A STUDY OF WISCONSIN PRAIRIE CHICKEN AND SHARP-TAILED GROUSE

BY F. N. HAMERSTROM, JR.

THE Central Wisconsin Game Project, Necedah,[1] is a hundred thousand acres of sand and peat. Lumbered off in the '50's, it has been drained, burned, farmed, abandoned, and is now being developed for wildlife.

Original conditions have been completely changed. Widespread marshes and timbered swamps once dominated the landscape; they were drained and chopped out. Fires ate out the peat. Bluejoint and willow, or aspen where the peat was burned, now hold the old marsh beds. White and red pine once grew on the better soils of the intervening sand ridges and islands, jack pine and scrub oak on the poorer. The saw mill has claimed the good timber, fires destroyed the leaf litter which grew it, jack pine and scrub oak have taken its place. The old lumber holdings were drained and cut up into farms. Poor soil, unseasonable frosts, and drainage taxes drove out all but the hardiest farmers and now they have been bought out by the federal government. The hard-won fields are slowly disappearing, and government dams are restoring some of the lost water.

As the country has been changed, so have the fortunes of its wildlife. Originally there were no Prairie Chicken [2] (*Tympanuchus cupido americanus*) and but few Sharp-tailed Grouse (*Pedioecetes phasianellus campestris*). Evicted from their range to the south, Prairie Chicken came into the newly cleared land of the first farmers. The combination of large blocks of open wild land and few scattered farms was to their liking. They throve, and for thirty years the central counties were the best Prairie Chicken country in the Middle West. Fires in the drained peat, however, have changed thousands of acres of open marsh into thickly seeded aspen flats. On the heels of the 1930 drought, in particular, fire-sown aspen came in with a rush. As a result of the increase in brush there were three or four times as many Sharp-tails as Prairie Chicken in 1936, and each year the disparity grows larger and larger.

These two grouse are the most important species of wildlife on the Project. As yet little is known about their management. With a million dollars to spend in developing the area for wildlife, it seemed wise to find out what wildlife needed. A research program was begun in January, 1936, and abandoned in August, 1937. The work done on other

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[2] Both pinnated and sharp-tailed grouse are often popularly called "Prairie Chicken"; in this paper however, "Prairie Chicken" is used in the strict sense to refer only to pinnated grouse.

species, and a description of methods of trapping Prairie Chicken and Sharp-tails (Hamerstrom and Truax, 1938), have been reported.

Population Density

On the grey silt loams of Illinois, where there are no Sharp-tails, Yeatter (1937) has found a late summer average of one Prairie Chicken per 13-16 acres. Leopold (1931) places the average population of both grouse together at one per 40 acres in the Wisconsin sand plain. On the best of this range and at the high of the cycle the figure rises to about one grouse per 10 acres. My work dealt with a population just past the cyclic low and on a badly damaged range; I estimated it at one grouse per 85-100 acres during the winter of 1936-37, with about three Sharp-tails to every Prairie Chicken.

Booming Behavior of Prairie Chicken

In 1937 we found 23 booming grounds on the Project, or about one per 4500 acres. I think we found practically all of them.

It is generally assumed that the same booming grounds are used year after year. I do not have complete data, but at least 11 were used in both 1936 and 1937, at least 13 in 1937 and 1938, at least 7 in all three years, and one has been known to have been used for at least six years. On the other hand, four which were regularly used in 1936 were not in 1937, and at least one 1937 booming ground was not reoccupied in 1938. One spot, to which a cock or two had occasionally come to boom in 1937, became a regularly used booming ground in 1938.

All but two booming grounds were in herbaceous cover in open places from 3 to 300 acres in size. Nineteen were in mixed grasses, sedges, and forbs, 6 in stubble or weedy fallow fields, 2 in grass and scattered willows. Low knolls were chosen for 10, 12 were level, 5 were in marshes and were covered wtih a half inch of water after each spring rain. Cocks continued to boom on these flooded grounds.

Each booming ground was used apparently by a definite number of cocks. Eighteen was the largest number and 3 the smallest, with 8 or 9 on most. During early spring cocks boomed and fought over the whole booming ground, as shown by the trampling of all the old vegetation. Late in the main part of the season, however, only certain plainly marked parts were used, as shown by trails in the new grass. These trails (see figure 1) were made by stamping and running; bowing and turning places were indicated by circular enlargements. It appears that the early season is spent in general fighting, each cock trying to cut out a place for himself. Once the boundaries have been set there is much less fighting, the cocks tending to remain in their respective trails. Something equivalent to "peck dominance" is clearly involved. Whether each individual stayed in the same trail all season was not determined, but awaits a study of marked birds.

