1	–	–	762	281	695	267
Spring to Winter																																
Ad**	51	6	40	7	22	9	6	5	3	1	1	3	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	123	33	111	33
Winter to Fall**																																
To 1st Fall*	1	–	–	1	2	–	1	2	–	2	2	–	1	–	–	–	–	–	–	–	1	–	1	1	1	1	–	1	10	8	10	8
To 2nd Fall																																
From 1st Winter	–	–	1	–	1	1	1	–	1	–	–	–	–	1	–	–	–	–	–	–	–	1	1	–	–	–	–	–	5	3	5	3
From 2nd Winter	–	–	–	2	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	3	1	3
Totals	1	–	1	3	4	2	2	2	1	2	2	–	1	1	–	–	–	–	–	–	1	1	2	1	1	1	–	1	16	14	16	14
Spring to Fall[c]**																																
1st Spr. to 1st Fall	14	1	5	1	2	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	23	3	23	3
1st Spr. to 2nd Fall	2	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	1	3	1
2nd Spr. to 2nd & later Falls	9	1[b]	4	–	1	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	15	2	15	2
Totals	25	3	9	1	4	1	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	41	6	41	6
Im	79	5	118	28	118	26	55	24	30	13	16	24	10	7	1	15	1	4	1	4	–	6	–	–	–	–	–	–	429	156		
Ad	186	22	184	49	107	53	44	36	16	25	12	10	7	7	2	8	1	3	–	1	1	4	3	1	2	2	–	1	565	222		
Age?	7	–	18	7	25	4	9	4	2	2	–	2	–	2	–	1	–	–	–	–	–	–	–	–	–	–	–	–	61	22		
TOTAL	272	27	320	84	250	83	108	64	48	40	28	36	17	16	3	24	2	7	1	5	1	10	3	1	2	2	–	1	1,055	400		

*1st Spring (Fall)=1st Spring (Fall) after banding
2nd Spring (Fall)=2nd Spring (Fall) after banding
1st Winter=banding winter
2nd Winter=the next winter after banding.

**All birds were adult at the time of recapture.

[a]Includes one move 2nd to 4th winter.

[b]Includes one hen 2nd spring to 5th fall.

[c]43 shot and 4 found dead.

TABLE 13. Greatest Distance from Booming Ground at Any Time (Miles)*

Age	0-1 M	0-1 F	1.1-2 M	1.1-2 F	2.1-3 M	2.1-3 F	3.1-4 M	3.1-4 F	4.1-5 M	4.1-5 F	5.1-6 M	5.1-6 F	6.1-7 M	6.1-7 F	7.1-8 M	7.1-8 F	8.1-9 M	8.1-9 F	9.1-10 M	9.1-10 F	10.1-15 M	10.1-15 F	No. of Moves M	No. of Moves F	No. of Individuals M	No. of Individuals F
Im[a]	54	–	77	2	68	–	40	2	21	2	15	2	9	1	1	–	1	1	–	–	–	1	286	11	318	18
Im[b]	6	–	4	1	9	2	6	2	2	–	3	–	2	1	–	–	–	–	–	–	–	1	32	7		
Ad[a]	54	1	59	3	60	7	18	3	4	8	5	–	1	–	–	–	1	–	–	–	–	–	202	22	224	38
Ad[b]	8	–	7	2	3	5	3	4	1	3	–	–	–	–	–	2	–	–	–	–	–	–	22	16		
Age?[1]	4	–	12	–	11	–	6	–	4	–	–	1	–	–	1	–	–	–	–	–	–	–	38	1	46	3
Age?[2]	–	–	2	–	5	–	1	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	8	2		
Total Im	60		84		79		50		25		20		13		1		2		–		2		336		–	
Total Ad	63		71		75		28		16		5		1		2		1		–		–		262		–	
Total M	126	–	161	–	156	–	74	–	32	–	23	–	12	–	2	–	2	–	–	–	–	–	588	–	–	–
Total F	–	1	–	8	–	14	–	12	–	14	–	3	–	2	–	2	–	1	–	–	–	2	–	59	–	–

Im = Banded as immature reached farthest point from booming ground as immature.

Ad = Reached farthest point from booming ground when adult, regardless of age at banding.

Age? = Banded as age? reached farthest point from booming ground as age?.

*Not necessarily direct movement to or from booming ground; the farthest point reached at any time in any combination of moves; only one move tabulated per individual.

All males in table are considered to have a "home" booming ground on which they were *known* to be regulars (526) or were *probably* regulars (62) in the first or later spring.

[1]Definitely regular cocks; hens who were on one booming ground for at least two springs and on no other; clearly with a "home" booming ground.

[2]Probably regular cocks; hens who were on one booming ground more than one spring but also on others; less certainly with a "home" booming ground (distance measured from the most used ground).

TABLE 14. Wing Tagging

	No. Tagged	No. Later Recovered	Males	Females	Sex?
1950	3	0	–	–	–
1951	35	10	3	4	3
1952	36	3	2	1	–
1953	12	0	–	–	–
1954	8	1	1	–	–
1955	29	1	1	–	–
1956	12	0	–	–	–
1957	1	0	–	–	–
1960	21	1	1	–	–
1964	5	1	–	1	–
Total	162	17	8	6	3

All but one immature hen (in 1951) were shot; all others were retrapped.

TABLE 15. Seasonal Movements

	Age & Sex	Percent of Moves: Less Than 2 miles	Less Than 3 miles	Less Than 5 miles	More Than 5 miles	Number of Moves
Within Winter	Im M	33	72	95	5	60
	Ad M	58	77	96	4	26
	Im F	45	84	97	3	31
	Ad F	–	–	100	–	8
Winter to Winter	All Ad					
	M	47	65	82	18	17
	F	52	62	81	19	21
Winter to Spring	Im M	48	74	93	7	369
	Ad M	64	85	96	4	342
	Im F	15	26	53	47	125
	Ad F	26	51	84	16	140
Spring to Winter	All Ad					
	M	74	92	99	1	123
	F	39	67	85	15	33
Winter to Fall	All Ad					
	M	13	38	56	44	16
	F	21	36	64	36	14
Spring to Fall	All Ad					
	M	83	93	97	3	41
	F	67	83	100	0	6
All Moves	Im M	46	73	93	7	429
	Ad M	65	85	95	5	565
	Im F	21	38	62	38	156
	Ad F	32	56	83	17	222
Greatest Distance from Booming Ground	Im M	44	69	90	10	318
	Ad M	57	85	97	3	224
	Im F	17	28	61	39	18
	Ad F	16	47	95	5	38

TURNOVER

METHODS

Prairie chicken cocks tend strongly to return each spring to the booming grounds on which they have established themselves. Hens also go to the booming grounds, although not as persistently to the same grounds as the cocks do. Because of this behavior we have been able to build a life table based on the direct observation of color-banded live birds that were identified as individuals over a period of years on booming grounds in spring.

Several assumptions are implicit in this scheme, and some weaknesses in the data should be pointed out.

Prairie chickens are wide-ranging birds (see "Movements"), hence a study area must be large. Ours is about 50,000 acres. There were 52 booming grounds on it (including 9 of uncertain status) at the time of highest population in 1950 and 1951, and from 16 to 23 during the low years of the 1960's. The section "Breeding Behavior" describes how birds were recognized as individuals and points to the difficulties in getting complete coverage. Despite these difficulties, however, we estimate that during the years 1956 through 1970 (when the last banded bird was seen) we identified 95 percent or more of the banded cocks and nearly as many of the hens, while during the earlier years we were no more than 90 to 95 percent successful with the cocks and less so with the hens.

Movement off the study area could distort the apparent survivorship series. We know that such movement has occurred, but we believe that

relatively few birds are involved, and that they are not birds that are part of the survival series. For example, we have record of 10 birds (7 cocks and 3 hens) that were shot off-area. Only one, a cock, was ever seen on a booming ground on the study area, and that bird for only one morning. He is included in the survivorship tables. Twelve of our banded birds have been seen on off-area booming grounds, but only two of them (one male and one female) had been recorded on the study area in spring. Except for one cock who returned to the Marsh, we have not included data from the off-area grounds, because most of these examples could not be followed systematically to extinction. It is, thus, not wholly sound to assume that the life tables are not affected by exodus, but the discrepancy seems to be within tolerable limits.

FINDINGS

The basic assumption is that prairie chickens do indeed return to the booming grounds with such persistence that their ultimate disappearance means that they are dead. The sheer force of numbers of the band returns is highly suggestive in itself, and in most cases, our last record of a bird with a booming ground history is on the booming ground. The assumption can be further tested in several ways: (1) 24 birds with booming ground histories have been found dead on the study area from causes not associated with our work—predator kills, wire kills, mowing, etc. In 21 cases the birds were on a booming ground during the spring immediately before their death. Only 3 were not seen on a booming ground in their last spring, and one of these was a cock from a ground that was not checked during his last possible spring; one was a hen whose time of death could not be accurately determined. (2) During the one hunting season (1951) on the area during the time of our study, 42 of the shot birds (37 cocks and 5 hens) had had an earlier booming ground history. Only 5 (4 cocks and 1 hen) had not been seen in the spring of 1951. Our coverage of the booming grounds was not at its best during the first few springs, so we could have overlooked them. Since we know that these 5 were alive during the second spring, we have included them in the tables. (3) We last saw 67 birds (49 cocks and 18 hens) still alive at a time other than spring, such as winter retraps, sight records on booming grounds in autumn or winter. In no case have we found such a bird that was not recorded on a booming ground during the spring immediately before!

Altogether, the evidence is convincing that a valid life table can be constructed on the basis of occurrence of banded cocks on booming grounds in spring. Some cocks have been missed due to the practical difficulties in gathering the data, but we suspect that the biases and inconsistencies in this method are no greater than found in the usual method based on recoveries of dead birds. For reasons already explained the calculations for hens are undoubtedly less precise than for cocks, in the direction of an overestimate of mortality; i.e., some hens still alive were recorded as having disappeared. We have no way of attacking the problem of turnover or survivorship in the birds that do not go to booming grounds, and it is entirely possible that their life expectancy is wholly different.

