— 8530 prairie chicken . Glen Sanderson

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PRAIRIE-CHICKEN RESEARCH REPORT TO COOPERATORS

FEBRUARY 1992

CENTER FOR WILDLIFE ECOLOGY

Cooperating Agencies:
Illinois Department of Conservation (IDOC)
Illinois State Natural History Survey (INHS)
Illinois Chapter, The Nature Conservancy (TNC)
Illinois Nature Preserves Commission (INPC)
Illinois Endangered Species Protection Board (IESPB)
Nature of Illinois Foundation (NIF)
Eastern Illinois University (EIU)
Central Illinois Public Service Company

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RESEARCH HIGHLIGHTS 1991

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POPULATION STATUS

Prairie-Chickens: Jasper Down; Marion Up.

Illinois' three remnant populations of prairie-chickens (Tympanuchus cupido pinnatus) were estimated at 68 birds in spring 1991 (Fig. 1), 10.5% lower than that (76) of spring 1990 (Westemeier 1990). After an increase in Jasper County from 13 booming males in 1989, to 25 in 1990, the count dropped to 16 males in 1991 (Fig. 2). As in recent springs, single booming grounds remained on or near the Marshall Field (9 males) and Donnelley (7 males) sanctuaries, in the heart of the sanctuary area (Fig. 3). The count of 16 cocks at Bogota in 1991 appeared to be well balanced with at least 15 hens. Heavy rains totaling 7.7 inches from 11-15 May 1990 may have suppressed reproduction in 1990, despite favorable nest success, cyclic phase, and other factors. By mid May, most prairie-chicken nests are well along in incubation

and some may be hatching.

In Marion County, the count increased from 9 cocks in 1990 to 15 in 1991 (Fig. 2). Three small booming grounds remained on or near the INHS, Copple, and Butler sanctuaries, which comprise the southern half of the Marion County sanctuary complex (Fig. 4). No chickens were seen or heard on the northern sanctuaries (Perbix, Lacey-Loy, and Lacey-Soldner) during our standardized censuses. Heavy rains occurred in Marion County in mid May 1990 just as in Jasper County, so the favorable increase in Marion County was somewhat intriguing.

Near Xenia in Clay County, where no sanctuaries exist, 3 male and at least 2 female prairie-chickens were censused on the same high "prairie" ridge as in recent springs. Despite late tillage and planting (mid June) in 1990, which might have facilitated successful nesting, the 3-cock count was a drop from the 4-7 males present from 1986-90.

Pheasants: Under Control, But Nuclei Persist.

During standardized crowing counts, 16 cock pheasants (Phasianus colchicus) were heard or seen on the 32-mi² census area at Bogota. This overall count was low and similar to that of 1989 and 1990 (Fig. 2). However, half (8) of the crowing ringnecks in 1991 were in close association with prairie-chickens, in contrast to only 2 crowers so located in 1990. Numbers of hen pheasants typically exceed numbers of cocks at Bogota.

In Marion County in 1991, only 2 crowing pheasant cocks were noted on the 36-mi² census area, the same as in 1990. Once again both cocks were in the heart of the remaining prairie-chicken area, but no interactions were observed.

Upland Sandpipers.

During routine activities in spring 1991, single upland sandpipers (Bartramia longicauda) were observed on the Yeatter-Field-McGraw and Galbreath sanctuaries. A brood was observed several times on or near the Donnelley-Walters unit and 2 pairs were seen several times on the C. McCormick Sanctuary.

In Marion County, 2 pairs of upland sandpipers were observed on the INHS Sanctuary.

Shortears & Harriers: No Nesting in 1991.

A spectacular surge in nesting by short-eared owls (Asio flammeus) and Northern harriers (Circus cyaneus) occurred on the

sanctuaries in 1990 (Westemeier 1990). In 1991, courtship flights by harriers were observed on the McCormick Sanctuary and Walters 40 prairie, but the count of prairie vole (Microtus ochrogaster) nests declined sharply and no raptor nests were documented. In 1990, 20 of the 21 raptor nests observed were in the very hearts of the occupied prairie-chicken areas in both Jasper and Marion counties. Although no direct evidence was observed in 1990, harriers will prey on prairie-chickens (Berger et al. 1963, Svedarsky 1980, Hammerstrom 1986, Toland 1986, Haukos and Broda 1989).

On Wisconsin's Buena Vista Marsh with some 11,000 acres of managed grasslands, 20 harrier nests coincided with a vole high in 1970; virtually every successful nest (n=14) was found (Hamerstrom 1979, 1986). That same year, at least 17 shortear nests fledged 104 shortears "in the heart of the prairie-chicken country" (Hamerstrom 1972). Yet, the count of prairie-chicken cocks increased 40% (n=141 to 198) by spring 1971 on Buena Vista (R. K. Anderson data, 1990). During 2 other vole-harrier highs, prairie-chickens on Buena Vista decreased 4% (1962) and increased 10% (1974).

In Jasper County, Illinois, the 350 acres of sanctuary grassland **occupied** by prairie-chickens, contrast greatly with the 11,000 acres of managed grassland on Buena Vista. From that standpoint, food sufficient to support harriers at 5 nests (3 successful) on the Yeatter-Field-McGraw and Donnelley units in 1990 might well have included prairie-chickens, especially young. The raptor phenomenon in 1990 might thus help explain the decline in prairie-chickens that year.

