PROCEEDINGS

PRAIRIE GROUSE SYMPOSIUM

September 17-18, 1980
Oklahoma State University
Stillwater, OK 74078

SPONSORED BY

Oklahoma Cooperative Wildlife Research Unit

Oklahoma Department of Wildlife Conservation

U.S. Fish and Wildlife Service

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Max McGraw Wildlife Foundation

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The National Audubon Society

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PREFACE

Prairie chickens and sharptailed grouse evolved and have survived in the grasslands of the central portions of the North American continent. The vegetation, fire, drought, extremes in temperature, native grazing species, and the prairie grouse coexisted in a dynamic system that was only minimally influenced by humans. The prairie grouse in general may have benefited by early agricultural activities of the more permanent settlers in the late 1800's and early 1900's. However, the grouse of today are providing a record of the changes in land use that affect not only the grouse but a flora and fauna that biologists refer to as the grassland ecosystem. This symposium focuses on only a few species of prairie birds with the purpose of providing a written record of the current status of these indicators of the grassland ecosystem.

The 1st 5 papers in these proceedings were invited. The remaining papers were volunteered by biologists working with research and management of the prairie grouse. The planning for the symposium began with the impetus of the Oklahoma Cooperative Wildlife Research Unit and the "blessing" of the Prairie Grouse Technical Council meeting in Pierre, South Dakota in Sept. 1977. Notices of the symposium were provided to all known prairie grouse biologists and other interested persons. All authors provided "camera ready" copy to reduce publication costs.

Not all current or immediate past research on prairie grouse is represented in this proceedings. It is hoped that studies and information not represented here will be published soon in other literature available to those interested in prairie grouse and the grassland ecosystem. We desire that the information contained on these pages will reach those decision makers, including landowners and or land operators, who can favorably influence the future of the prairie grouse and their grasslands support base.

STATUS, PROBLEMS, AND RESEARCH NEEDS OF THE LESSER PRAIRIE CHICKEN

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Abstract: During the past 100 years, the range and population size of the lesser prairie chicken (*Tympanuchus pallidicinctus*) decreased by more than 90%. Overgrazing of rangelands and developments of extensive tracts of cultivation largely accounted for this decline. Grazing and cultivation remain as the principal land use factors affecting lesser prairie chicken populations. During 1979, the continental population during fall was estimated at 44,400 to 52,900 birds; trends were stable to declining. This species was the subject of numerous scientific inquiries, but many aspects of its life-history, ecology, and biology remain unknown. Habitat requirements, especially on small units of land, and the role of limiting factors, such as the relationship of weather to reproduction and survival, rank as high priorities for research. Other research needs include a better understanding of the effects of land use, evaluation of potential management procedures, studies of population dynamics, censusing techniques, and behavior.

My purpose is to trace the history and status of lesser prairie chicken populations relative to the effects of human activities, to report the current status, to identify problems related to the management of this species, to summarize previous research, and to propose certain areas of research worthy of investigation.

A number of biologists were contacted regarding the status of lesser prairie chicken populations and habitat and research needs during the preparation of this paper. This work represents a synthesis of some of the ideas and information provided by these biologists, the literature on the lesser prairie chicken, and my own research experiences and ideas. I gratefully acknowledge the assistance of the following people: M.E. Byard, R.W. Cannon, C.A. Davis, D. Dvorak, F.S. Guthery, D.M. Hoffman, G.J. Horak, R.E. Jones, H.G. Kothmann, W. McCaslan, J.D. Miller, A.K. Montei, J.H. O'Connor, R.J. Robel, R.S. Saito, J.L. Sands, and M.A. Taylor. R.G. Anthony and B.E. Coblentz critically reviewed the manuscript. This is Technical Paper No. 5352 of the Oregon Agricultural Experiment Station.