Tables 16 and 17 give the raw data, combining all years to show the number of birds that were last seen during each successive spring following banding (Table 16), then building back from these data to show the number alive each spring, including those not seen during a particular spring but known to be alive because they were seen in a later spring (Table 17). Birds banded as immatures (less than one year old) were about 10 months old when seen on a booming ground in the first spring after banding, since the peak of hatch is generally in late June. Thus, for immatures the number of springs after banding is the approximate age of the bird. Age of the adults cannot be so directly interpolated, since we do not know their hatch year; each spring contains a mixed lot of birds known only to be more than one year old. Age categories—immature or adult—were determined at the time of banding by depth of bursa and/or degree of wear on primary tips, sex by tail pattern and pinna length, all standard methods.

Rough inspection of these tables, especially Table 17, shows that among the larger samples—immature cocks, all immatures, adult cocks and all adults—there is an approximate halving of the numbers remaining in each successive year through the third or fourth spring in the series.

With the help and direction of Donald R. Thompson, we have applied a more sophisticated analysis to these data, based on the discussion of dynamic life tables in Hickey (1952).* Each of our banding cohorts has been followed to the point of complete extinction. It should be emphasized that our survivorship series does not start with the time of banding, as is commonly the case, but with birds already almost one year old, by which time substantial mortality has already occurred; therefore, at Thompson's suggestion, we used symbols 1' x, d' x, and q'x to serve as reminders of this departure from standard usage. Our figures on mortality rates are not precisely comparable with rates derived in the usual way, although rough comparison should be justifiable, but will be directly comparable with similar survival series to be published for ruffed grouse (Gullion) and sage grouse (Eng).

Tables 18 and 19 are thus composite dynamic life tables in which the time intervals are from one spring to the next, starting with the first spring after banding; 1' x is the number of birds alive during the first spring of the interval; d'x is the number of deaths (literally the number of birds failing to reappear) between the first and second springs of the interval; and q'x is the mortality rate during the interval. In these tables, the first spring of each interval tells the approximate age of the immatures, as already explained. Adults have arbitrarily been advanced one year, at the suggestion of Thompson, on the grounds that all were more than one year old by definition, and the majority were probably two years old at first appearance with correspondingly fewer in each older age class. Table 18 gives life tables for immature cocks, immature hens, adult cocks, and adult hens. Table 19 combines immatures of both sexes in one part, and adults of both sexes in the other.

Table 20 goes still farther in lumping data by including birds of unknown age to show life tables for all cocks, all hens, and the entire sample combined. Here, since we are dealing with mixed ages, time periods do not differentiate between young and old birds but simply represent the number of springs following banding (it is true,

* Hickey, J. J. 1952. Survival studies of banded birds. U. S. Dep. Interior, Fish and Wildl. Serv., Spec. Sci. Rep.: Wildlife 15, p. 5-12.

of course, that the birds are progressively older in each successive time period).

There was one open season on the area during our study, in 1951. Table 21 gives life tables for the two cohorts that were shot, as compared with the combined remaining unshot cohorts. Since there was only one hunting season, the unshot cohorts should be more truly representative of the usual condition. In the three parts of the table, all ages (including age unknown) and both sexes are combined; adults have not been advanced one year as they are in Tables 18 and 19.

DISCUSSION

According to Hickey (1952) the average annual mortality figure is the most conservative expression of mortality rate. That figure was (Table 18): for immature cocks, 52 percent; immature hens, 59 percent; adult cocks, 55 percent; and adult hens, 51 percent. These values, however, are not significantly different at the 95 percent level. It seems reasonable then to combine sex classes: both immatures and adults show an average annual mortality rate of 54 percent (Table 19). Since there is no difference between immatures and adults, it is fair to enlarge the sample by including birds of unknown age: males show an average annual mortality rate of 53 percent, females 56 percent, and both sexes and all ages combined 54 percent (Table 20). This figure includes the effect of one hunting season; for the unshot population it is 52 percent (Table 21).

Again following Hickey, we have not calculated mortality rates for samples in which there were fewer than 100 birds at the beginning of the time interval, except for the two small shot cohorts. This means that we cannot show annual mortality rates beyond the interval from the third to the fourth spring; for immature hens we cannot go beyond the second spring. When numbers drop below 100, we have combined all the rest in one calculation. The tables do not show a constant mortality rate of 54 percent for each interval: after the interval "third to fourth spring" the rate is always higher, except for immature hens, and the rate for the combined small samples at the end of each series is always highest of all, with the same exception. We cannot evaluate this situation because the combined samples are so small, but we do call attention to it.

There was one hunting season and it included only two cohorts, and so our data on the influence of hunting are few. Despite the small samples, however, the two shot cohorts show higher average annual mortality rates (59 % and 63 %) than the unshot years combined (52 %), and one can readily see where the hunting season came by the jump in mortality during that interval (79% during the interval "second to third spring" for the 1949-50 cohort, and 66% for the "first to second spring" interval for the 1950-51 cohort). It would seem that the hunting season increased normal mortality by about 25 percent.

SUMMARY

Prairie chickens, especially cocks, tend strongly to return to booming grounds year after year. Thus it is possible to construct composite dynamic life tables based on sight records of live birds—color-marked individuals identified on the booming grounds. There are some stipulations to be observed, discussed in the text; nevertheless our data show: (1) There is no significant difference at the 95 percent level between average annual mortality rate of immature cocks (52%), immature hens (59%), adult cocks (55%), and adult hens (51%). (2) Combining the sexes gives an average annual mortality rate of 54 percent for both immatures and adults. (3) Including the birds of unknown age, all cocks show an average annual mortality rate of 53 percent and all hens, 56 percent; both sexes and all ages combined, 54 percent.

The above figures are for a population which was hunted during one autumn, 1951. The average annual mortality rate for the combined unshot cohorts was 52 percent. Two cohorts (1949-50 and 1950-51) were hunted; their average annual mortality rates by comparison were 59 percent and 63 percent, respectively, and for the time interval which included the hunting season the annual rate was 79 percent and 66 percent, respectively. We estimate that the hunting season increased mortality during that year by about 25 percent.

TABLE 16. Disappearance of Prairie Chickens from Booming Grounds, 1950–1970

Spring Last Seen Alive	No. of Males				No. of Females				Males Plus Females			
	Im**	Ad	Age?	Total	Im**	Ad	Age?	Total	Im**	Ad	Age?	Total
1*	194	120	20	334	87	44	12	143	281	164	32	477
2	100	58	24	182	30	32	3	65	130	90	27	247
3	64	29	5	98	8	16	2	26	72	45	7	124
4	31	18	5	54	10	6	1	17	41	24	6	71
5	5	2	2	9	4	4	–	8	9	6	2	17
6	2	1	–	3	1	–	–	1	3	1	–	4
7	1	–	–	1	–	–	–	–	1	–	–	1
8	1	–	–	1	–	–	–	–	1	–	–	1
Total Birds	398	228	56	682	140	102	18	260	538	330	74	942

*First spring after banding, etc.

**Im, Ad., etc.–Age at time of banding.

TABLE 17. Prairie Chickens Known to be Alive on Booming Grounds, 1950–1970

Known to be Alive	No. of Males				No. of Females				Males Plus Females			
	Im**	Ad	Age?	Total	Im**	Ad	Age?	Total	Im**	Ad	Age?	Total
1*	398	228	56	682	140	102	18	260	538	330	74	942
2	204	108	36	348	53	58	6	117	257	166	42	465
3	104	50	12	166	23	26	3	52	127	76	15	218
4	40	21	7	68	15	10	1	26	55	31	8	94
5	9	3	2	14	5	4	–	9	14	7	2	23
6	4	1	–	5	1	–	–	1	5	1	–	6
7	2	–	–	2	–	–	–	–	2	–	–	2
8	1	–	–	1	–	–	–	–	1	–	–	1

*First spring after banding, etc.

**Im, Ad., etc.–Age at time of banding.

TABLE 18. Composite Dynamic Life Table, Prairie Chickens, by Sex and Age Classes (Birds of Unknown Age Excluded)

Age*	Im*Males			Im* Females			Ad** Males			Ad** Females		
	l'_x	d'_x	q'_x(%)	l'_x	d'_x	q'_x(%)	l'_x	d'_x	q'_x(%)	l'_x	d'_x	q'_x(%)
1–2	398	194	49	140	87	62	–	–	–	–	–	–
2–	204	100	49	53	30		228	120	53	102	44	43
3–	104	64	62	23	8		108	58	54	58	32	
4–	40	31		15	10	55	50	29		26	16	59
5–	9	5		5	4		21	18		10	6	
6–	4	2	71	1	1		3	2	67	4	4	
7–	2	1					1	1				
8–	1	1										
	762	398	52	237	140	59	411	228	55	200	102	51

*Immature at banding (10 months at age 1).

**Adults arbitrarily advanced 1 year, since none were 1 year old and the majority were probably 2 years at the time of first appearance, with progressively fewer in each succeeding age class.

TABLE 19. Composite Dynamic Life Table, Prairie Chickens, Sexes Lumped (Birds of Unknown Age Excluded)

Age*	All Immatures* l'_x	d'_x	q'_x(%)	All Adults** l'_x	d'_x	q'_x(%)
1–2	538	281	52	–	–	–
2–	257	130	51	330	164	50
3–	127	72	57	166	90	54
4–	55	41		76	45	
5–	14	9		31	24	
6–	5	3	71	7	6	66
7–	2	1		1	1	
8–	1	1				
	999	538	54	611	330	54

*Immature at banding (10 months at age 1).

**Adults arbitrarily advanced 1 year, since none were 1 year old and the majority were probably 2 years at the time of first appearance, with progressively fewer in each succeeding age class.