EFFORTS TO ENHANCE GENETIC DIVERSITY

Background Perspective

Millions of prairie-chickens occurred throughout Illinois about 1860. Numbers declined to perhaps 25,000 by 1933, an estimated 2,000 by 1963, and only 68 in 3 remnant populations probably isolated from one another by spring 1991. Gene flow between populations through natural dispersal was probably reduced drastically by the 1960's. Declining fecundity and fertility may be symptomatic of inbreeding depression and Illinois would seem to be a classic setting for such genetic problems.

In his 1943 bulletin on Illinois prairie-chickens, Dr. Ralph E. Yeatter, pioneer wildlife researcher for the Survey, presented evidence for occasional infertility of eggs and embryo mortality. From a total sample of 39 nests found in Jasper County in 1935-36, Yeatter (1943) reported a hatch rate of 93% for 148 eggs in 12 clutches judged to have undergone normal incubation. Studies in other states revealed similar hatch rates for prairie-chickens as

did the first 7 years (1963-69) of the present Illinois project. From a data base of over 1,100 nests spanning 29 consecutive years (1963-91), reproductive parameters for Jasper County nests have been examined for changes over time that might be expected as a result of inbreeding. Clutch size appears to be showing normal variation around an overall mean of 12 eggs, except for increases during the last 4 years. These increases are probably due to predator control and high success of early large clutches. However, egg fertility, hatch rate of all eggs, and hatchability of fertile eggs showed significant downward trends with time. Because of infertility and embryo mortality, hatch rate during 7 of the past 11 years ranged from 70-79%, and was only 55% in 1990. These worrisome trends were independent of clutch size.

A host of factors, other than inbreeding, may suppress fertility and hatching success of bird eggs. These include pesticides, oil contamination, and aflatoxin from moldy grain in cropfields. Tissue analyses on over 100 pheasants and a limited sample of salvaged prairie-chickens from Jasper County have been analyzed by Dr. Sue Wood and associates (INHS), and they show negligible levels of chlorinated hydrocarbons. Environmental contaminants in general tend to be ruled out by apparently normal reproduction by bobwhites (Colinus virginianus) and pheasants which often nest in close proximity to prairie-chickens on the Illinois sanctuaries. These resident species are in large measure ecological counterparts to prairie-chickens. Thus, the available evidence does not rule out a genetic problem for prairie-chickens.

Following a decision to address possible inbreeding depression in Illinois prairie-chickens by the Illinois Department of Conservation (IDOC), the Survey, Illinois Nature Preserves Commission, and Illinois Endangered Species Protection Board, an effort was undertaken in 1990-91 to exchange clutches of eggs under incubation in Jasper and Marion counties. The objective was to enhance genetic variation in both gene pools that typically occurs by natural dispersal. The first egg exchange (1990) was described by Westemeier (1990), Simpson (1990), Westemeier, Simpson, and Cooper (1991), and Ambrose (1991). In contrast to a large-scale effort in 1990, nest searching was reduced from 361 acres to 178 acres in 1991. Much credit is due IDOC Division of Natural Heritage biologists and volunteers for valuable field assistance.

Second Egg Manipulation Successful -- Barely!

Encouraged by our first success in 1990, a second egg exchange between the Jasper and Marion county populations was planned for 1991 and almost carried out. Seven prairie-chicken nests were found in Jasper County; 5 were being incubated, 1 was hatched, and another nest effort was terminated but its fate was unknown. In Marion County, 2 nests were being incubated and 1 nest was already depredated when discovered.

Using the egg-floating technique (Westerskov 1950), it appeared we had a clutch in each county that was in reasonable synchrony with one another. The estimated hatching dates were 24 and 25 May. On 20 May, 08:30 (CDT), we made simultaneous checks of both nests, hoping to make an egg exchange. The Jasper clutch of 14 eggs (hen flushed) was estimated at 23 days incubation, but unfortunately the Marion nest (16 eggs + hen) had recently been destroyed by a predator -- presumably coyote.

What do we do? The third and last-known Marion clutch of 12 eggs was estimated to be in close synchrony with a different Jasper clutch of 16 eggs. Should we risk possible desertion by making an egg exchange since 2 Marion nests were already wiped out? That same day (20 May) a call from a farmer in Clay County changed our strategy. A clutch of 13 eggs had been salvaged from a plowed-into nest in weedy corn stubble. The eggs were under a bantam hen. We thanked the farmer for his cooperation and rushed the eggs to an incubator in Jasper County.

On 21-22 May, the eggs from Clay County were divided between 2 Jasper nests estimated to be closely timed in incubation. Despite sudden increases of 50% in the first nest (M. Field #1-91, 5 eggs above average) and 56% in the second nest (Donnelley #1-91, 2 eggs above average), both prairie-chicken hens returned after being flushed and accepted their modified clutches. Unfortunately, in the first added-to clutch only host eggs hatched, but both host (8) and foster (4 of 6) eggs hatched in the second clutch -- success! A Jasper County hen left her nest with a fine brood of 12 chicks of Jasper and Clay County origin.

In regard to the aging "miscalculation" in the first nest, Westerskov (1950) admitted that "considerable overlapping occurs" in aging criteria. Also, the 5-day spread in incubation period (23-27 days) (Silvy 1968, McEwen et al.1969, Svedarsky 1979, 1988) for prairie-chickens may greatly compound error in estimating embryo age. This explains the miscalculation in aging embryo development in the M. Field #1 nest.

OTHER 1991 HIGHLIGHTS

Nest Success Continued High in Jasper Co.

At least 6 of the 7 prairie-chicken nests observed in Jasper County produced young (fate unknown in 1 nest). Hopefully, success of a similar number of unobserved nests was also high. None of the 7 observed nests contained pheasant eggs, the fourth consecutive year with no observed parasitism by pheasants. Control of both pheasants and nest predators continues to be highly successful in Jasper County.