HISTORICAL PERSPECTIVE

Little is known about the prehistoric distribution of the lesser prairie chicken, although Hubbard (1973) postulated its presence in the Chihuahuan Refugium during Pleistocene glaciation. The earliest specimens were taken in the Staked Plains in 1854 by Pope (Bailey 1928). Numerous accounts relating to the latter 1/2 of the 19th century indicated that lesser prairie chickens were abundant and broadly distributed within their range (Bendire 1892, Judd 1905, Bent 1932, Baker 1953, Sands 1968) (Fig. 1). This bird was described initially in 1873 by Ridgway (1873) as a race of greater prairie chicken (*T. cupido*), but was assigned species status in 1885 (Ridgway 1885). During the late 1800's, land development began within the range of the lesser prairie chicken, primarily in the form of grazing by cattle; before the turn of the century, farms were established in parts of this area.

Litton (1978) reported estimates of 2 million prairie chickens in Texas prior to 1900. If derived from winter counts, the 2 million birds may have represented a large percentage of the total population because Texas seemingly was the primary wintering area (Fig. 1). Although population estimates were unavailable, lesser prairie chickens reportedly were common to abundant throughout their range during the first several decades of the 20th century (Bent 1932, Baker 1953, Bailey and Niedrach 1965, Oberholser 1974). During this time, overgrazing of rangelands continued and increasing amounts of land were cultivated. Apparently, early land use by settlers was not detrimental to lesser prairie chicken populations. Cultivation of former rangeland resulted in some loss of habitat (Copelin 1959a), but the "patchwork" arrangement of farms and agricultural

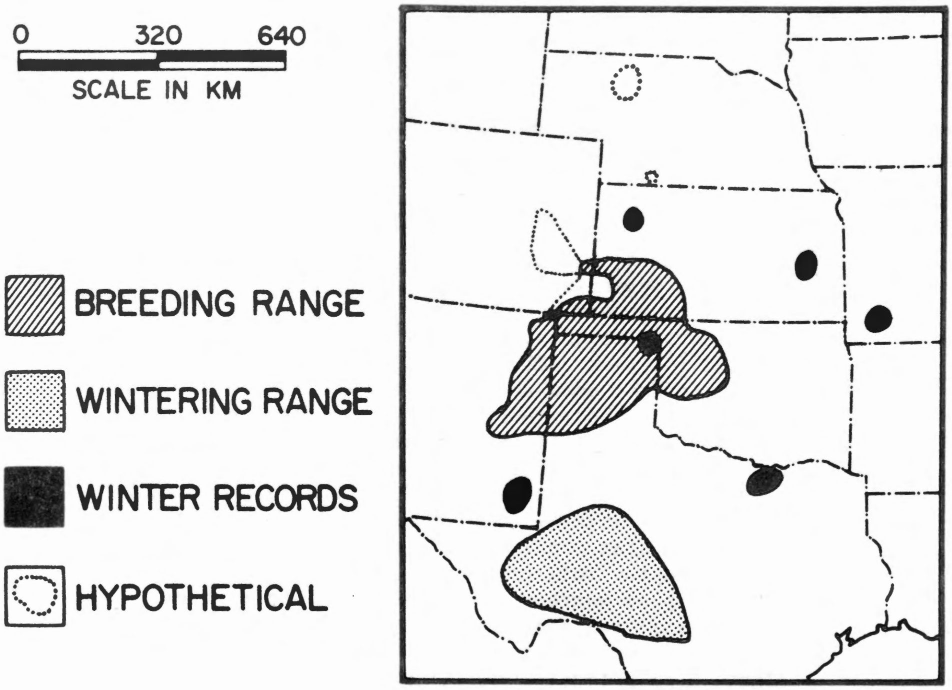

Fig. 1. Historical distribution of the lesser prairie chicken.

practices resulted initially in an increased food supply for the birds.