TABLE 20. Composite Dynamic Life Table, Prairie Chickens Entire Sample (Mixed Ages)

No. of Springs After Banding	All Males* l'_x	d'_x	q'_x(%)	All Females* l'_x	d'_x	q'_x(%)	Entire Sample* (Including Age Unknown) l'_x	d'_x	q'_x(%)
1–2	682	334	49	260	143	55	942	477	51
2–	348	182	52	117	65	56	465	247	53
3–	166	98	59	52	26		218	124	57
4–	68	54		26	17		94	71	
5–	14	9		9	8	59	23	17	
6–	5	3	76	1	1		6	4	75
7–	2	1					2	1	
8–	1	1					1	1	
	1,286	682	53	465	260	56	1,751	942	54

*Adults not advanced where all ages are lumped. Birds of unknown age are included.

TABLE 21. Effect of the Hunting Season of 1951 on the Two Cohorts Involved

No. of Springs After Banding	1949–50* l'_x	d'_x	q'_x(%)	1950–51* l'_x	d'_x	q'_x(%)	1951-52 Through 1964-65* l'_x	d'_x	q'_x(%)
1–2	103	47	46	93	61	66	746	369	49
2–	56	44	79	32	16		377	187	50
3–	12	7		16	12		190	105	55
4–	5	5	71	4	1	58	85	65	
5–				3	3		20	14	
6–							6	4	75
7–							2	1	
8–							1	1	
	176	103	59	148	93	63	1,427	746	52

*Adults not advanced where all ages are lumped. Birds of unknown age are included.

HABITAT

METHODS

Cover-type mapping in the field followed standard procedures. Section outlines, roads, drainage ditches, etc., were traced directly from air photos, along with such major cover-type boundaries as were clearly visible. The sectional maps were then taken to the field where the detailed typing was done. Since we were interested in cover types as they relate to wildlife, and in particular to prairie chickens, we were not concerned with age classes and stocking rates in timber stands, and simplified the usual treatment of wooded areas.

Some problems were encountered in comparing maps made at different times, especially in the case of the Portage County Management Area because of its large size. Precise ground control did not seem necessary for the comparisons we wish to make, and slight differences in scale of the base photos were not strictly compensated. Acreage totals for 1953 and 1969, thus, did not agree, and one half-section is missing from the 1953 map. We have compensated for the lacking half-section by inserting values taken from field mapping in 1951, knowing that there was little if any change between 1951 and 1953. In the case of the three part-townships which were farthest out of agreement in total acreage (2.2 %, 2.9 % and 6.7%) we accepted the 1969 sectional maps as the more nearly correct and increased the acreage of each major type as recorded in 1953 by the appropriate percentage to allow comparison. The largest discrepancy, 6.7 percent, involved a total of only 480 acres–the small part of T23N, R8E which lies within the area. Values in this report, therefore, vary somewhat from those given for 1953 in *A Guide to Prairie Chicken Management.*

Preparation of the 1953 type map was described and acknowledged in *A Guide to Prairie Chicken Management.* The 1969 mapping was done under contract with the University of Wisconsin-Stevens Point, followed by complete field checking by the following men in the Department of Natural Resources: J. Ashbrenner, J. Kubisiak, L. Jonas, R. Zeller and F. N. Hamerstrom.

We made our first map of the heart of the Leola Marsh when we were graduate students. It was done in 1942 and 1943, but, with the help of air photos, local farmers, and our own intimate knowledge of the area, was made to represent conditions in

Grassland is of vital importance to prairie chickens.
With some slight admixture of broad-leaved herbaceous plants
and sedges it is virtually indispensable as nesting and rearing cover.

1941-42. Our original mapping was on a much more detailed scale than the more recent ones, and it was a simple matter to consolidate the finer types into the broader ones of later years. We made a second map in 1947, when it was apparent that drastic changes in land use were in progress. From September 1956 to March 1957, O. E. Mattson, as game manager for the Department of Natural Resources, mapped the entire Leola Prairie Chicken Management Area, larger than but including all of our mapped area. We took from his map the part that we mapped earlier. In 1969, F. N. Hamerstrom mapped our original area once again, using as a base a set of photos specially flown for the purpose by the Department of Natural Resources. Finally, in 1970, the 1969 map was enlarged in order to permit comparison with 1957 of a larger area which included land at the edge of the Marsh. Two half-sections and one 80, no longer important to prairie chickens, were not remapped (east halves of Sections 6 and 7 and Section 30, E½ SE¼, all in T20N, R7E).

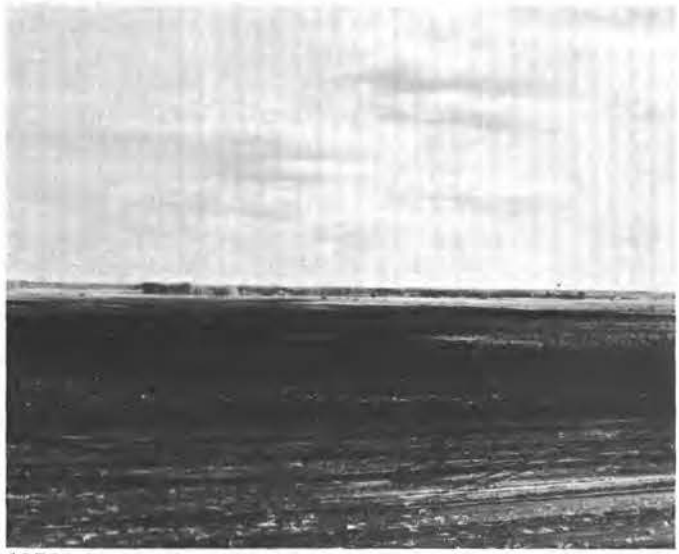
FINDINGS

A formalized representation of the cover map of the Portage County Management Area for 1969 is given in Figure 18, and for 1953 in Figure 19. The individual section sheets are on file in Madison; no mosaic was made of the 1969 mapping. Table 22 compares cover type acreages in 1969 with 1953 for the area as a whole and for each of the partial townships which are included.

Leola Marsh data are shown in Figure 20 (1941-42), Figure 21 (1947), Figure 22 (1956-57), Figure 23 (1969), all of which deal only with our original sample area in Sections 9-11, 14-16, 21-23, north halves of 26-28, T20N, R7E; and Figures 24 and 25 which show in addition parts of Sections 2 and 3, Sections 4 and 5, east halves of Sections 6 and 7, Sections 8, 17 and the east half of 18, Section 20, north half Section 29, and the SE¼, NE¼ Section 30. Figures 24 and 25 compare cover types on the larger area in 1956-57 and 1969-70, summarized in Table 24; Table 23 includes the acreages of Figures 20-23.

Leola Marsh Habitat Changes . . .

1941: *Land in grass–hay, pasture, Canary grass (Leola Twp., Sec. 22 SWNE) . . .*



1972: *Plowed for cultivated crops.*

1941: *Mowed and grazed hay meadow, supported "horse booming ground" . . .*

1972: *Plowed for cultivated crops.*

DISCUSSION

It is no secret that prairie chickens have lost range on a catastrophic scale due to man's ever intensifying use of the land. There are, however, few examples in which such losses have been precisely documented. We have what is perhaps a unique example in the history of land use changes on the Leola Marsh from 1940-41 to 1969, and another excellent case history on the much larger Portage County Management Area from 1953 to 1969. It is our purpose here to put these data on record.

Portage County Management Area

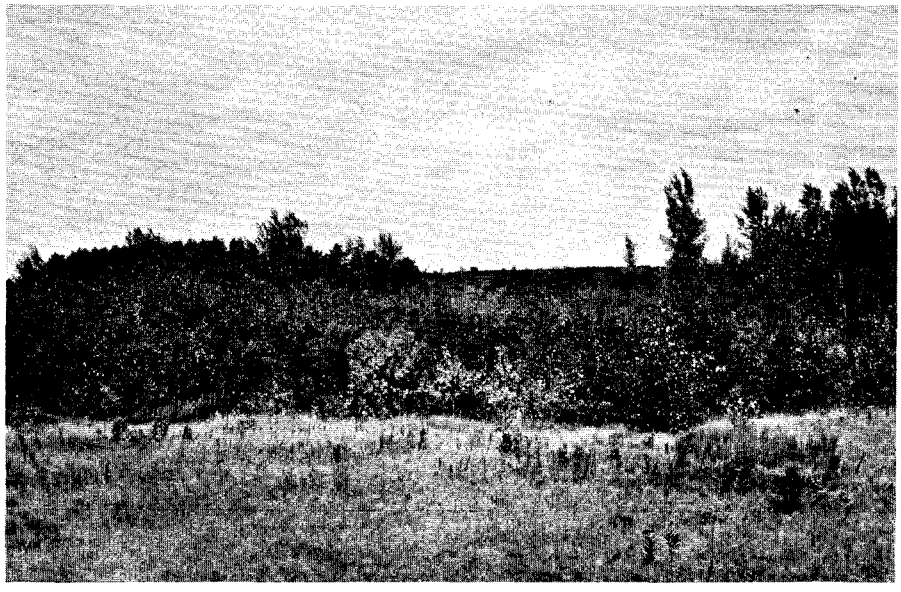
Table 22 suggests that the Buena Vista Marsh was not used unduly hard. Cropland decreased overall by about 12 percent; woods, brush, and miscellaneous types increased by about 10 percent; grass-forbs, the essential type for prairie chickens, hardly changed in total since 1953.