Unfortunately, in Marion County 2 prairie-chicken nests each

with 16 eggs, and including 1 hen, were depredated on the Butler Sanctuary. On the Copple Sanctuary, a nest only 6 yards from private cropland, seemingly vulnerable to predation, showed a 100% hatch of 12 eggs. In addition, broody hens (broods assumed present) were observed on the Survey and Butler sanctuaries. A dry spring in 1991 in both counties, much unlike the wet spring of 1990, may have been conducive to good brood survival.

Egg Fertility High; Egg Success Still Low.

In Jasper County in 1991, prairie-chicken egg fertility of 96.8% (N=61/63) was the fifth highest on record, but it is too early to be sure of a turnaround in the long-term downward trend. The hatch rate of all eggs, however, was only 70.9% (n=56/79). Similarly, hatchability of 61 fertile eggs was only 72.1%; the second lowest in 29 years.

Despite inadvertant "rough" flushes (by volunteer nest searchers) followed by long flights by hens at the time of their discovery, full hatches (100%) of 14 eggs occurred in Donnelley #2-91 and in Copple #1-91 with 12 eggs. In contrast, one of the poorest hatches of prairie-chickens on record -- only 3 hatched of 15 eggs -- occurred in 1991 on the Yeatter Sanctuary following a single gentle flush of the incubating hen. At first it appeared that the brief disturbance coincided with the heavy loss, indeed, the deaths of 2 partially hatched young may have been so caused. It became clear that when the hen flushed, 9 embryos were either already dead or their development was spaced too far behind those pipping to have hatched together -- and 1 egg was infertile. It was later determined that as the Yeatter prairie-chicken was completing her clutch (by about 28 April), a pheasant hen had been nearby during her most likely time for "dropping wasted eggs" -- just prior to laying in her own nearby nest (about 1 May). The timing was perfect for the parasite and most vulnerable for the host. Although no parasitism occurred, delayed initiation of incubation of some eggs or a slowing in development of part of a clutch may occur, theoretically, if a prairie-chicken hen must invest valuable time to thwart a pheasant hen attempting to parasitize. This seems a most logical possibility for the high loss of embryos in the Yeatter #1-91 nest.

EFFECTS OF FLUSHING NESTING PRAIRIE-CHICKENS

During the first 20 or so years (1963-mid 1980s) of nest studies at Bogota, searching of sanctuary meadows did not begin in earnest until early June in order to avoid disturbance to most nesting prairie-chickens. In contrast, by the mid 1980s nest searching commenced about 1 May in order to (1) remove pheasant eggs from prairie-chicken nests prior to hatching time and (2) terminate active pheasant nests. Early searching continued in

1990-91 for the same reasons, but mainly to find nests suitable for genetic management. Thus, a much higher proportion of nests were still active when found in recent years compared with past years. What were the effects of flushing prairie-chickens 1 or more times.

Does Hen Flushing Reduce Nest Success?

Parasitized Nests.--Among 83 disturbed nests, 14 were parasitized and 1-11 pheasant eggs were removed. Hens returned to $\geq$13 of these 14 nests and 12 (86%) were successful in producing young. The 2 unsuccessful nests were destroyed by predators. This compares very favorably with 46% success for 24 nests from which pheasant eggs were not removed, and 51% success for 63 prairie-chicken nests which were not parasitized; however, sample sizes were small and these differences were not significant ($P > 0.20$) (Westemeier 1988).

Unparasitized Nests.--For 69 normal nests disturbed by flushing hens mainly during incubation, hens returned to $\geq$59 (86%) and 49 (71%) were successful. Of the 20 unsuccessful nests, 16 were depredated, 3 clutches had apparently sterile eggs, and only 1 involved a desertion. The difference in nest success was significantly higher for disturbed nests compared with 398 of their undisturbed counterparts ($X^2_1 = 7.14$, $P < 0.01$). This difference may have been due to the fact that nests well along in incubation have a higher probability of hatching than the nests used for comparison. Such bias may be unavoidable in this instance.

The 1 desertion (1982) above involved 8 embryos that died at 11 days of development, but pheasants were implicated in that loss. In another instance in 1982, not included above, a prairie-chicken abandoned her nest after being flushed by a cable-chain drag, but there was good evidence that the hen did in fact return after that flush, and abandonment occurred later. The nest was surrounded by pheasant nests; there was a gradual die-off of embryos; thus, pheasants were again implicated and nest searchers were probably not to blame.

The following 3 examples further underscore the exceptionally strong bonding typified by prairie-chickens to their nests:

(1) On 29 May 1967, a Jasper prairie-chicken hen flushed ca. 10:15 h under a tractor just in time for the farmer to avoid destruction of her nest by plowing in weedy corn stubble. When the hen was inadvertantly flushed a second time (10:30 h), rain was imminent; her 8 eggs were removed from the nest and placed in an incubator. After the shower, the hen was flushed near (or on?) her **empty** nest. By then (11:30 h), the farmer agreed to leave a small patch unplowed in his field; the 8 eggs were replaced in the nest by 11:45 h. The hen was back on her eggs by 12:45 h as viewed with a 20X spotting scope from a nearby field lane. On 1 June (15:00-17:30 h), a 2-strand electric fence was established around the

unplowed patch as a predator deterent. Use of a small portable blind facilitated fence erection without flushing the hen again. Inspections via spotting scope on 2 and 5 June futher verified the hen's steadfastness, but by 9 June the nest was destroyed. Evidently, a skunk had slipped under the hot wires.