One cock was seen booming at the top of a small fire-killed oak at the edge of a booming ground. Leonard Wing has told me of a Wisconsin Prairie Chicken which he saw booming in the top of a young jack pine only 30 inches tall; Gross (1929) reports a Heath Hen (*T. c. cupido*) booming in an oak. The European Birkhahn (*Lyrurus tetrix*), of course, often booms in trees.

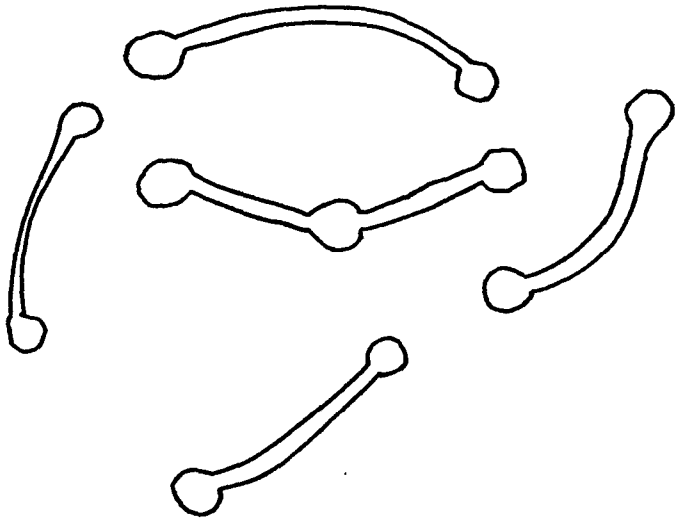

Figure 1. Diagrammatic drawing of late-season trails on a small booming ground of the Prairie Chicken

The mating display was not confined to regularly used booming grounds. What may be called "casual booming" was often seen, a few cocks booming at places which were not used regularly, perhaps only once. A wide variety of cover types, including food patches, open oak woods, blueberry knolls, and open grass meadows, were used for casual booming. Whether the birds so engaged had been unable to hold a place on a booming ground and so had to put on a private show, or whether chance meetings brought about these displays, are still moot questions. The casual booming on the food patches in early spring suggests the latter explanation.

The main part of the booming period fell between early April and early June, although first and last records embrace a much wider span.

The earliest mating displays were seen during thaws on February 25, 1936, and February 5, 1938. On both occasions cocks were strutting on snow covered ground, going through the usual motions with pinnae, wings, and tail, but not making the booming sound. The complete performance was first reported in 1936 on March 21, in 1937 on

March 13 and in 1938 on March 2. Affected by the weather, March booming was sporadic, vigorous for several days at a time, with little or none on other days.

Like the breeding display of the domestic chicken (see Pezard, 1920; Hamilton, 1938), booming is probably influenced by internal secretions of the testes. But what activates the process? Bissonnette (1938) summarizing a large volume of experimental work, has concluded that light, not temperature, activates the gonads of a number of birds and mammals, but also points out that not all species are sexually photoperiodic. Nice (1937) has shown that the start of egg laying in the Song Sparrows she studied was correlated with temperature and not with light, and quotes other authors to show that still other factors influence the start of laying in other species. Without denying the possibility that even in these cases light may have an important function in pre-conditioning the gonads, it is plain that factors other than light may influence the translation of physiologic readiness to actual breeding.

The field observations of Marshall and Jensen (1937) have shown that the dancing of the Columbian Sharp-tail (*P. p. columbianus*) is correlated with light conditions. My own field work leads me to believe that the booming of Prairie Chicken is regulated by the joint action of light and temperature.

That the light-temperature effect lies between upper and lower limits, and does not operate through a lower threshold only, is suggested by: (a) late winter displays occurred on days warmer than usual, (b) early spring displays occurred for an hour or two after sunrise on clear bright mornings with temperatures a few degrees below freezing, but not on raw cloudy mornings which were five or six degrees warmer, (c) during the early part of the main booming season booming occurred all day on cloudy days; later, in warmer weather, cloudy days did not produce the day-long response, (d) during the height of the season booming occurred from the first faint trace of light until an hour or two after sun-up, again for about two hours before dark; there was less activity on unusually hot days than on moderate ones, (e) on those hot days and toward the end of the season generally, there was more activity in the cooler early morning than in the evening, and morning booming stopped earlier than usual, (f) at the end of the season, although cocks continued to come to their regular stations morning and evening, booming was heard only on occasional clear frosty mornings and stopped as soon as the air grew warmer shortly after sunrise.