During the 1930's, several events occurred concurrently that resulted in extreme reductions in population numbers and contraction of the range of the lesser prairie chicken. Much of the range in the southern plains was depleted from intensive grazing, and a considerable amount of habitat valuable to prairie chickens was destroyed by cultivation. The poor condition of the habitat combined with the severe drought of the 1930's reduced the Texas population to 12,000 birds by 1937 (Oberholser 1974), resulted in the near extirpation of the species in Colorado (Bailey and Niedrach 1965), Kansas (Baker 1953), and New Mexico (Lee 1950), and caused a considerable decrease in numbers in Oklahoma (Davison 1940). During this decade, the lesser prairie chicken was established on the island of Niihau, Hawaii (Fisher 1951).

Prairie chicken numbers increased during the 1940's. However, drought during the 1950's caused marked fluctuations in population sizes. For example, Duck and Fletcher (1944) estimated the population at 15,000 birds in Oklahoma in 1940; by the 1950's, the population was reduced to between 2,500 and 3,000 individuals (Summars 1956). The Oklahoma population increased nearly 5 fold by 1960 (Copelin 1963). Between 1949 and 1961, populations in New Mexico peaked at 40,000 to 50,000 birds (Sands 1968). By the 1960's, the New Mexico population was approximately 20% of that during the previous decade (Sands 1968). From the 1960's through the 1970's, population levels decreased in Oklahoma, increased in Texas, and remained relatively stable in Colorado, Kansas, and New Mexico. Johnsgard (1973) conservatively estimated the continental population at 36,000 to 43,000 birds during the mid-1960's. Likely, the total fall population was closer to 60,000 during this time.

During the past century, the range of the lesser prairie chicken decreased by 92% (Taylor and Guthery 1980) and population size declined by 97%. In addition to reductions in range and numbers, human activities possibly altered movements by the birds. The lesser prairie chicken once was considered a migratory species; however, based on records from the American Ornithologists' Union (1957) and Oberholser (1974), this species was likely more of a "winter vagrant". Apparently, cultivation of large tracts of land resulted in the cessation of major movements during winter (Jackson and DeArment 1963). Consequently, numerous isolated populations were formed, many of which gradually disappeared.

CURRENT STATUS AND PROBLEMS

Lesser prairie chicken populations occur in 6 states (Fig. 2). The lesser prairie chicken is listed as threatened in Colorado where the fall population numbers about 500 (Table 1). Virtually nothing is known about this species in Hawaii, except that it is present. The lesser prairie chicken has not been observed in Missouri for nearly a century, and the species is considered hypothetical in Nebraska (Sharpe, pers. comm.). The lesser prairie chicken is a gamebird in Kansas, New Mexico, Oklahoma, and Texas where fall populations number between 6,000 and 18,000 per state (Table 1). Current estimates for the contiguous 48 states yield a total fall population of 44,400 to 52,900 birds (Table 1). Currently, lesser prairie chicken populations are stable to declining. The bird was listed by the U.S. Fish and Wildlife Service in publications dealing with rare, threatened, and endangered species (U.S. Fish and Wildlife Service 1966, 1973), but no special status was assigned.

Current threats to lesser prairie chicken populations and their habitat parallel those listed by Bent (1932) and Hamerstrom and Hamerstrom (1961) and include overgrazing of rangelands and extensive cultivation. In rangeland habitats, brush control may be a detriment to prairie chicken populations (Jackson and DeArment 1963) or an asset (Donaldson 1969) depending on the plant community, and the type and extent of control. Elimination of native range for the establishment of pastures, commonly switch grass (*Panicum virgatum*), may result in increased grass cover for use by lesser prairie chickens, but on a large scale it is detrimental because of the loss of the brush component. Although extensive conversion of rangeland to cultivation is detrimental, a limited amount of cultivation adjacent to suitable habitat apparently is beneficial (Crawford and Bolen 1976a). Technological advances in agriculture resulted in mixed effects of lesser prairie chicken populations. Modern farming methods and equipment reduce waste grain, an important source of food for prairie chickens in agricultural areas (Crawford and Bolen 1976b). Use of center-pivot irrigation systems to allow cultivation of previously non-arable lands results in reduction of available rangeland habitat. Waddell and Hanzlick (1978) estimated that lesser prairie chicken habitat in Kansas was lost at rates varying from 1.5 to 6% annually, largely because of center-pivot irrigation. Contrastingly, minimum tillage techniques may be of considerable benefit (Crawford and Bolen 1976a). Gas, oil, and mineral development may increase human access to areas and result in disturbance of birds (Davis et al. 1979). However, abandoned oil pads provide lek sites (Crawford and Bolen 1976c, Taylor 1980, Davis, et al. 1979)