(2) In 1973, an incubating hen's tail feathers were accidently driven over and extracted as she flushed; the hen returned and hatched 11 of her 12 eggs.

(3) In 1987, prairie-chicken hens on 2 Jasper nests (excluded above) on private land were repeatedly flushed by hay mowing, raking, baling, and bale-hauling activities. Both hens returned to their **intact** eggs to continue incubation. Since concealing cover had been removed, both nests were subsequently depredated. A hen on a third nest in the same 15-acre field (normally pastured) was killed by the hay mower.

Does Hen Flushing Exacerbate Embryo Mortality?

In the 4 prairie-chicken nests disturbed in 1990-91 for the purpose of clutch modification and enhancement of genetic diversity, 8 of 42 embryos died. Enough was known about the timing of this mortality relative to the hen flushes to say that 5 of the 8 deaths occurred prior to our intervention, 1 death roughly coincided with a hen flush, and 2 deaths occurred well after the hen flushes (near hatching). Thus, 3 deaths might have been caused by our intervention, but since embryo deaths are most frequent in in the late stages of incubation -- disturbed or not disturbed -- the causes for these losses remain conjectural. Nevertheless, the excessive losses of prairie-chicken embryos in recent years prompted a closer look at the embryo mortality recorded during 29 years of nest studies in Jasper County.

Parasitized Nests.--During the period of 1970-87, mortality of prairie-chicken embryos was 21.4% in 42 nests parasitized by pheasants. In the same years that this mortality occurred, embryo mortality was 4.5% in 209 unparasitized nests. This difference was highly significant ($X^2_1 = 136.72$, $P < 0.001$). Surprisingly, embryo mortality was no different in 12 nests where pheasant eggs were removed than in 12 nests not found soon enough to remove pheasant eggs (Westemeier 1988). Was there a trade-off in embryo mortality; i.e., was mortality caused by pheasants being substituted for mortality associated with flushing the incubating hens? In these "managed" parasitized nests, accurate aging of embryo development was possible by opening the collected parasitic pheasant eggs. Thus, enough was known about the timing of the prairie-chicken embryo deaths to say with certainty that 65% of the embryos (n=15/23) died **prior to** intervention by nest searchers, 35% (n=8/23) died 4-18 days **after** hen flushes. As with the heavy mortality of embryos in the Yeatter #1-91 nest, most of the deaths occurred before human intervention. Unlike Yeatter #1-91 where pheasant intrusion was strongly suspected, these nests were

definitely linked to interference by pheasants because they had been parasitized. As such, it seems unlikely that human intrusion caused any of the observed mortality of embryos.

Unparasitized Nests.--The above findings led to an analysis of embryo mortality in nests disturbed by flushing incubating hens compared with undisturbed nests, including only unparasitized, successful nests (Table 1). Mortality accounted for 15.3% of 451 prairie-chicken embryos in 44 disturbed nests, but only 4.1% of 1,844 embryos in 197 undisturbed nests. The difference was highly significant ($X^2_1 = 73.02$, $P < 0.001$). Again, however, 42% (n=29/69) of the mortality occurred prior to hen flushes, 17% (n=12/69) coincided roughly with hen flushes (including 3 embryo losses in 1 nest stepped on by nest searcher), 32% (n=22/69) died well after hen flushes, and the timing of 6 losses was unknown (Table 2). Thus, the 29 losses that occurred prior to human intervention plus 4.1% of the remaining 40 deaths, gives an estimate of about 31 embryo losses that can be deducted from 69 total. Hence, the embryo loss possibly due to hen flushing becomes 8.4% (38/451); still double the 4.1% loss in undisturbed nests ($X^2_1 = 13.98$, $P < 0.001$).

One possible bias considered was that disturbed nests might tend to involve proportionately more early large clutches -- those more vulnerable to pheasant interference -- than the sample of undisturbed nests used for comparison. After further examination of the data this hypothesis was rejected.

Another potential for bias involved the use of minimum counts (estimates) of fertile and hatched eggs to calculate embryo mortality. Minimum estimates allowed maximum sample sizes. This approach was compared with the use of egg counts considered to be actual numbers of fertile and hatched eggs. Both approaches resulted in higher ($P < 0.001$) embryo loss in disturbed nests compared with undisturbed nests.

There can be little doubt that higher embryo mortality occurred in prairie-chicken nests disturbed by hen flushing than in undisturbed nests. Evidently, some hens are slow in returning to their clutches after being flushed which may result in excess exposure to sun, cooling, or drying with attendant weakening and killing of some embryos.

Despite the preceding analyses, there can be exceptions that defy explanation. Of the 6 Clay County eggs that failed to hatch in the first intended foster nest (M. Field #1-91), 3 eggs hatched healthy embryos in our incubator on 8 June 1991. As embryos, these 3 chicks had survived the time span of 1 June PM (hen departure with brood) - 3 June AM in the absence of an incubating hen. This feat was verified by hatching of a reference egg from M. Field #1-91 on 1 June (pipped on 31 May) and examination of the nest at 09:00 h, 3 June (intact eggs collected and placed in incubator).

Dr. Yeatter once said prairie-chickens were tough, but it is doubtful that he experienced such a phenomenon.

UNBIASED EMBRYO MORTALITY 1963-91: WORRISOME !

In order to track symptoms of possible inbreeding in Illinois prairie-chickens with unbiased data, nests parasitized by pheasants and those nests disturbed by flushing incubating hens were excluded from analyses. Mortality of prairie-chicken embryos in Jasper County nests that were unparasitized, undisturbed, and successful showed an upward trend as early as 1971 (Table 1). The correlation with time waned to insignificance by 1977, went back to significance by 1984, waned again by 1987, but retained statistical significance for 1989-91. Overall, the correlation coefficient was $r = 0.528$ ($P < 0.01$). Annual means ranged from 0 in 1963 to a high of 36% in 1990.