Light rains did not deter booming cocks, heavy rains silenced them completely. Birds were once seen booming in a late spring snowstorm.

The season ended even more gradually than it began. Long after the last scattered booming of the main season had stopped, some of the booming grounds were still used as meeting places. In early July the

trails made well-marked alleys in the tall grass on some of the grounds; at a few the cocks were seen at their regular stations until even later, on one in particular in September, 1937. Desultory booming was heard on three mornings in mid-October, 1938, and one farmer reported that booming is regularly heard again for a short time, after the late summer silence, after the first hard frost of autumn. Several of the booming grounds were not wholly abandoned during the winter: to these, even while the ground was covered with snow, Prairie Chicken sometimes came to loaf.

It seems that in the behavior pattern of Prairie Chicken there is, in some cases at least, a carry-over of some connection with the booming ground well beyond the main booming period. As already pointed out, the beginnings of the display were seen in February. There may have been earlier ones. Where, then, does one season stop and the next begin?

There is a close parallel between the booming of Prairie Chicken and of the Heath Hen, as reported by Gross (1928), particularly in respect to the extent of the main seasons, times of day during which booming occurs, and the effect of weather on the performance.

Dancing Behavior of Sharp-tails

Although Sharp-tails greatly outnumbered Prairie Chicken during the winter, only seven dancing grounds were found. An eighth, found by Franklin Schmidt about 1929 and still in use, was also visited. At least two were used in both 1937 and 1938; a third, Schmidt's, was known to have been used for at least five years (1929, 1934, 1935, 1936, 1937). Of the eight dancing grounds, four were open grassy knolls, one in an open marsh, two on buckwheat stubble, and one on a fairly open knoll with a few jack pines.

Sharp-tails were known to dance at 11 "casual" spots on ditch banks, food patches, grassy knolls, and meadows. Five of these spots were used on several occasions, 6 apparently but once.

As with Prairie Chicken, the first Sharp-tail display occurred in late winter, in 1938 on the fourth of February. Grange (1936) reports fighting "as early as the middle of February, although March is the more usual time in Wisconsin and Minnesota." The main season, marked by regular early morning and evening dancing, came a little earlier than the Prairie Chicken's booming season, and like it tapered off to a gradual end. Here again there was a summer and early autumn period during which Sharp-tails came to the grounds but did not dance. In late October, 1938, I found Sharp-tails dancing, as vigorously as in spring, on three dancing grounds and at three other places. Several dancing grounds were used as winter loafing places. Marshall and Jensen (1937) found that Columbian Sharp-tails often range year-long close to their dancing grounds.

Joint Booming and Dancing Grounds

Three of these booming and dancing grounds—one a marsh and the other two knolls in bluegrass pastures—were used jointly, with both species in action at the same time. Several booming grounds were used casually by Sharp-tails, and a few dancing grounds were also casual booming places. These were at food patches at which both Prairie Chicken and Sharp-tails had fed through the winter, and most of the casual visitors were seen in spring.

Nesting Habits of Prairie Chicken and Sharp-tails

Twenty-three nests of Prairie Chicken and 17 of Sharp-tails were found by nest hunting crews and other cooperators.

Data on nesting chronology are given in Tables 1 and 2, fertility

TABLE 1
Nesting Chronology:
Prairie Chicken

	Apr. 1–15	Apr. 16–30	May 1–15	May 16–31	June 1–15	June 16–30	July 1–15	Year & Source of Data
Laying began	4	7	11	4	3	1	0	1929–30, Gross
	1	5	2	2	3	0	0	1936–37, Hamerstrom
	5	12	13	6	6	1	0	1929–30 1936–37
Hatched in				3	7	5	2	1929–30, Gross
				0	2	2	4	1936–37, Hamerstrom
				3	9	7	6	1929–30 1936–37

TABLE 2
Nesting Chronology:
Sharp-tailed Grouse

	Apr. 1–15	Apr. 16–30	May 1–15	May 16–31	June 1–15	June 16–30	July 1–15	Year & Source of Data
Laying began	1	3	0	0				1930, Gross
	0	4	2	3				1936–37, Hamerstrom
	1	7	2	3				1930 1936–37
Hatched in					4	0	0	1930, Gross
					4	0	2	1936–37, Hamerstrom
					8	0	2	1930 1936–37

and viability of eggs in Tables 3 and 4, size of completed clutches in Table 5, 6, and 7, and causes of nest failures in Table 8. I have drawn upon Gross' (1930) report on his central Wisconsin nesting study and unpublished notes of the late Franklin J. W. Schmidt (in the files of Prof. Aldo Leopold) in order to bring together all the available Wisconsin material.