Of the currently occupied range of the lesser prairie chicken, 95% is in private ownership; the remaining 5% (2/3 of which is in New Mexico) is administered primarily by the U.S. Forest Service and the Bureau of Land Management (Taylor and Guthery 1980).

Although once subjected to market hunting (Judd 1905), lesser prairie chickens have received

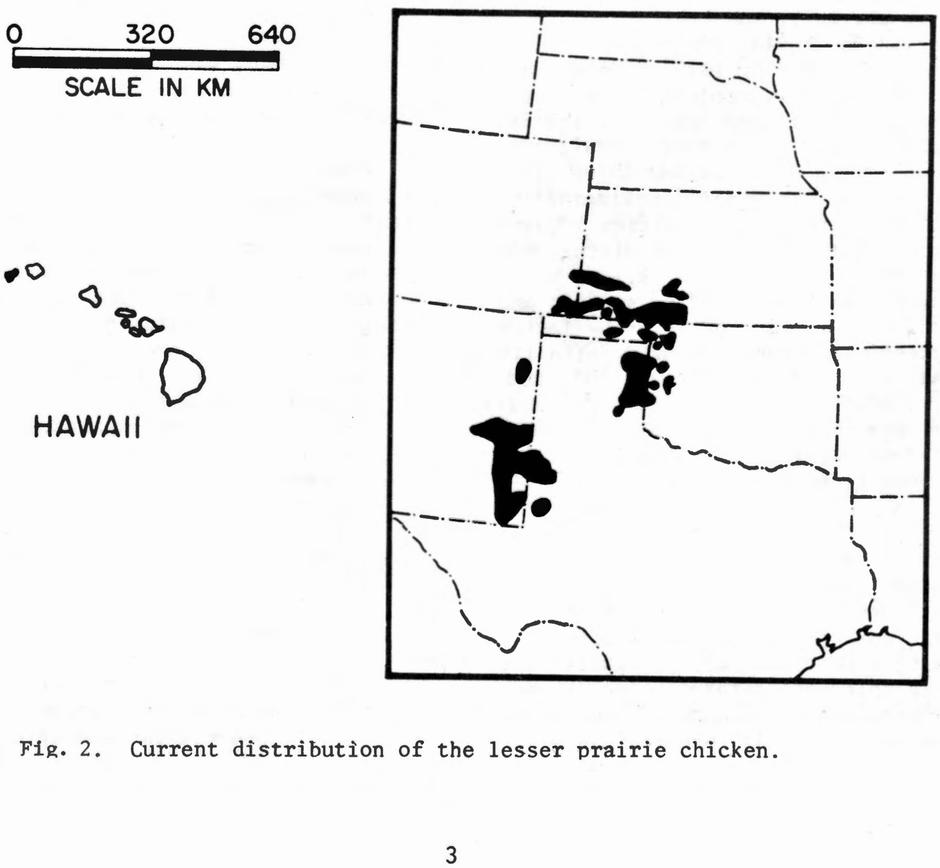

Fig. 2. Current distribution of the lesser prairie chicken.

Table 1. Numbers, harvest figures, status, and trends of lesser prairie chicken populations in 1979.