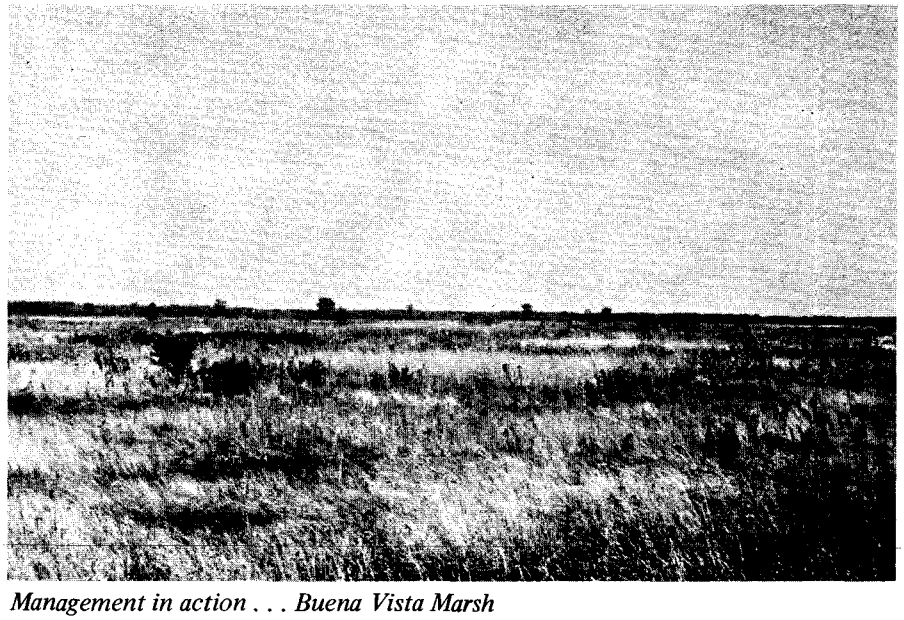
These figures do not tell the whole story, however. More than half of the remaining grass-forbs type is under management for prairie chickens, and a considerable part of it has been reclaimed from brush and trees. The unmanaged grasslands are for the most part extremely hard-grazed and produce few if any chickens. Where we were least successful in getting land for management, irrigated farming has crowded onto the Marsh–for a distance of 3 miles in the northeast and more than a mile along the north, reducing the effective size of the area by about 5,000 acres. This invasion is partly evident in the township acreage totals for T22N, R8E and T23N, R8E in Table 22, and shows clearly in Figure 18. We reported on this situation in our Job Completion Report, Job V-A, 1968, which is quoted here: "To show just how little prairie chicken habitat remains in the northern part of the management area because of intensified farming, we cover-mapped: (1) a strip one and a half miles deep across the north end plus the half of Section 12, T22N, R7E which lies within the area [Fig. 26], and (2) everything east of Highway 51 in T22N, R8E. The acreages of the different cover types as of late June, 1968, are given in Table [25].

"We should point out that this was a rapid reconnaissance.... Absolute precision would have required far more time and would add very little: the picture is wholly clear as it stands.

"In the North End [Table 25] there remain about 477 acres of good prairie chicken habitat–grass-forbs, tame hay in Soil Bank, and tame hay in the chicken management program–for a total of only 20 percent of the 2,350 acres involved. Of this suitable habitat, 357 acres or *75 percent is in Soil Bank and the last contract runs out in 1969.* Only 80 acres have been bought for prairie chickens. Further, 260 acres of Soil Bank lands are in one ownership and the owner has said that he is unwilling to sell because he plans to farm the land as soon as the Soil Bank contract ends.

"We have known for some time that the Northeast Corner–north of Ditch 4 and east of Highway 51–was essentially finished as far as chickens are concerned, largely through the farm practices of a single owner. The Northeast Corner totals 2,976 acres. There is *no* good chicken habitat left. A few birds might still be produced in 327 acres (11%) of moderately to heavily grazed grass-forbs pasture when grazing pressure permits and in 271 acres of tame hay (9%) when the odd nest escapes mowing. Undisturbed grass-forbs totals 22 acres (0.7%) in two small pieces: the lack of disturbance is probably only temporary and in any case neither is likely to be productive because of its isolation. Plowed ground–mainly muck farming for vegetables and mint–totals more than 1,834 acres (62%; more is included in the 300 acres not mapped). Altogether 2,356 acres (79%) are wholly unsuitable as prairie chicken habitat. All former booming grounds





Management in action . . . Buena Vista Marsh area before (above) and after treatment (mowing, spraying and burning) to create nesting cover.