TABLE 3
FERTILITY AND VIABILITY OF EGGS:
PRAIRIE CHICKEN

No. of clutches	No. of eggs	Fertility	No. of fertile eggs	Dead embryos	Year and source of data
20	248	97.6%	242	8.3%**	1929–30 Gross
9	95	98.9%	92*	2.2%	1936–37 Hamerstrom
29	343	98.0%	334	6.6%	1929–30 1936–37

*The remaining fertile eggs were broken or deserted before the hatching date.
** Over half (11 of 20) were in one nest, and probably died of excessive heat rather than inherent weakness.

TABLE 4
FERTILITY AND VIABILITY OF EGGS:
SHARP-TAILED GROUSE

No. of clutches	No. of eggs	Fertility	No. of fertile eggs	Dead embryos	Year and source of data
5	60	100.0%	60	0.0%	1930 Gross
7	76	98.7%	61*	1.6%	1936–37 Hamerstrom
12	136	99.3%	121	0.8%	1930 1936–37

*The remaining fertile eggs were broken or deserted before the hatching date.

TABLE 5
NUMBER OF EGGS PER COMPLETED CLUTCH:
PRAIRIE CHICKEN

Year	Av. size of clutch	Range	No. of clutches	Source of data
1929	12.0	10–17	8	Gross
1930	11.9	9–17	22	"
1931	11.6	?	12	Schmidt
1932	13.8	?	12	"
1936	11.1	8–13	8	Hamerstrom
1937	10.0*	5–15	4	"
6 years	12.0	5–17	66	

* One clutch was of only five eggs. It may have been atypical, in which case the other three, averaging 11.7 eggs, might be closer to the true figure.

TABLE 6

NUMBER OF EGGS PER COMPLETED CLUTCH: SHARP-TAILED GROUSE

Year	Av. size of clutch	Range	No. of clutches	Source of data
1930	12.8	11–17	5	Gross
1931	11.8	?	15	Schmidt
1932	13.3	?	8	"
1936	11.4	9–13	5	Hamerstrom
1937	10.3**	9–11	3	"
5 years	12.1	9–17	36	

** Misleadingly low. Four other clutches which may or may not have been complete contained 11, 11, 11, and 13 eggs.

TABLE 7

SEASONAL DECLINE IN SIZE OF CLUTCH: PRAIRIE CHICKEN

	Apr. 1–15	Apr. 16–30	May 1–15	May 16–31	June 1–15	June 16–30	Year and source of data
Av. no. of eggs per completed clutch begun:	15	11.7	11.5	11.2		10.0	1929–30 Gross
No. of completed clutches	4	7	11	4		1	
Av. no. of eggs per completed clutch begun:	15	13	13	10.5	7.3		1936–37 Hamerstrom
No. of completed clutches	1	2	2	2	3		
Av. no. of eggs per completed clutch begun:	15	12.0	11.7	11.0	7.3	10.0	1929–30 1936–37
No. of completed clutches	5	9	13	6	3	1	

The tables show that:

(a) The nesting season of both Prairie Chicken and Sharp-tails extends from the first half of April into the first half of July. A few Prairie Chicken may hatch as late as the last half of July, as shown by the fact that at least one clutch was begun in late June.

(b) Most of the nests of both species are begun in late April and early May, during the height of the booming and dancing seasons.

(c) Fertility of both species is very high, and few of the fertile eggs fail to hatch. Some eggs hatch after the brood has left the nest and are thus lost; but hatches observed by Gross (1930) and Cleveland Grant (unpublished) show that such losses are slight.

TABLE 8

CAUSES OF NEST FAILURES:
PRAIRIE CHICKEN AND SHARP-TAILED GROUSE

	Skunk	Dog, fox or coyote	Man**	Mink	Unident. mammal	Crow	Horned Owl	Flooded	Heat of Sun	Destroyed—Agent unknown	Deserted—Cause unknown	Eggs taken for expt. hatching	Success or failure unknown	Total nests found	No. hatched	Year and source of data
Prairie Chicken		3*	1	1*		4	1*	4	1	2	3	2		42	20	1929–30. Gross.
	4	1*	1							5*			1	23	11	1936–37. Hamerstrom
Totals, PC	4	4	2	1		4	1	4	1	7	3	2	1	65	31	1929–30; 1936–37
Sharp-tailed Grouse														5	5	1930. Gross
	3	1	2		1					2	1		1	17	6	1936–37. Hamerstrom
Totals, ST	3	1	2		1					2	1		1	22	11	1930, 1936–37
Totals, PC & ST	7	5	4	1	1	4	1	4	1	9	4	2	2	87	42	1929–30, 1936–37

* Nesting hen mortality: 3 killed by coyotes, one each by mink and Great Horned Owl, one by unknown predator.