State	Fall population	Approximate harvest	Status	Trend
Colorado	400-500	0	Threatened	Stable
Hawaii	Unknown	Unknown	Introduced	Unknown
Kansas	17,000-18,000	2900	Gamebird	Declining
Missouri	0	0	Extirpated	-
Nebraska	0	0	Hypothetical	-
New Mexico	10,000	1200	Gamebird	Stable
Oklahoma	6,000- 6,400	1000	Gamebird	Stable-Declining
Texas	11,000-18,000	600	Gamebird	Stable-Declining

the protection of restrictive season lengths and bag limits for nearly 80 years. The current kill averages approximately 12% of the fall population and ranges from 0 to about 20% in local populations. Except in areas of the poorest habitat, hunting mortality likely is compensatory.

PREVIOUS RESEARCH AND FUTURE NEEDS

Previous research efforts focused largely on life history and ecology (Copelin 1958b, 1963; Hoffman 1963; Jackson and DeArment 1963; Litton 1978; Davis et al. 1979) and habitat requirements (Jones 1963a, 1963b, 1964a, 1964b; Crawford 1974; Suminski 1977; Taylor 1978). Nevertheless, a better understanding is needed of the habitat (i.e. food, water, cover, and space) of the lesser prairie chicken. Studies by Frary (1957, 1959), Copelin (1960, 1963), Crawford and Bolen (1976b and Davis et al. 1979) revealed considerable plasticity in the diet of this species. However, little information is available on dietary preferences and energy requirements in various habitats or on the relationship of breeding success and survival to diet. Drinking of water by lesser prairie chickens was documented by Copelin (1963), Jones (1964a), Crawford and Bolen (1973), and Davis et al. (1979), yet Frary (1957) found little use of water developments in his study. Thus, the necessity of free water, especially during periods of drought, bears further investigation.

Brush species such as shinnery oak (*Quercus havardii*) or sand sagebrush (*Artemisia filifolia*) and tall grasses like sand bluestem (*Andropogon hallii*) constitute the critical components of lesser prairie chicken habitat. Because of ever-decreasing amounts of habitat available to lesser prairie chickens, determination of the minimum size area that can support a population is one of the most critical research needs. Experimental studies should be conducted to determine if intensively managed, small units of brush-grassland habitat can support viable populations. Identification of minimum areas and necessary habitat components is the only way to reduce the progressive elimination of small populations. Basic studies in behavioral ecology and movements of the birds are needed to delineate space requirements.

As biologists, we usually assume that most limiting factors of galliform populations function in a density-dependent fashion. Therefore, limiting factors have received only minimal attention by researchers. Virtually nothing is known about the parasites and diseases of this species with the exception of the description of helminths by Pence and Sell (1979). Campbell (1950), Frary (1955), Davis et al. (1979), and other general references provided what little is known about predators of lesser prairie chickens. Ligon (1951) and Copelin (1963) discussed accidents, particularly collision with power lines, as decimating factors in the species. Most biologists would agree that the fate of a grouse population lies in the quality of the habitat and not in the proximate limiting factors addressed above. However, factors that act in a density-dependent manner in good habitat may function in a density-independent fashion in marginal habitat and become critical factors to be addressed in management. Research dealing with the effects of predators, diseases, or similar factors must incorporate the condition of the habitat and status of the population if it is to be of value.

Immediate attention should be directed to the role of weather as a limiting factor. The sensitivity of lesser prairie chickens to drought is well documented (Hamerstrom and Hamerstrom 1961); however, the specific action is unknown.

A long-term project relating weather in conjunction with habitat characteristics to population status (e.g. size, breeding success, recruitment, and survival) might provide information to mitigate some of the most severe effects of drought. Without such knowledge, the recurrence of a drought like that of 1930's could greatly deplete or actually result in the extinction of the continental population.