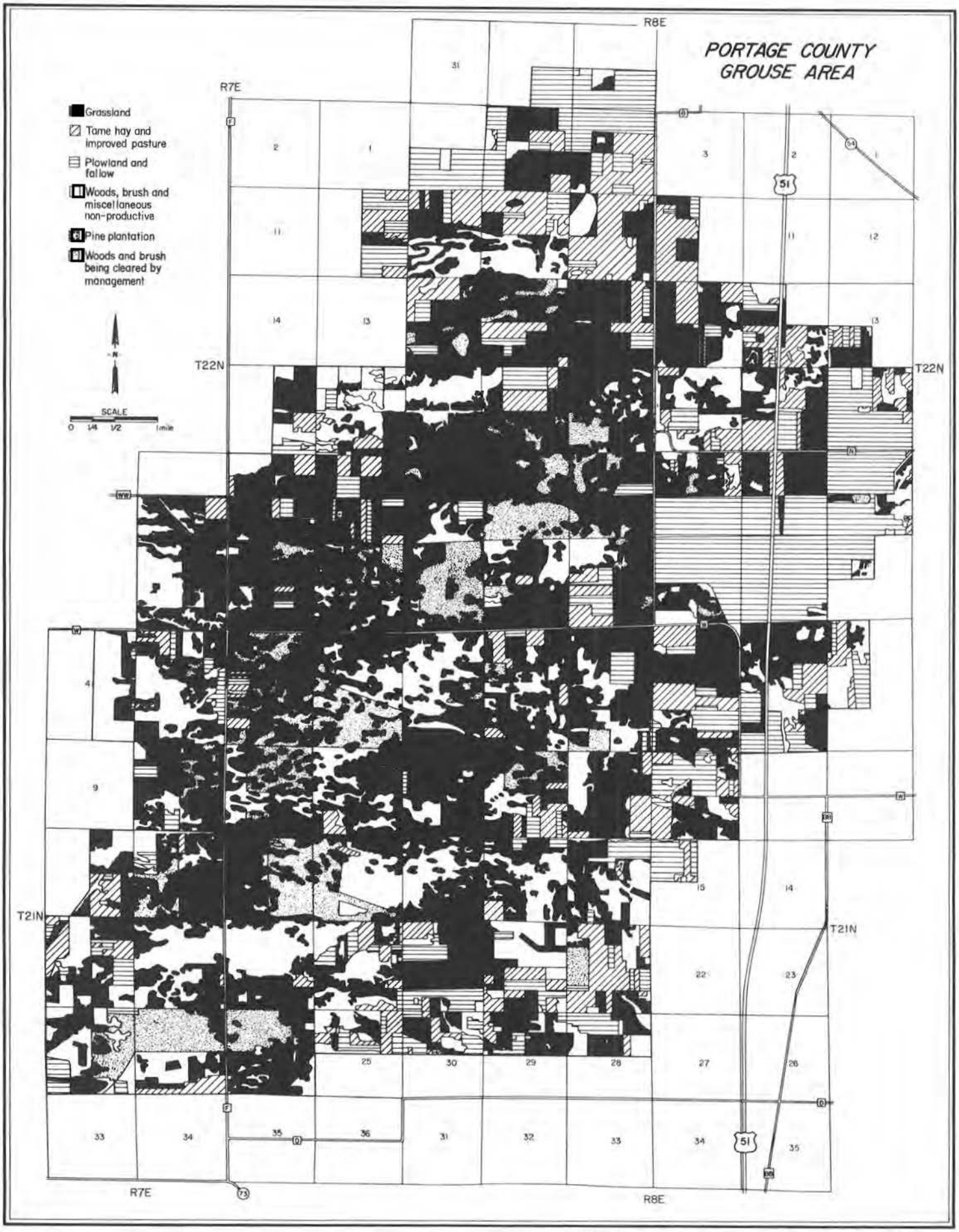


FIGURE 18. *Cover map of the Portage County Management Area, 1969.*

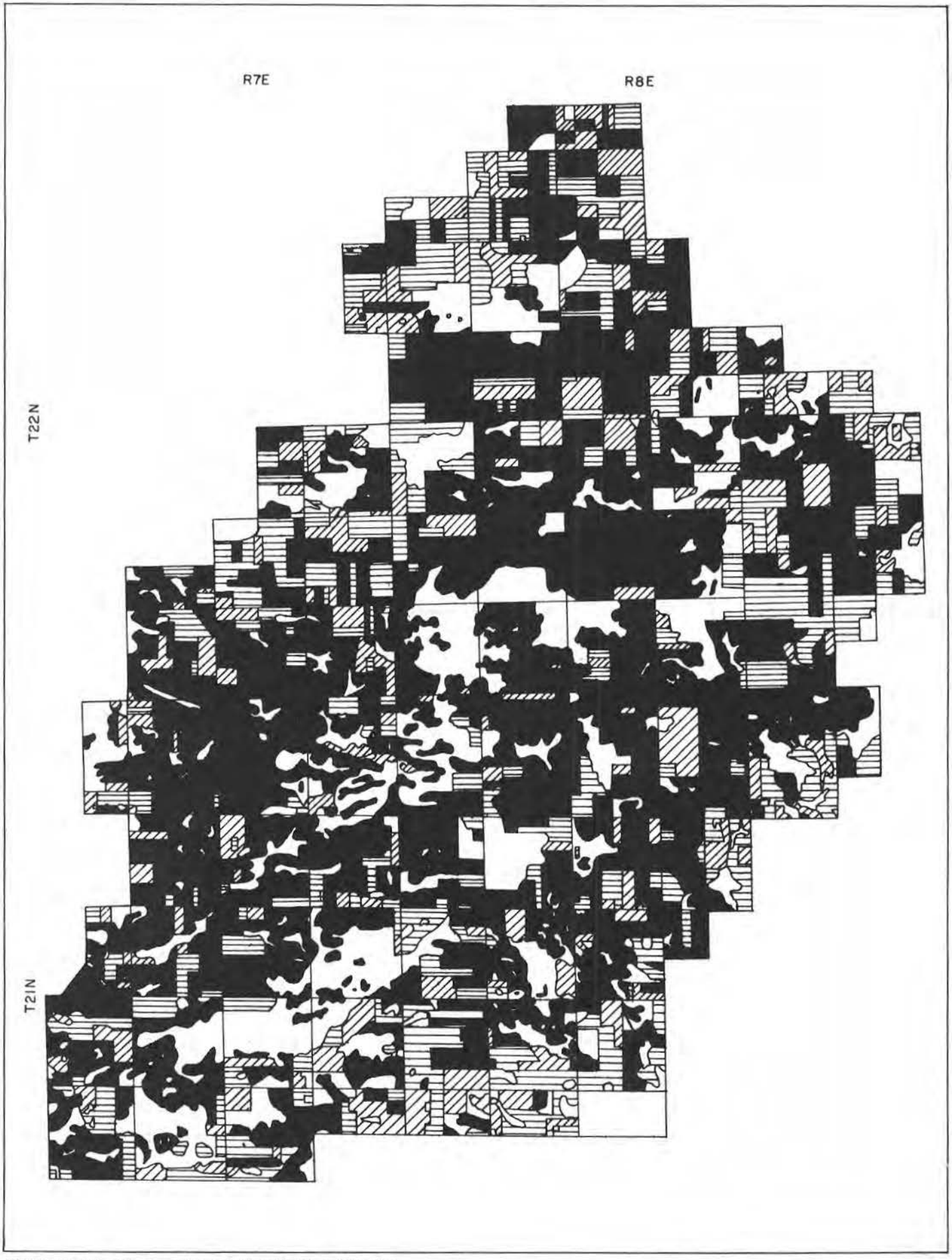


FIGURE 19. *Cover map of the Portage County Management Area, 1953.*

FIGURE 20. *Cover types on the Leola Marsh sample area, 1941-42.*

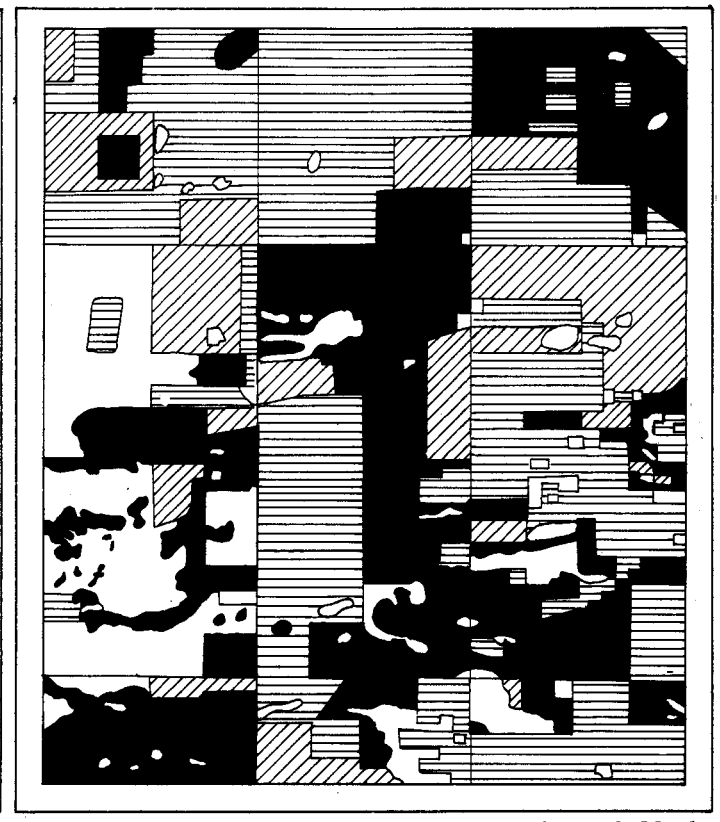


FIGURE 21. *Cover types on the Leola Marsh sample area, 1947.*

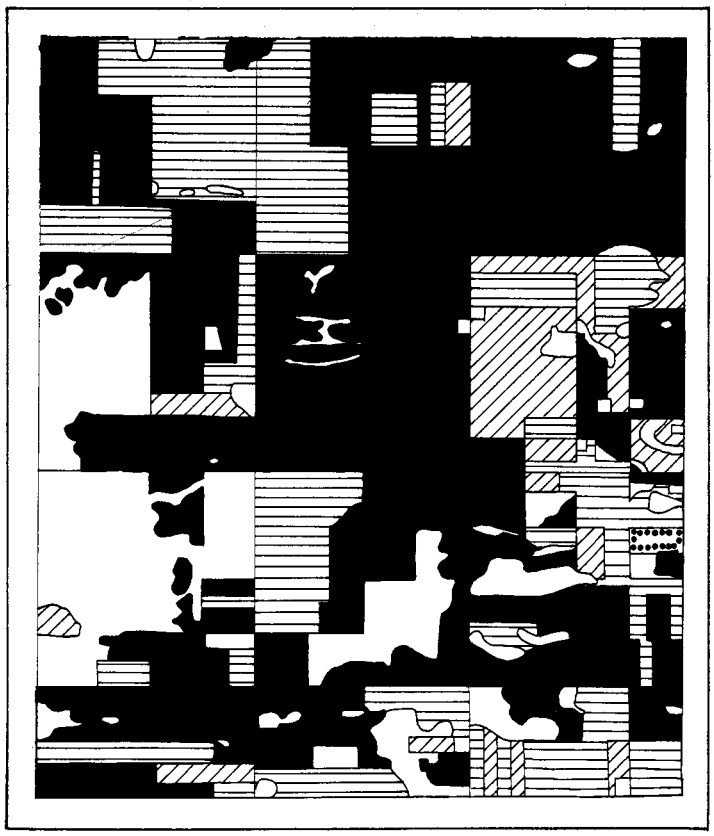


FIGURE 22. *Cover types on the Leola Marsh sample area, 1956-57.*

FIGURE 23. *Cover types on the Leola Marsh sample area, 1969.*

Grassland

Tame hay and improved pasture

Plowland and fallow

Woods, brush and miscellaneous non-productive

Pine plantation

Woods and brush being cleared by management

9	10	11
16	15	14
21	22	23
28	27	26

Section numbers, all in T20N, R7E

FIGURE 24. *Cover types on the enlarged Leola Marsh sample area, 1957.*

FIGURE 25. *Cover types on the enlarged Leola Marsh sample area, 1969-70.*

have disappeared.

"It is misleading to include so much now unproductive land within the boundaries of the management area. A more realistic boundary would cut out all of Sections 13, 24, 25, and 36; and everything east of Highway 51 in Section 35 and in the south half of Section 26. It might be worth retaining what is now within the area east of 51 in Sections 14, 23 and the north half of 26 because a high proportion of grassland still exists and there is still a chance–admittedly slim–for improvement in the future. Or perhaps we should write off everything north and east of the junction of Highway 51 and Ditch 4: the exact boundary is perhaps not important, as we own no land and have no management in progress east of the highway.

"To show the degree of intensification of farming in these two parts of the area Table [26] gives the amounts of cropland, tame hay, and improved pasture–land currently or recently plowed–in 1968 as compared with 1953. In the North End land in rowcrops–mainly potatoes, corn, and small grains–has increased by 68 percent; in the Northeast Corner, with mint and vegetables in addition to the foregoing, the increase has been 122 percent.

"In short, it is plain enough why booming has disappeared from the Northeast Corner, and that the North End is in serious trouble. The northernmost mile and a half of the North End will be dead in 1969 unless someting can be done. Two ownerships are probably the key: one tract of 7½ forties, all but one in Soil Bank until 1969, and two parcels of 40 and 20 acres, both in Soil Bank until 1968 (this year!); all these parcels are in Section 5, T22N, R8E. There is little time left and neither owner shows any willingness to sell. Additionally, the two grassland forties in E½ SW¼, Section 33, T23N, R8E would be useful but not enough in themselves. Because of current trends in land use, only a large block would suffice such as the 7½ forties in Section 5.

"Finally, there is no reason to believe that agricultural invasion will not penetrate even deeper from the north. In the next tier of sections below our mapped area, one owner in Section 8, T22N, R8E is said to be planning two quarter section irrigation rigs; he needs only one more forty. Sections 9 and 10 are already used hard and produce few chickens. The present heavy use in Section 12, T22N, R7E is shown in Table [25]."

As this is written in 1972, we are forced to report that the North End is indeed dead. All of the Soil Bank land in Section 5 was plowed, as predicted; the only unplowed land in the entire section is the 17-acre woods in the SWNW and the 20-acre plantation in the SENW. The management area could well drop all land in T23N, R8E; T22N, R8E, Sections 5 and 6; and T22N, R7E, Section 12.

Leola Marsh

Figures 20-23 hardly require comment. The percentage of grassland dropped from 47 percent in 1941-42 to 18 percent in 1969.

Figure 27 plots the four major habitat types graphically. After the strong decline in grassland acreage in the 1940's, the rise in 1956-57 was a surprise. It is accounted for by the fact that three landowners, whose holdings totalled 1,678 acres or 25 percent of the mapped area, turned from general farming to grass for hay and pasture for a few years just at that time.

Our original sample area was set up in the heart of the Leola Marsh, the best of the Plainfield Area. The Marsh, and especially its central part, produced the best grass and the most chickens. It has been turned into the richest and most intensively farmed part of the Plainfield Area, for the production of irrigated crops. From Figures 20-23, one might wonder that any prairie chickens are left at all. Grasslands around the edge and just off the Marsh proper are now helping to support the chickens on the Marsh, and for that reason we were led to enlarge our original sample in the comparison shown in Figures 24 and 25.

From Figures 24 and 25, and Table 24, one can see that the peripheral strip on the north and west also lost grassland to farming, but to a much lesser degree than was true on the Marsh proper. The enlarged mapped area also gives a better demonstration of the way the larger booming grounds are related to the larger remaining blocks of grassland.