** Nests destroyed through acts of man: one each in plowing and mowing, one because of nest hunting crew, one because of dyke-building crew.

(d) Prairie Chicken clutches over a six-year period averaged 12.0 eggs, range 5 to 17; Sharp-tail clutches over a five-year period averaged 12.1 eggs, range 9 to 17. Ralph King's well-known but unpublished statement that in Ruffed Grouse there is a marked cycle, inversely synchronized with the population cycle, in the size of the clutch has raised the question for other grouse. The tables show no such trend. There is no significant variation from the average mid-way in the rise of the cycle (Gross' nests), at the high (Schmidt's nests), or just past the low (Hamerstrom's nests).

(e) Prairie Chicken clutches grow progressively smaller in size as the nesting season advances, with the largest begun during the height of the booming season. Sharp-tail data on this point are still incomplete.

(f) As with most gallinaceous birds, nest failures were very frequent. Schmidt's notes bear out this statement: of 38 Prairie Chicken nests which he studied in 1931, half were destroyed or deserted. Thus, of 100 Prairie Chicken nests studied during five years, one half failed

TABLE 9
NESTS FOUND IN DIFFERENT COVER TYPES, 1936–37

Cover type	Prairie Chicken	Sharp-tailed Grouse	Ruffed Grouse	Mallard	Blue-winged Teal	Total	Cover plants which make up the type
Dry marsh or marsh edge.	3	1		2	4	10	*Calamagrostis* sp., or *Carex* spp., with varying amounts of mixed *Carex* spp., *Rubus villosus* (?-dewberry), *Solidago* sp., *Spirea salicifolia;* may be a few scattered patches of invading low *Populus tremuloides, Salix* spp.
Grass meadow along drainage ditch. May show slight brush invasion.	11	2		1	4	18	*Poa pratensis, Phleum pratense,* plus those above; plus scattered invading low *Prunus pennsylvanica, Pinus Banksiana.*
Open edges of, or small* openings in, open jack pine-scrub oak woods.	3	2		1		6	*Andropogon furcatus, A. scoparius, Carex pennsylvanicus, Vaccinium pennsylvanicum, Myrica asplenifolia.*
Bank of major drainage ditch.				1		1	Same as for marsh edge, plus *Rubus* spp. (raspberry, blackberry), clumps of *Populus tremuloides, Salix* spp., *Prunus pennsylvanica,* occasional *Betula alba* var. *papyrifera.*
Small* openings in light stands of brushy aspen or willow.	2					2	*Calamagrostis* sp., *Rubus villosus* (?-dewberry), *Solidago* sp.
Small* openings in dense stands of brush: generally aspen or willow.		3	1	7	1	12	Same as next above.
Scattered brush, small trees, and grass; fairly open.	3	1		3	2	9	*Populus tremuloides, Salix* spp., *Pyrus melanocarpa, Vaccinium pennsylvanicum, Pinus Banksiana;* undercover as next above.
Same, as strip at edge of marsh, dense brush, or woods.		8	2	6		16	Same as next above.
Dense tall brush, generally aspen or willow.			1**	1		2	*Populus tremuloides, Salix* spp.; undercover *Calamagrostis* sp.
Rather dense mixed hardwoods.	1		1**			2	Mainly *Quercus* spp., with *Populus tremuloides, Ulmus americana, Betula alba* var. *papyrifera,* undercover *Pyrus melanocarpa, Corylus americana, Rosa* sp.
Total nests	23	17	5	22	11	78	

*From 50 feet in diameter to a half-acre in size.
**Ruffed Grouse nest at the edge of the stand.

to hatch. As far as the data go, this mortality rate of 50 per cent shows no significant variation during different phases of the cycle. It was the same mid-way in the rise of the cycle (1929-30), just before the high (1931), and just after the low (1936-37).