In order to maximize sample size, the preceding analysis included nests (n=390) with minimum counts of fertile and hatched eggs. As a further refinement, an analysis was made using only nests (n=211) with egg counts considered to be actual numbers fertile and hatched. The result was similar ($r = 0.550$, $P < 0.01$), embryo mortality increased significantly with time. Thus, the positive trend in embryo mortality, in concert with the downward trend in egg fertility, is indeed worrisome and may reflect inbreeding depression in Jasper County prairie-chickens. If inbreeding is not supressing reproduction, perhaps pheasants persist as our most likely alternate explanation.

ARE PHEASANTS STILL A SERIOUS FACTOR ?

This report reveals several instances of pheasants probably impacting prairie-chickens in subtle ways other than harassment on booming grounds and nest parasitism (Vance amd Westemeier 1979, Westemeier 1984, 1988). Rearing of prairie-chicken chicks mixed with pheasant chicks appears to present serious problems for the grouse chicks (McEwen et al. 1969, Westemeier 1984, unpubl.). The heavy embryo loss in the Yeatter #1-91 nest suggests that pheasants that are unsuccessful in their attempts to parasitize prairie-chicken nests may still cause serious losses of prairie-chicken embryos. This scenario may be the mechanism for much of the embryo loss in unparasitized nests -- particularly the loss rate of at least 42% which occurred prior to our flushing of incubating prairie-chickens. Several desertions of unparasitized nests occurred in close proximity to pheasant nests. Embryo loss was high in parasitized prairie-chickens nests whether pheasant eggs were or were not removed (Westemeier 1988). Most (65%) of the loss in these "managed" nests was irrefutably linked to pheasants because the embryo losses occurred in **parasitized** nests **prior to** our disturbance of the incubating hens. During the years (1970-87)

of observed parasitism by pheasants of 74 prairie-chicken nests, embryo mortality in unparasitized nests correlated with the percent of parasitism ($r = 0.641$, $P < 0.01$).

Also, egg fertility was negatively correlated with the parasitism rate ($r = -0.551$, $P < 0.02$). How might pheasants suppress fertility of prairie-chicken eggs? Svedarsky (1988:202) reported egg laying by prairie-chickens prior to copulation. His study area had no pheasants (1991 pers. commun.), but it seems logical that pheasant harassment on booming grounds might exacerbate egg laying prior to copulation -- and thereby amplify infertility of prairie-chicken eggs. If a prairie-chicken hen starts a clutch prior to copulation, she may be further delayed in getting back to a booming ground for copulation if she must spend time defending her nest from pheasant hens intent on parasitism.

Thus, these observations and analyses give pause to ready acceptance of inbreeding as the only factor that might be suppressing reproduction by prairie-chickens. Pheasants might well be a continuing factor of greater consequence than we realized.

SUMMARY DISCUSSION AND RECOMMENDATIONS

As of spring 1991, Illinois prairie-chickens remained imperiled. Subsequent observations of broods and fall-winter flocks do not provide an optomistic outlook for spring 1992. In the last report (Westemeier 1990), I implied that pheasant interactions with prairie-chickens may at last be "negligible" considering the success of IDOC pheasant control efforts. Further analyses and subtle implications of ongoing pheasant interactions with prairie-chickens in 1991, suggest that my 1990 assessment may have been premature. Pheasant control efforts must be intensified especially on sanctuaries still supporting prairie-chickens.

The continued high nest success in Jasper County speaks well for predator control efforts by the IDOC -- and perhaps for local coyote hunters as well on private lands surrounding the sanctuaries. On the Marion County sanctuaries, however, predation presumably by coyotes appears to be severe. Coyote predation, in concert with the new egg-production facility near Farina, was implicated in 1987-89 when prairie-chickens completely disappeared from the northern half of the Marion sanctuaries.

Should nest studies continue? The evidence is clear that prairie-chicken hens are remarkably steadfast and tenacious when disturbed on their nests. This appears to be true whether egg laying, incubating, pipping, or hatching is underway at the time a hen is flushed. Hens readily return to their clutches despite a wide array of disturbances and readily accept sudden changes of up to about 50% in clutch size and eggs from different members of their own species. Inspection of active nests by nest searchers

whether hens are flushed or not, has caused no apparent increases in either predation or desertion. In fact, no clear cases of desertion or depredation of prairie-chicken nests have been attributed to nest-searcher activities in our 29 years of nest studies.

However, the data indicate higher mortality of embryos in disturbed nests (8.4%) compared with their undisturbed counterparts (4.1%). For average clutches of 12 eggs, this means an average loss of 1 embryo per disturbed clutch compared with a normal loss of 1 embryo per 2 undisturbed clutches. This may be the price we must accept if egg exchanges or egg additions are the most feasible means of rebuilding genetic diversity in Illinois prairie-chickens.

Should efforts to exchange Illinois prairie-chcken eggs continue -- or should we consider eggs from another state? If genes from another state (Kansas?) are deemed desirable and if we are understandably unwilling to sacrifice whole clutches of Illinois prairie-chicken eggs, the addition of "foreign" eggs at laying time may be feasible. Adding unincubated eggs at laying time solves the problem of synchronizing incubation. As few as 4 nests, 2 near each booming ground in Jasper County, may suffice for egg additions. This assumes all 4 will be successful. Three experienced nest searchers may realistically cover 60 acres of brome in 1 week and find 4 prairie-chicken nests in the clutch-development stage. Two average clutches of 12 unincubated eggs from Kansas would provide 6 eggs for each of 4 Illinois nests. Timely procurement of 2 such clutches may pose the greatest hurdle.