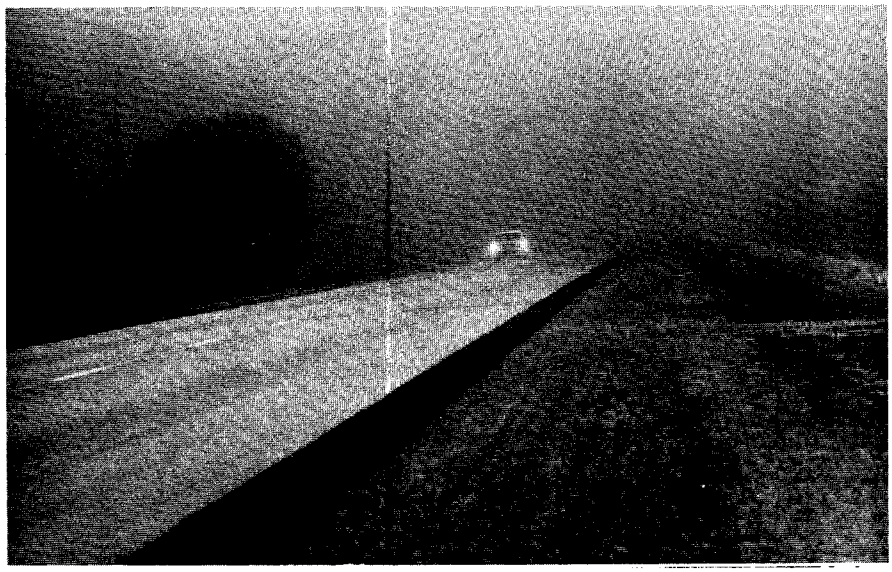
The future of prairie chickens on the Leola Marsh is highly uncertain. Two of the largest booming grounds in Figure 25 are close to the two largest parcels of state-owned lands. State purchases total only 500 acres, however. More grassland has been lost since 1969, including part of the large block in the northern part of our sample area. No lands except the state-owned parcels are under chicken management; hard-grazing and mowing are common on private lands, and none of the pastures along the northern edge are sure to persist. The third of the largest booming grounds in Figure 25 (and a ground of 7 cocks is small indeed compared to former numbers) is on a farm now entered under the Cropland Adjustment Program and certain to be returned to cultivation before long. Without further management, the prognosis is bleak.

Agro-business

The effective size of the original Portage County Prairie Chicken Management Area has shrunk by 5,000 acres from 1953 to 1969. Losses on the Leola Marsh since 1941 can only be described as catastrophic. There are long-term side effects which have even wider and more serious implications.

These habitat changes are the result of a shift to a large-scale agro-business type of farming, including the new and ever-expanding use of overhead irrigation. The most obvious change, clearly shown in Figures 20-23, is the shift from a varied to a monotypic landscape. Current practices are highly exploitive of ground water and at times of the soil itself; massive use of aerially sprayed pesticides and herbicides is also common. This development has caused us increasing concern, and not only for prairie chickens.

The U.S. Geological Survey has studied irrigation and its effects in the very part of central Wisconsin which includes both the Plainfield and Portage County Areas. Their findings show that our concern is well founded: "The pumping of water from ground water storage results in long-term water level declines" (p. 15)*. "Average stream flow in July and August would be reduced by irrigation, at the level undertaken in 1967, in Big Roche a Cri [a stream flowing through the center of the Plainfield Area] by 25 or 30 percent of natural flow and in Tenmile Creek [flowing through the Buena Vista Marsh], by 30 to 40 percent of natural flow. Depletion of summer stream flow is much more severe during drought, and could reach 60 percent of natural flow in Big Roche a Cri and 90 percent in Tenmile Creek" (p. 23)*. "In the Leola and Buena Vista Marshes, drainage with subsequent irrigation development and intensified cultivation has decreased the value of the Marsh as habitat for prairie



Drained marshes are highly vulnerable to wind erosion. Willow windbreaks, much touted as the answer to wind erosion, are plainly not doing the job here. Buena Vista Marsh, about 2:00 p.m. on a spring afternoon.

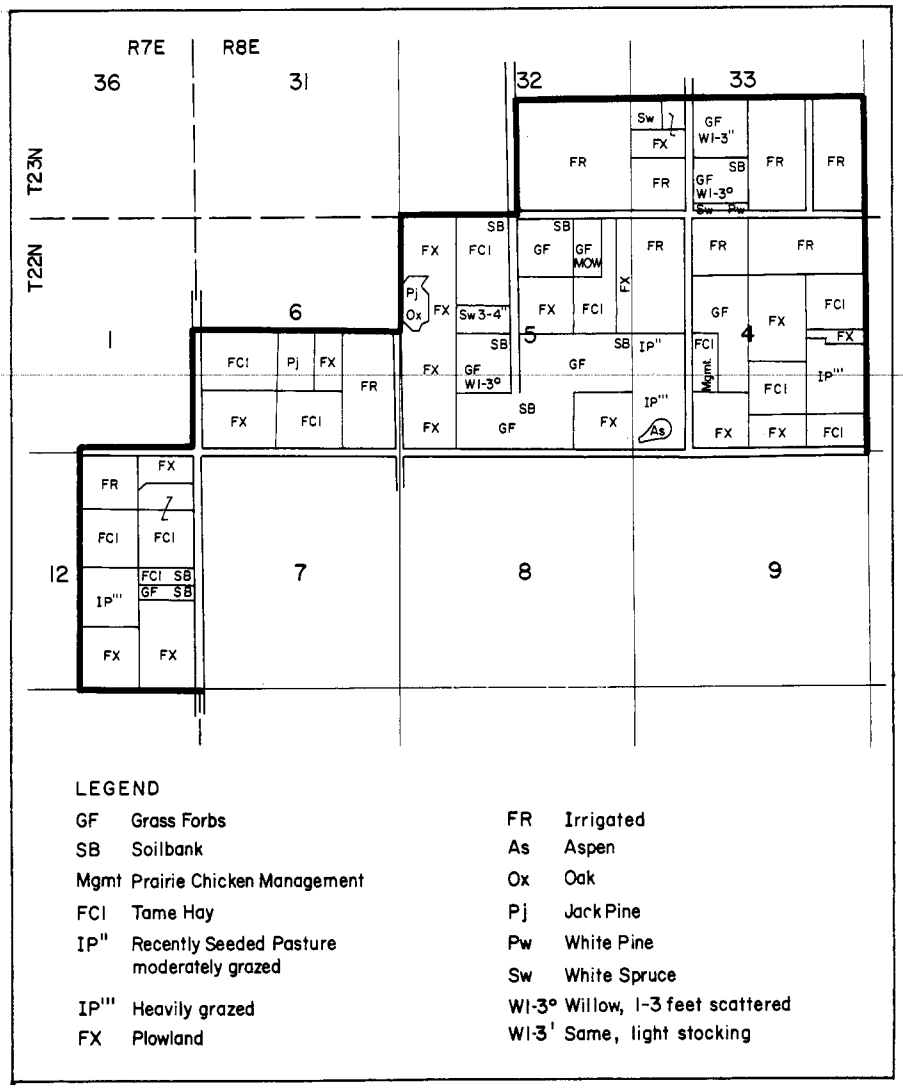


FIGURE 26. *Cover types, North End, 1968. (From Job Completion Rep. V-A, 1968).*

chickens, rabbits, foxes, and other wildlife" (p. 22)*.

We reiterate (Hamerstrom, F. and F., 1968):

"It is not surface water that the prairie chicken needs, it is moisture—sufficient moisture in the soil to grow good grass and food plants. Paradoxically, before a marsh can be irrigated it must first be drained, not only dried out but so ditched or tiled that it can be controlled: dried out at will when rain following irrigation puts too much water on the crop, dried out in spring quickly enough that heavy machinery will not bog down when it is time to prepare the seed bed. But the neighbor's land is also dried out. This land does not get irrigation water and so is in a state of ever-recurring drought. Not only prairie chickens, but many forms of wildlife may suffer. So do farmers, especially those who are near pumping projects but who raise their cattle and their crops not from water pumped out of the ground, but from a naturally moist condition in the top six or eight inches of the soil which they pasture or till.

"Wildlife has no artesian wells nor even sand point pumps. Most of our wildlife and many of our farmers are utterly dependent on the moisture conditions near the surface of the soil, not the water which is fifty feet beneath.

"May man not overlook the needs of his neighbors—his more defenseless brethren, the wildlife.

"The price for pumping is paid in two ways: one is in dollars and cents which shout, and the other in depletion of habitat. We raise our voice for the wildlife, which cannot speak for itself."

SUMMARY

The Portage County Management Area was cover-mapped in 1953 and in 1969. Although there was little change in the total acreages of the individual types, there was a net loss of 5,000 acres of former prairie chicken habitat along the northeastern and northern edges of the area due to intensified farming. Within the area, more than

* Hine, Ruth L. 1970. Water on the land. Wis. Dep. Natur. Resour., Madison. Compiled from: Weeks, E. P. and H. G. Stangland. 1971. Effects of irrigation on stream flow in the central sand plain of Wisconsin. U.S. Geol. Surv., Madison, Wis.

half of the grassland is under management; the unmanaged remainder is for the most part heavily grazed and/or mowed and produces fewer birds.

We cover-mapped a sample block of 6,714 acres within the Leola Marsh in 1941-42 as the best habitat on our 50,000-acre Plainfield Area. The same block was mapped again in 1947, 1956-57, and 1969. Grassland decreased from 47 percent in 1941-42 to 18 percent in 1969, with a corresponding increase in plowland from 29 percent to 64 percent. A larger block of 12,708 acres, including the original sample plus additional lands on the north and west, was mapped in 1956-57 and 1969-70. Loss of grassland was less severe on the peripheral land. Although it was inferior habitat in 1941-42, the bordering strip is now probably the major support of the population on the Leola Marsh. Further losses are to be expected. Without additional management, the prognosis is most discouraging.

The major losses on both areas are the result of widespread changeover from general farming to agro-business, which has caused a pronounced shift from a varied to a monotypic environment associated with exploitive use of ground water and sometimes of the soil, plus massive use of biocides.