Do Prairie Chicken and Sharp-tails raise more than one brood a year? Do they re-nest if early nests are destroyed? I know of no direct evidence on either of these questions. The shortness of the mating season would seem to rule out the first. By analogy the following line of evidence might be adduced for the second: (a) nesting frequency data for Prairie Chicken (Table 1) are similar to those of Quail (Stoddard, 1931; Errington, 1933), Hungarian Partridge (Yeatter, 1934; Middleton, 1936), and Pheasant (Hamerstrom, 1936; Errington and Hamerstrom, 1937), but the peak comes earlier and the spread embraces a shorter time-span; (b) like those species, Prairie Chicken lay smaller and smaller clutches as the nesting season progresses; (c) spread of nesting dates and declining clutch in these species reflect re-nestings; (d) Prairie Chicken, by analogy, probably do re-nest but to a far smaller extent. The argument is supported by V. W. Lehmann (MS) who has found that the Attwater Prairie Chicken (*T. c. attwateri*) sometimes re-nests. If Prairie Chicken do re-nest, the proportion of hens which actually bring off a hatch is higher than that implied by the number of nest failures, as in the case of Pheasants (Errington and Hamerstrom, 1937).

Nine of the 23 Prairie Chicken nests were within a half mile of a booming ground, 10 between a half mile and a mile and a quarter. The distances from the other four to the nearest booming ground were unknown. The same thing seems to hold for Sharp-tails, although, since both nests and dancing grounds were harder to find, I have fewer instances to draw upon. Figure 2 is witness that this grouping of nests is not chance distribution. Schmidt (MS) found that most Prairie Chicken and Sharp-tail nests were within a mile of booming or dancing grounds.

However, 6 nests of Prairie Chicken and four of Sharp-tails were as near (or nearer) the casual as the regular booming or dancing grounds. Where did mating occur? It is often assumed that hens come to the booming and dancing grounds to be bred: these observations, plus the many other instances of casual displays, suggest that mating may occur at other places as well.

Cover types used for nesting are shown in Table 9. They agree with those already noted by Gross (1930) and Bent (1932). Schmidt (MS) noted the value of haymarshes and drained-peat grasslands as nesting cover for both species. His findings, like mine, showed that the sparse vegetation of sand prairies is seldom used for nesting. One point of significant difference stands out: Schmidt concluded that sphagnum bogs are particularly important as nesting cover for Sharp-tails. The

relatively small quantity of this sort of cover on the Project may account for the discrepancy in our findings. It may, in fact, explain why I saw more nests of Prairie Chicken than of Sharp-tails even though