There are various techniques other than clutch modification that may be considered and perhaps even tried in our attempts to enhance genetic diversity of Illinois prairie-chickens. We must, however, caution ourselves about getting too sidetracked into unproven strategies that have difficult logistics and may be too demanding of limited funding and valuable time.

Definitive tests of genetic diversity are needed. Much depends on findings by Texas A&M University on the genetic variability of Illinois prairie-chickens. We anxiously await those findings. If concurrent increases in heterozygosity, egg fertility, hatching success, and prairie-chicken numbers can be documented, a step forward may have been made in the genetic management of prairie-chickens in Illinois. Nest studies and additional genetic tests will be needed to provide such documentation.

Is it still desirable to check active prairie-chicken nests for parasitic pheasant eggs? Are we able to terminate enough pheasant hens and nests to help justify early nest searching? Each spring an assessment of (1) pheasant numbers, (2) their distribution, and (3) the proclivity of local individuals to release pheasants may be needed to answer these questions.

Nest studies have been the backbone of research efforts to preserve Illinois prairie-chickens. If the various reasons for early nest studies are no longer valid, nest searching can safely continue as it did during the first 20 years of the project. Nest searching can be delayed to about mid June or even 1 July when nesting is virtually complete and young chickens are well grown. Broods are seldom encountered in good nest cover.

If we can continue to show that other resident species, especially bobwhites and pheasants, have normal egg fertility and hatchability, but chickens do not, we will have a basis to rule out such factors as ag chemicals, oil contamination, aflatoxin, and possibly disease as causing problems for prairie-chickens. Causitive factors for suppressed reproduction by prairie-chickens may at least be narrowed to inbreeding depression or pheasants.

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Table 1. Prairie-chicken **embryo mortality** in unparasitized, successful nests disturbed by flushing incubating hens compared with undisturbed nests, Jasper County, Illinois, 1963-91. Data include nests with minimum counts of eggs.

	Hens flushed			Hens not flushed			Total		
		Embryos			Embryos			Embryos	
Year	Nests	n	% dead	Nests	n	% dead	Nests	n	% dead
1963	4	47	6.4	6	44	0.0	10	91	3.3
1964				9	84	1.2	9	84	1.2
1965				7	60	0.0	7	60	0.0
1966				5	51	2.0	5	51	2.0
1967	1	10	0.0	5	59	1.7	6	69	1.4
1968				14	159	0.6	14	159	0.6
1969				18	184	4.3	18	184	4.3
1970				41	440	3.0	41	440	3.0
1971	1	5	40.0	39	359	5.0	40	364	5.5
1972				50	468	2.4	50	468	2.4
1973	3	35	5.7	20	181	3.3	23	216	3.7
1974	1	9	0.0	24	201	6.5	25	210	6.2
1975				23	214	1.4	23	214	1.4
1976	3	22	13.6	12	129	1.6	15	151	3.3
1977	3	30	10.0	10	107	1.9	13	137	3.6
1978	1	10	10.0	16	146	1.4	17	156	1.9
1979	1	13	23.0	13	97	0.0	14	110	2.7
1980				12	87	2.3	12	87	2.3
1981				14	134	8.2	14	134	8.2
1982	1	9	0.0	14	140	2.9	15	149	2.7
1983	1	7	0.0	8	82	3.7	9	89	3.4
1984	3	32	0.0	9	79	5.1	12	111	3.6
1985	3	32	21.9	9	80	8.8	12	112	12.5
1986	5	40	20.0	3	38	0.0	8	78	10.3
1987	3	33	27.3	2	20	0.0	5	53	17.0
1988	3	28	7.1				3	28	7.1
1989	1	15	0.0	5	55	10.9	6	70	8.6
1990	4	41	26.8	1	14	35.7	5	55	29.1
1991	5	61	27.9	1	13	15.4	6	74	25.7
						a			
1963-91 "comparables" **b** :									
	44	451	15.3	197	1,844	4.1	241	2,295	6.3
Totals, means:									
	47	479	14.8	390	3,725	3.4	437	4,204	4.7

a Means for hens not flushed (% column) vs. 28 yrs: r=0.528, P <0.01, m=0.447, b=-29.60, t_c=3.17

b X^2_1 = 73.02, P <0.001

Table 2. **Prairie-chicken embryo mortality** in nests **disturbed** by flushing incubating hens compared with **undisturbed** nests, including unparasitized, successful nests, and 18 comparable years only.

Parameter	Hens flushed	Hens **not** flushed
Nests	44	197
Embryos	451	1,844
% dead	**15.3**[a] **8.4**[b]	**4.1**

$X^2_1 = 73.02$, P < 0.001.

a . 42% (29) died **prior to** hen flushes.

. 17% (12) died ~**coinciding with** hen flushes. c

. 32% (22) died **well after** hen flushes.

. 9% (6) timing unknown.

b Excludes (1) embryos known to have died prior to hen flushes and (2) a 4.1% adjustment for normal loss. Adjusted $X^2_1 = 13.98$, P <0.001

c Includes 3 embryo losses in 1 nest stepped on by nest searcher.