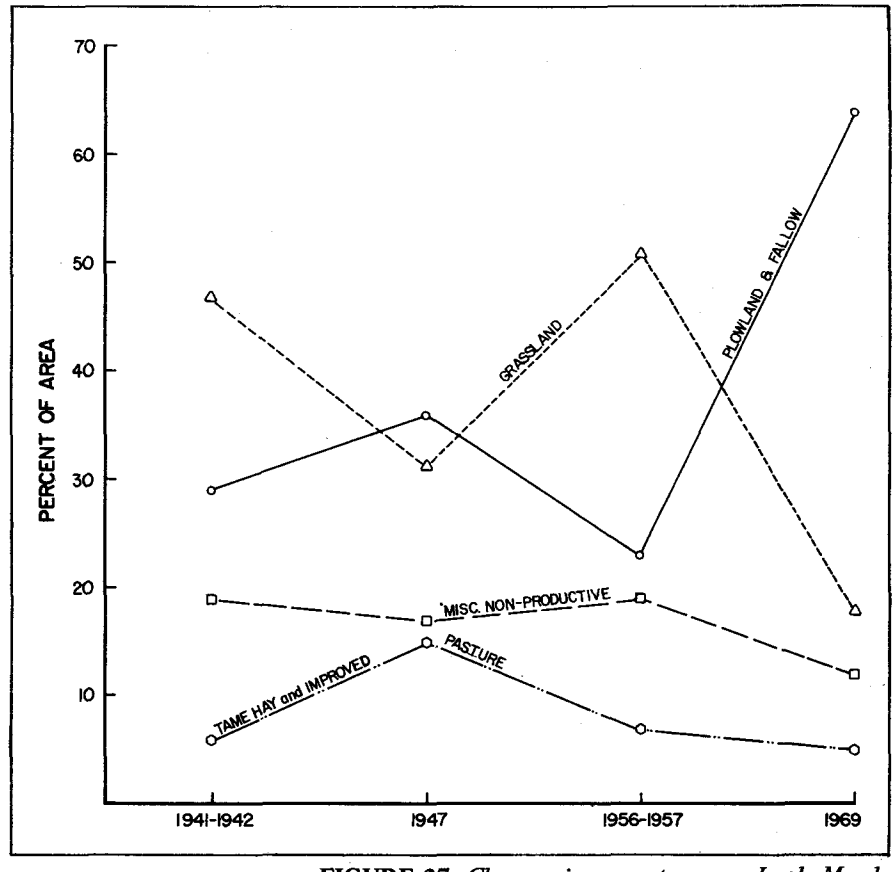


FIGURE 27. *Changes in cover types on Leola Marsh, 1941-42 to 1969.*

It is abundantly clear that the grassland reserves and their management on the Portage County Management Area are vitally important to the population there right now. Unless there are further drastic changes, the current management operation—developed by this study—should secure a substantial population for the future.

Dew drops are not enough for a prairie chick.

TABLE 22. Cover Type Acreages in 1969 as Compared with 1953, Portage County Management Area

Town & Range	Year & Change	Plowland & Fallow	Tame Hay & Recently Seeded Pasture	Grass–Forbs**	Woods, Brush, Wet Marsh, Farmyards, Etc.	Totals
T21N, R7E	1969	467	641	5,575	5,153	11,836
	Change*	– 980	– 418	+ 101	+1,306	–
T21N, R8E	1969	1,593	1,443	5,883	3,079	11,998
	Change	– 731	+ 59	+ 584	+ 88	–
T22N, R7E	1969	390	575	2,814	1,021	4,800
	Change	– 733	– 132	+ 601	+ 229	–
T22N, R8E	1969	4,172	2,590	7,270	3,601	17,633
	Change	+1,142	+ 479	–1,169	– 451	–
T23N, R8E	1969	427	0	17	36	480
	Change	+ 382	– 126	– 237	– 19	–
Total 1969	1969	7,049	5,249	21,559	12,890	46,747
	Change	– 920	– 138	– 120	+1,153	–
1953		7,969	5,387	21,679	11,737	46,772

*Change as compared with 1953.

**Includes grassland with thin scattering of brush or brush in small clumps, i.e., not enough brush to reduce the value for nest-brood cover.

TABLE 23. Cover Type Acreages, Leola Marsh, 1941–1969

Date of Cover Mapping	Plowland & Fallow	Tame Hay & Recently Seeded Pasture	Grass–Forbs*	Woods, Brush, Wet Marsh, Farmyards, Etc.
1941–42	1,934	375	3,143	1,262
1947	2,438	1,013	2,136	1,127
1956–57	1,555	456	3,420	1,283
1969	4,310	367	1,202	835
Change 1941–1969	+2,376	– 8	–1,941	– 427

The mapped area totals 6,714 acres.

*Includes grassland with thin scattering of brush or brush in small clumps, i.e., not enough brush to reduce the value as nest-brood cover.

TABLE 24. Cover Type Acreages, Plainfield Area, 1957–1969

Date of Cover Mapping	Plowland & Fallow	Tame Hay & Recently Seeded Pasture	Grass–Forbs*	Woods, Brush, Wet Marsh, Farmyards, Etc.
1956–57	2,480	635	5,118	4,475
1969–70	4,902	565	3,404	3,837
Change	+2,422	– 70	–1,714	– 638

The mapped area totals 12,708 acres and includes the Leola Marsh sample shown in Table 23.

*Includes grassland with thin scattering of brush or brush in small clumps, i.e., not enough brush to reduce the value as nest-brood cover.

TABLE 25. Cover Types in 1968, North End and Northeast Corner

	North End							Northeast Corner								
	T23N, R8E		T22N, R8E			T22N R7E		T22N, R8E								
	Sec.		Sec.			Sec.		Sec.								
	32	33	4	5	6	12	Total	13	14	23	24	25	26	35	36	Total
Productive Types																
Grass–Forbs																
Undisturbed		40	60				100					10		12		22
Soil Bank		37		240		10	287									
Tame Hay																
Soil Bank				60		10	70									
Management Program			20				20									
Low Productivity or None																
Grass–Forbs																
Mowed				20			20									
Moderately Grazed								80	16	71			160			327
Recently Seeded Pasture			20				20									
Tame Hay			111	42	95	100	348	34**	32	195				10		271
Unproductive Types																
Recently Seeded Pasture			93			40	133									
Plowland		30	128	242	75	113	588	34**	40	77	480	490	212	381	120	1,834
Irrigated Plowland	160	200	200		80	40	680									
Woods, Farmyards, etc.			8	16		7	31	12	88	32			30	20	40	222
Tree Plantation		13		20	20		53									
Not Mapped in Detail*											160	140				300
TOTALS	160	320	640	640	270	320	2,350	160	176	375	640	640	402	423	160	2,976

*No productive habitat in either tract–woods, brush and small fields.

**In several alternating strips; totals are estimates.

From Job Completion Report V-A, 1968.

TABLE 26. Acres Under Cultivation, 1953 vs 1968

	1953								1968		
	T23N, R8E		T22N, R8E			T22N, R7E					
	Sec.		Sec.			Sec.			Totals		Increase from 1953
NORTH END	32	33	4	5	6	12			1953	1968*	to 1968
Cultivated, including small grain	–	42	205	260	88	162			757	1,268**	67.5%
Tame hay	–	118	185	95	60	61			519	348	
Recently seeded pasture	–	–	–	–	–	–			0	153	
Totals	0	160	390	355	148	223			1,276	1,769	

	T22N, R8E										
	Sec.								Totals		
NORTHEAST CORNER	13	14	23	24	25	26	35	36	1953	1968*	
Cultivated, including small grain	107	18	5	67	70	126	320	114	827	1,834	121.8%
Tame hay	40	41	135	24	73	20	32	–	365	271	
Recently seeded pasture	–	–	–	–	–	–	–	–	0	0	
Totals	147	59	140	91	143	146	352	114	1,192	2,105***	

*See Table [25] for section-by-section acreages.

**Including at least 680 acres (and probably more) under irrigation; none in 1953.

***160 acres in Section 24 and 140 acres in Section 25 were not mapped but contain some additional plowland. These acres are excluded from the 1953 figures also. They contained no prairie chicken producing habitat in 1968 (woods, brush, and small fields).

From Job Completion Report, V-A, 1968.

APPENDIX

PUBLICATIONS... From the Prairie Grouse Management Research Project, 1949-1971.

Anderson, Raymond K.

1969. Prairie chicken responses to changing booming-ground cover type and height. J. Wildl. Manage. 33(3):636-643. (under supervision of FNH, Jr.)

1969. Mating and inter-specific behavior of greater prairie chickens. PhD Thesis, Univ. of Wis.–Madison. 118 p. (under supervision of FNH, Jr.)

Anderson, Raymond K. and Frances Hamerstrom

1967. Hen decoys aid in trapping cock prairie chickens with bownets and noose carpets. J. Wildl. Manage. 31(4):829-832.

Berger, Daniel D. and Frances Hamerstrom

1962. Protecting a trapping station from raptor predation. J. Wildl. Manage. 26(2):203-206.

Berger, Daniel D., Frances Hamerstrom and F. N. Hamerstrom, Jr.

1963. The effect of raptors on prairie chickens on booming grounds. J. Wildl. Manage. 27(4):778-791.

Hamerstrom, F. N., Jr.

1963. Sharptail brood habitat in Wisconsin's northern pine barrens. J. Wildl. Manage. 27(4):792-802.

Hamerstrom, F. N., Jr., and O. E. Mattson

1964. A numbered, metal color-band for game birds. J. Wildl. Manage. 28(4):850-852.

Hamerstrom, F. N., Jr., Oswald E. Mattson and Frances Hamerstrom

1957. A guide to prairie chicken management. Wis. Conserv. Dep., Tech. Wildl. Bull. 15. 128 p.

Hamerstrom, Frances

1950. Hahnenjagt in North Dakota. Der Deutsche Jäger 14, October 20, 1950.

1950. Range, habits and food requirements of prairie chicken. Wis. Conserv. Bull. 15(11):9-11.

1952. Of wilderness and the sharp-tailed grouse. Passenger Pigeon 14(3):97-99.

1953. The ecology of resort country. The Wilderness News 1(3):3.

1969. Singing the dogs. American Field, Nov. 1, 1969:483.

Hamerstrom, Frances, Daniel D. Berger and F. N. Hamerstrom, Jr.