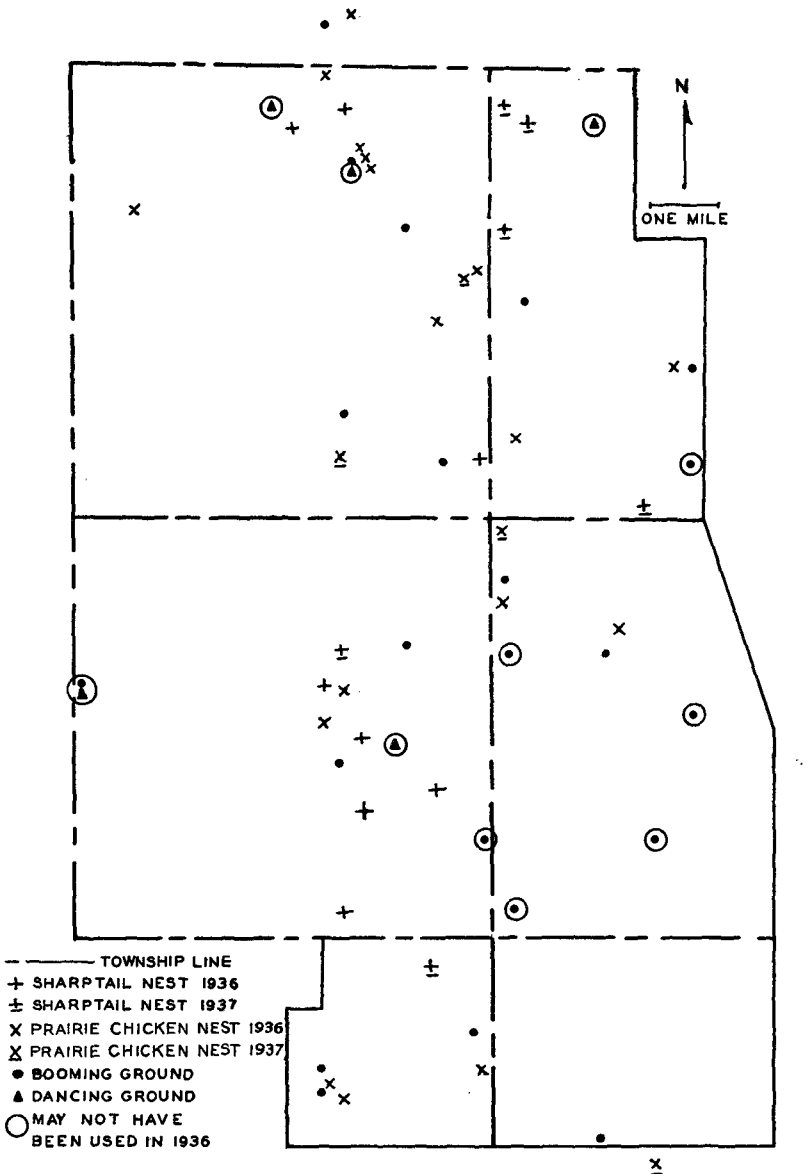

Figure 2. Map of part of the study area, showing nests, booming grounds, and dancing grounds.

there were, during the winter, many more Sharp-tails on the area than Prairie Chicken.

To make the discussion of nesting ecology more complete, I have included in Table 9 some of the other species whose nests were found in the same types of cover.

Nests of both Prairie Chicken and Sharp-tails were made by lining shallow bowl-shaped depressions in the ground with grasses, leaves, or small twigs, apparently scraped together from material at the spot. Concealment of nests was quite variable, but since man-made estimates have been shown to be of questionable value, in terms of relative security from predators (Hamerstrom, 1936; Kalmbach, 1937), I omit a tabulation of this factor. No nests were roofed, although the cover often arched naturally over them. Eggs were not covered while the hen was away.

Many plants were included in the cover at the nests. A few, however, occurred again and again at the nests of all five species. They were: bluejoint, sedges, goldenrod, dewberry—Yeatter (1937) has already commented on the value of this plant—bluegrass, willows, blueberry, sweet fern, and aspen. An abundance of these plants is, on the Project, generally an indication of better soils.

More important than the individual cover plants is the fact that most of the nests of all species were in cover mixtures rather than in pure stands. Conversely, 448 acres of haymeadow, chosen for cutting because the grass was particularly free from "weeds" and brush (i.e., mixtures) were examined a day or two after mowing: no nests were found. Two Prairie Chicken nests were found by farmers cutting hay in other fields, but in both cases sedge clumps or dewberry were part of the nest cover.

What was the origin of these cover mixtures? Everyone knows what a cover edge is. One glance is enough to tell where the woods end and the meadow begins, a second to see the fringe of brush between. But the significance of that combination of woods, brush, and meadow is not to be grasped in a casual moment. The key lies in the fringe of brush. It is a battle ground with the grass of the meadow in the role of defender. The shrubs of the brush zone act as skirmishers: trees generally cannot invade grassland directly, brush must go before. When it has weakened the sod and taken over the battle zone trees come in from behind. With the heavy fighting won, shrub is shaded out by tree, and the edge of the woods has advanced another notch. Grass retreats before brush, woods advance from the rear. It is one step in plant succession (Weaver and Clements, 1929).

So also with marshes, but with another step added. The dead tops of the marsh plants, as they die back each winter, slowly fill the basin. Since a marsh is shallowest toward the shore, it is there that the filling in is first complete. The shoreline, like a slowly tightened noose, draws

in toward the center. On the drier parts of this new ground the old fight between brush and sod continues, with trees again the final victor. Plant succession in the marshes also moves at a slow march toward a forest stage.

Normal succession is slow. The central Wisconsin marshes have persisted since the last glacial period, but the peat beds are witness that succession has been slowly moving forward.

Now comes man. In a space of time, geologically speaking, no longer than a flash of the wing of a drumming Partridge he has thrown the slow orderly process out of gear. On the uplands, lumbering and fire have turned the forest back to the brush stage in many areas. Marsh succession has been tremendously speeded up by drainage, which has encouraged the peripheral advance of brush; and by drainage followed by severe fires, which has jumped the burned peat basins into solid stands of brushy aspen in a single season.

The origin of the grass meadows is more complex. Once marshes, they have become bluegrass meadow through an involved series of ecological changes which Frolik (1936) has traced as follows:

In those marshes which did not have their sod destroyed by fire, the original grasses and sedges persisted for a time. They were mowed and grazed. The now drier soil was compacted under the feet of grazing animals. Drying and packing of the soil weakened the old sod, encouraged the development of a new one made up of bluegrass and timothy. In such wise bluejoint-sedge marshes became bluegrass-timothy meadows. Mowing, grazing, and light burning kept brush out.

In the meadows mixed cover for nesting, as opposed to pure stands of grass, was made by further disturbance. The new sod was broken in spots, as by over-grazing, plowing, grub injury. In these spots succession was turned back to a stage characterized by goldenrod, aster, and dewberry.