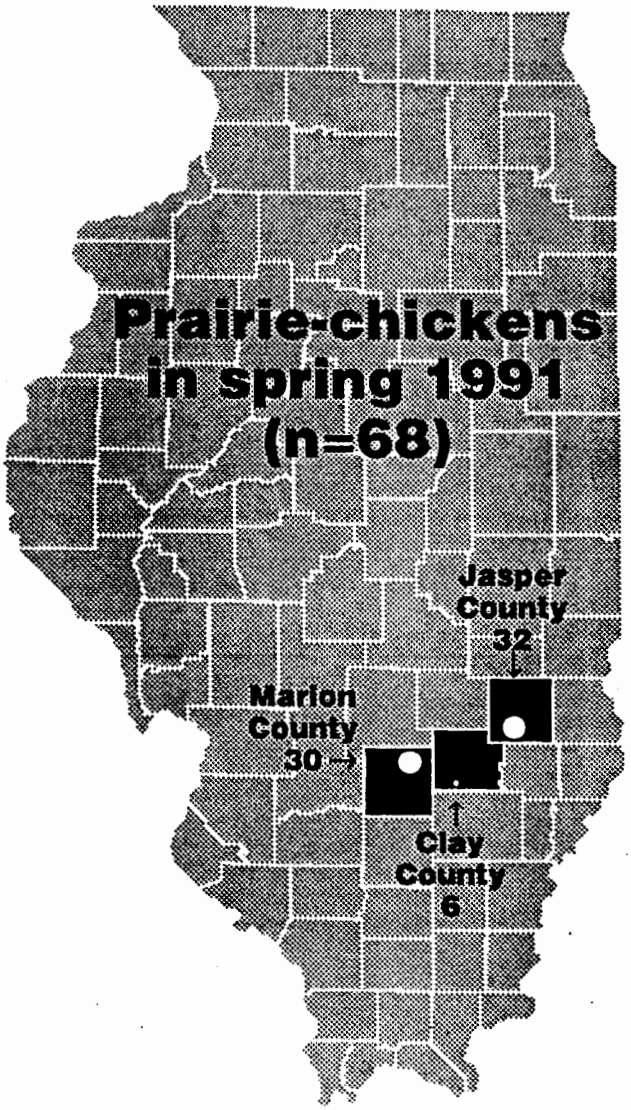

Fig. 1. Distribution and numbers of remnant native prairie-chickens in Illinois, Spring 1991. The count of cocks (n=34) was doubled to include a rough estimate of hen numbers.

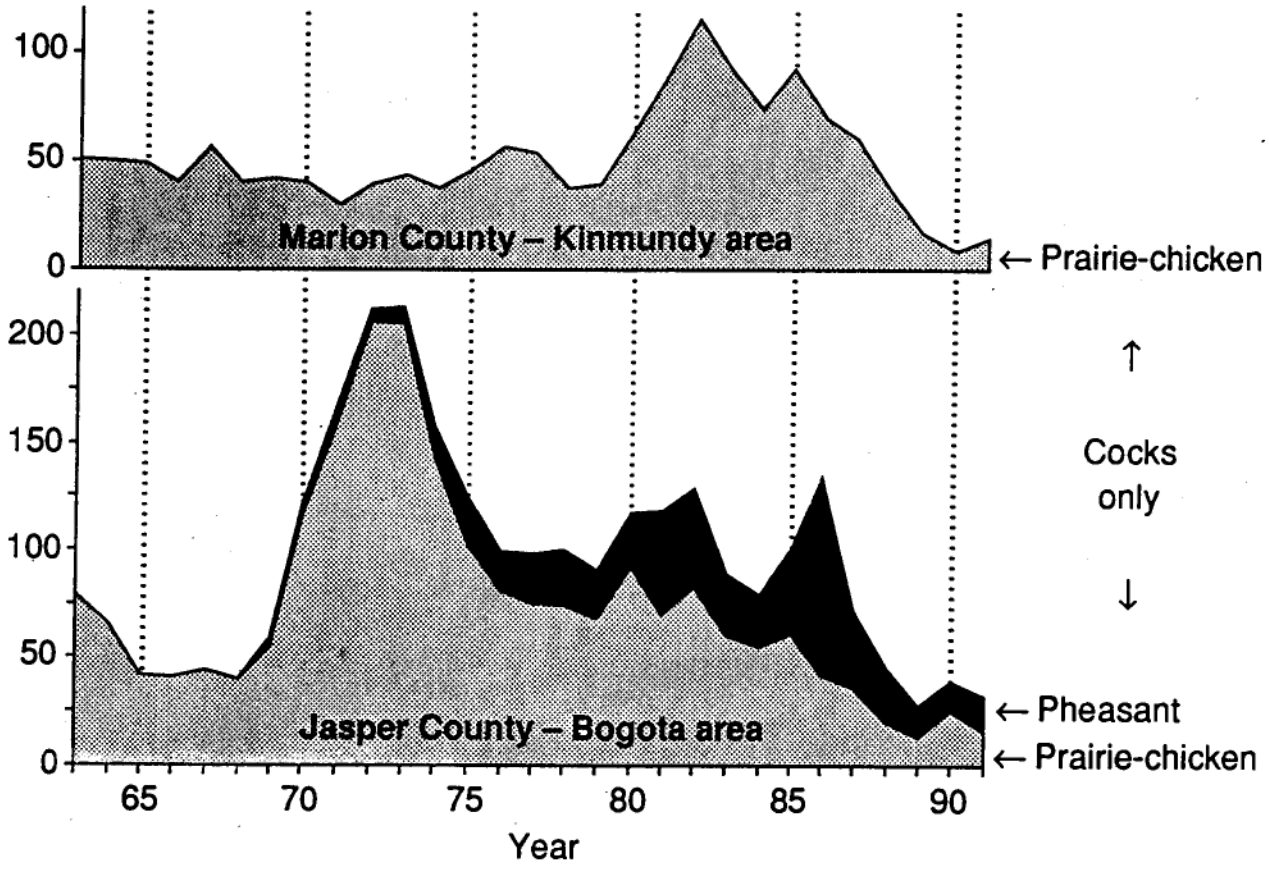

Fig. 2. Trends in counts of prairie-chicken and pheasant cocks on the Jasper and Marion county study areas, 1963-91.