1965. The effect of mammals on prairie chickens on booming grounds. J. Wildl. Manage. 29(3):536-542.

Hamerstrom, F. and F.

1968. Water and the prairie chickens. Wis. Acad. Review 15(1):10-11.

1970. Not on the far side of the earth. Wis. Acad. Review 16(4):33-34.

Hamerstrom, Frederick and Frances

1951. Grouse of the brushlands. Wis. Conserv. Bull. 16(10):7-9.

1955. Population density and behavior in Wisconsin prairie chickens *(Tympanuchus cupido pinnatus)*. Proc. Internat. Orn. Congress 11:459-466.

1960. Comparability of some social displays of grouse. Proc. Internat. Orn. Congress 12:274-293.

1961. Status and problems of North American grouse. Wilson Bull. 73(3):284-294.

1963. The [grouse] symposium in review. J. Wildl. Manage. 27(4):868-887.

1964. Grouse. *In* Thomson, A. Landsborough, ed. "A new dictionary of birds", Nelson, London. p. 343-345.

1966. Stove in the popples. Wis. Conserv. Bull. 31(5):3-5.

1967. Biologists at work: trapping and banding. Wis. Conserv. Bull. 32(1):14-15.

1969. Es war einmal ein Balzplatz. Wild und Hund 72(11):266-267.

Hamerstrom, Frederick and Frances, and O. E. Mattson

1952. Sharptails into the shadows? Wis. Conserv. Dep., Wis. Wildl. No. 1. 35 p.

Mattson, O. E.

1962. The chicken gets a chance. Wis. Conserv. Bull. 27(3):15-17.

Westemeier, Ronald L.

1969. The history and ecology of prairie chickens in central Wisconsin. MS Thesis, Univ. of Wis.–Madison. (under supervision of FNH, Jr.)

1971. The history and ecology of prairie chickens in central Wisconsin. Univ. of Wis., Col. of Agric. and Life Sciences, Res. Bull. 281. p. vii+63. (under supervision of FNH, Jr.)

ACKNOWLEDGMENTS

Our study has been enriched by the help of many people over the years—so many that we cannot acknowledge them all individually. For example, between 5,000 and 6,000 observers have cooperated in the booming ground work, as described in the chapter on Booming Ground Surveys and our two published papers on this phase.

The early history of prairie grouse research in Wisconsin and the sponsorship of our non-Departmental studies are outlined in *A Guide to Prairie Chicken Management* (Hamerstrom et al. 1957), which also acknowledges the help of other divisions of the Department and points to the help of our friends and neighbors in the vicinity of Plainfield and Bancroft, including their all-important share in gathering information on nest-brood cover during seed harvest on the Buena Vista Marsh.

Three project assistants have had especially significant roles: O. E. Mattson was a full-time member of the research project 1950-53 and then the first to take charge of the prairie chicken management program which he had helped to plan. Despite his management responsibilities, he continued to help with winter banding through 1959 and with booming ground work through 1963. F. V. Holzer carried out the banding, dancing ground, and brood studies on sharptails, full time from May 1949 through summer 1953, worked part time on dancing grounds and broods 1954-1956, and full scale again from January 1959 through March 1960. D. D. Berger was a part time assistant from February 1958 through March 1964, generally working from 3-5 months per year.

We also want to acknowledge outstanding contributions of several others who had shorter assignments: R. A. Hunt, for a total of about 8 months over a 3-year period; and for about 2-5 months each, Paul Drake, Jr., R. E. Kyro, A. L. Millard, F. B. Renn, C. R. Sindelar, Jr., and G. J. Socha. S. J. Mack and J. K. Sawyer were assistants for a few months each. Wanda M. Crawford was most patient and helpful in the sometimes tedious extraction and tabulation of data as a part time assistant for a year and 9 months between January 1970 and January 1972.

We have another and special sort of gratitude to our supervisors, first Cyril Kabat and later J. B. Hale, for their support and encouragement during the rather long and not always smooth course of this investigation, and to Ruth L. Hine whose editorial help has been one of the most enjoyable (as well as efficient) parts of the whole proceeding.

From December 1960 through November 1963 the project had the support of the National Science Foundation through grant No. G-14947 to the University of Wisconsin, Madison, with the field research under the cooperative supervision of this project. The grant paid all salaries and travel expenses except FNH's and a few months of Berger's, both fellowships, and bought materials not otherwise available. The two theses and the publications of R. K. Anderson and R. W. Westemeier, listed in the Appendix, are the direct result of that grant, as are most of the other findings during the grant period.

This report covers prairie chicken research carried out under Wisconsin Pittman-Robertson projects W-13-R, W-79-R, and W-141-R.

Drawings are by Frances Hamerstrom, and photographs by Frederick Hamerstrom, except as follows: Bernard L. Schwartz (p. 8); The Sheboygan Press (p. 17); Dept. of Natural Resources (p. 18); Univ. of Wisconsin, Dept. of Photography (p. 25-funnel trap, 26); The Milwaukee Journal (p. 25-Mattson); and A. O. Gross (p. 39).

The authors were biologists with the Bureau of Research, Plainfield.

Edited by Ruth L. Hine

4000-30-3K30028

TECHNICAL BULLETINS
Currently Available From The Department of Natural Resources

No. 10 Role of refuges in muskrat management. (1954) Harold A. Mathiak and Arlyn F. Linde

No. 13 Seasonal variation in stress resistance and survival in the hen pheasant. (1956) Cyril Kabat, R.K. Meyer, Kenneth G. Flakas and Ruth L. Hine

No. 19 The European pine shoot moth and its relation to pines in Wisconsin. (1959) Daniel M. Benjamin, Philip W. Smith and Ronald L. Bachman

No. 21 Forest insect surveys within specified areas. (1960) R.D. Shenefelt and P.A. Jones

No. 22 The state park visitor: a report of the Wisconsin park and forest travel study. (1961) H. Clifton Hutchins and Edgar W. Trecker, Jr.

No. 23 Basal area and point sampling: interpretation and application. (1970) H.J. Hovind and C.E. Rieck

No. 24 Licensed shooting preserves in Wisconsin. (1962) George V. Burger

No. 26 Effects of angling regulations on a wild brook trout fishery. (1962) Robert L. Hunt, Oscar M. Brynildson and James T. McFadden

No. 28 An evaluation of pheasant stocking through the day-old-chick program in Wisconsin. (1963) Carroll D. Besadny and Frederic H. Wagner

No. 31 Evaluation of liberalized regulations on largemouth bass: Browns Lake, Wisconsin. (1964) Donald Mraz

No. 35 Production and angler harvest of wild brook trout in Lawrence Creek, Wisconsin. (1966) Robert L. Hunt

No. 36 Muskrat population studies at Horicon Marsh, Wisconsin. (1966) Harold A. Mathiak

No. 37 Life history of the grass pickerel in southeastern Wisconsin. (1966) Stanton J. Kleinert and Donald Mraz

No. 39 Guidelines for management of trout stream habitat in Wisconsin. (1967) Ray J. White and Oscar M. Brynildson

No. 41 Occurrence and significance of DDT and dieldrin residues in Wisconsin fish. (1968) Stanton J. Kleinert, Paul E. Degurse and Thomas L. Wirth

No. 42 Foot of angler-caught pike in Murphy Flowage. (1969) Leon Johnson

No. 43 The Lake Winnebago sauger: age, growth, reproduction, food habits and early life history. (1969) Gordon R. Priegel

No. 44 Significance of forest openings to deer in northern Wisconsin. (1969) Keith R. McCaffery and William A. Creed

No. 45 Reproduction and early life history of walleyes in the Lake Winnebago region. (1970) Gordon R. Priegel

No. 47 Evaluation of intensive freshwater drum removal in Lake Winnebago, Wisconsin, 1955-1966. (1971) Gordon R. Priegel

No. 48 Responses of a brook trout population to habitat development in Lawrence Creek. (1971) Robert L. Hunt

No. 49 Growth of known-age muskellunge in Wisconsin and validation of age and growth determination methods. (1971) Leon D. Johnson

No. 50 Harvest and feeding habits of largemouth bass in Murphy Flowage, Wisconsin. (1971) Howard E. Snow

No. 51 A guideline for portable direct current electrofishing systems. (1971) Donald W. Novotny and Gordon R. Priegel

No. 52 Mercury levels in Wisconsin fish and wildlife. (1972) Stanton J. Kleinert and Paul E. Degurse

No. 57 Biology and Control of Selected Aquatic Nuisances in Recreational Waters. (1972) Lloyd A. Lueschow

No. 58 Nitrate and Nitrite Variation in Ground Water. (1972) Koby T. Crabtree

No. 59 Small Area Population Projections for Wisconsin. (1972) Douglas B. King. David G. Nichols and Richard J. Timm

No. 60 A Profile of Wisconsin Hunters. (1972). Lowell L. Klessig and James B. Hale.

No. 61 Overwinter Drawdown: Impact on the Aquatic Vegetation in Murphy Flowage, Wisconsin. (1973) Thomas D. Beard.

No. 62 Eutrophication Control: Nutrient Inactivation by Chemical Preciptation at Horseshoe Lake, Wisconsin. (1973). James O. Peterson, J. Peter Wall, Thomas L. Wirth and Stephen M. Born.

No. 63 Drain Oil Disposal in Wisconsin. (1973). Ronald O. Ostrander and Stanton J. Kleinert.

No. 64 The Prairie Chicken in Wisconsin. (1973). Frederick and Frances Hamerstrom.