It was in the zone of mixed plants between brush and open, and between grass and herbs, that nearly every nest was found. Prairie Chicken and teal preferred the more open nesting sites, Sharp-tails, Ruffed Grouse, and Mallards the heavier brush.

Man-made changes have provided just these types of cover, but they must be directed toward a better balance. Wildlife management is mainly planned regulation of plant succession: without it, on the Project, it is only a matter of time until succession has gone beyond the proper stage for booming, dancing, and nesting ground cover. Brush invasion, particularly by aspen, has already been pushed too far.

The water restoration program has begun to win back some of the aspen flats to marsh grass. With the removal of resident farmers, provision must be made to mow, graze, or lightly burn meadows and marsh edges to keep them open. Probably all three will be necessary, as mowing alone tends to make a sharp edge between brush and grass

in place of the natural gradation from one to the other. Spot plowing may be needed to maintain patches of mixed herbaceous vegetation in the meadows and marsh edges.

Man has already interfered once to increase by a thousand-fold the speed of succession in the grasslands. He must now put a bridle on the natural forces which he has loosed. He once, by accident, made here the best Prairie Chicken country in the Middle West: can he now, by design, do it again?

Literature Cited

Bent, A. C.
1932 Life Histories of North American Gallinaceous Birds. U. S. Nat. Mus. Bull. No. 162.

Bissonnette, T. H.
1938 Experimental Control of Sexual Photoperiodicity in Animals and Possible Applications to Wild Life Management. *Jour. Wildlife Management,* 2:104–118.

Errington, P. L.
1933 The Nesting and the Life Equation of the Wisconsin Bob-white. *Wilson Bulletin,* 45:122–132.

Errington, P. L. and F. N. Hamerstrom, Jr.
1937 The Evaluation of Nesting Losses and Juvenile Mortality of the Ring-necked Pheasant. *Jour. Wildlife Management,* 1:3–20.

Frolik, A. L.
1936 Studies of the Vegetation on the Peat Lands of Dane County, Wisconsin. Unpubl. thesis, Univ. of Wisconsin.

Grange, Wallace
1936 The Interesting Sharp-tailed Grouse. *Game Breeder & Sportsman,* 40:82–83.

Gross, A. O.
1928 The Heath Hen. *Memoirs Boston Soc. Nat. Hist.,* 6:491–588, 12 pls.
1929 The Heath Hen Census for 1929. *Wilson Bulletin,* 41:67–71.
1930 Progress Report of the Wisconsin Prairie Chicken Investigation. Wisconsin Conservation Commission, Madison, Wis.

Hamerstrom, F. N., Jr.
1936 A Study of the Nesting Habits of the Ring-necked Pheasant in Northwest Iowa. *Iowa State College Jour. Sci.,* 10:173–203.

Hamerstrom, F. N., Jr. and Millard Truax
1938 Traps for Pinnated and Sharp-tailed Grouse. *Bird-Banding,* 9:177–83, 5 figs.

Hamilton, J. B.
1938 Precocious Masculine Behavior Following Administration of Synthetic Male Hormone Substance. *Endocrinology,* 23:53–57.

Kalmbach, E. R.
1937 Crow-Waterfowl Relationships. U. S. Dept. Agric. Circ. 433.

Leopold, Aldo
1931 Game Methods the American Way. *American Game,* March–April issue.

Marshall, W. H. and M. S. Jensen
1937 Winter and Spring Studies of the Sharp-tailed Grouse in Utah. *Jour. Wildlife Management,* 1:87–99.

Middleton, A. D.
1936 Factors Controlling the Population of the Partridge (*Perdix perdix*) in Great Britain. *Proc. Zool. Soc. London,* for 1935:795–815

NICE, M. M.
1937 Studies in the Life History of the Song Sparrow—I. *Trans. Linn. Soc.* N. Y., 4.

PEZARD, A.
1920 Secondary Sexual Characteristics and Endocrinology. *Endocrinology,* 4:527–540.

STODDARD, H. L.
1931 The Bobwhite Quail, Its Habits, Preservation, and Increase. Charles Scribner's Sons, New York.

WEAVER, J. E. and F. E. CLEMENTS
1929 Plant Ecology. McGraw-Hill Book Co., Inc., N. Y.

YEATTER, R. E.
1934 The Hungarian Partridge in the Great Lakes Region. *Univ. Mich. School of Forestry and Conservation Bulletin No.* 5.
1937 A Prairie Chicken Management Program for Illinois. *Illinois Conservation,* Mid-winter issue: 9–11.

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