FIG. 3. **PRAIRIE CHICKEN SANCTUARIES, JASPER COUNTY**

1. Ralph Yeatter, 77 acres
2. Max McGraw, 20 acres
3. Donnelley Brothers, West 60 acres
4. Cyrus H. Mark, 17 acres
5. Jamerson McCormack, [illegible]es
6. Mr. and Mrs. Chauncey McCormick, 140 acres

* Grassland Wildlife Ecology Lab.

7. Cyrus H. Mark, 40 acres
8. Stuart H. Otis, 58 acres
9. Donnelley Brothers, East 60 acres
10. Marshall Field III, 135 acres
11. Fuson Farm, 164 acres
12. Joseph W. Galbreath, 110 acres
13. Walters, 40 acres
14. CIPS, 200 acres
15. Donsbach Lot, 5 acres
16. Donsbach Farm, 155 acres

Ownership or Lease By:

Illinois Department of Conservation	767 acres
The Nature Conservancy	594 acres
TOTAL	1,361 acres

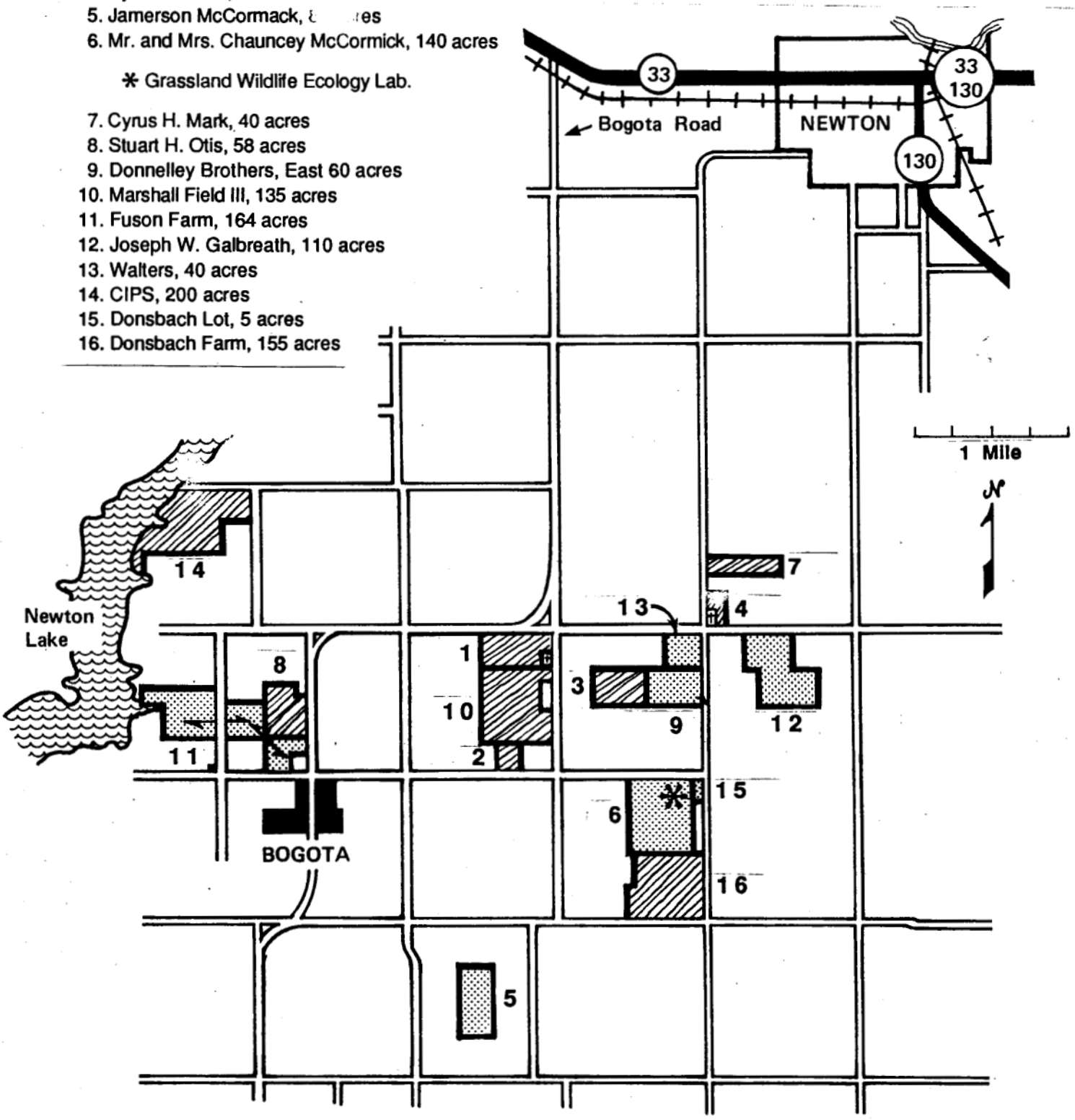

FIG. 4. **PRAIRIE CHICKEN SANCTUARIES, MARION COUNTY**