Management procedures and effects of land use such as fire (Cannon and Knopf 1979), food plots (Copelin 1958a, 1959b), farming practices (Crawford 1974, Crawford and Bolen 1976a), brush control (Donaldson 1966, 1969), and ranching practices (Davis et al. 1979) were the subject of numerous investigations. Studies dealing with these topics should be continued and expanded. For example, range improvement practices, such as rotational grazing and prescribed burning, require study. More information on the relative effects of various brush control procedures would be valuable, and alternatives to traditional brush control methods, especially in sand sagebrush areas, should be investigated. Potential management procedures including the creation of lek sites should be further developed and tested. Counts of males at leks traditionally are used to enumerate lesser prairie chicken populations, yet little is known about the accuracy or precision of these counts. Development of improved censusing methods is a fundamental research need. Banding studies to augment the works of Davison (1940), Lee (1950), and Campbell (1972) are necessary for a better understanding of the population dynamics of this species. Although numerous techniques are available to determine sex and age of lesser prairie chickens, the chronology of primary feather replacement in juveniles to determine the timing of reproductive activities is unknown.

The lesser prairie chicken is a most worthy subject for research in basic biology. The reproductive behavior of males is rather well known (Grange 1940; Sharpe 1968; Hjorth 1970; Crawford and Bolen 1975, Crawford 1978), but other behaviors, especially of females, remain poorly understood. The taxonomic status, investigated by Jones (1964a), Short (1967) and Sharpe (1968, 1969), remains unresolved. Most anatomical studies, with the exception of Tiemeier (1941) and Holmes (1963), dealt with plumages and other external characteristics (Ridgway and Friedmann 1946; Sutton 1964, 1968, 1977; Crawford 1978).

It is possible that certain currently unoccupied habitats may be able to support prairie chicken populations. Because of the rather slow pioneering rate of this species, reintroduction in selected areas may be a viable strategy for enhancement of populations. Reintroduction attempts are fraught with difficulties and should be attempted only after adequate research advance preparation, and in conjunction with intensive monitoring of released birds. We have some information on propagation of captive birds (Ligon 1954, Coats 1955), but introductions attempted with birds raised on game farms often fail. Additional considerations involve the difficulty of capturing wild birds, the effects of trapping and removal of birds on source populations, and the problem of establishment of populations of transplanted birds.

The range of the lesser prairie chicken has diminished greatly in the past 100 years, and current populations are fragmented into discrete units. Although the current population numbers in the many thousands, we as biologists and managers should not become complacent because numbers do not impart stability to lesser prairie chicken populations. Constant attention is needed to maintain existing populations because of continually changing land use practices. Innovative research and aggressive management will help offset losses and degradation of lesser prairie chicken habitat; enlightened research will aid our understanding of those factors that control populations.

The lesser prairie chicken is at a threshold. It is not sufficiently rare to elicit intensive management and research efforts as is the Attwater's prairie chicken (*T. c. attwateri*), nor is it as wide spread as the northern greater prairie chicken (*T. c. pinnatus*) to have broad-scale support. Thus, the responsibility lies with a rather small group of people from federal and state agencies, universities, and other interested parties to provide the necessary information and to implement required actions.

LITERATURE CITED

American Ornithologists' Union. 1957. Check-list of North American birds. 5th ed. Port City Press, Inc. Baltimore, Maryland. 691pp.

Bailey, A.M., and R.J. Niedrach. 1965. Birds of Colorado. Vol. 1. Denver Mus. Nat. Hist. Denver, Colorado. 454pp.

Bailey, F.M. 1928. Birds of New Mexico. Judd and Detweiler, Inc. Washington, D.C. 807pp.

Baker, M.F. 1953. Prairie chickens of Kansas. Univ. of Kansas Mus. Nat. Hist. and Biol. Surv. of Kansas, Misc. Publ. 5. 68pp.

Bendire, C.E. 1892. Life histories of North American birds with special reference to their breeding habits and eggs. U.S. Natl. Mus. Spec. Bull. 1. 446pp.

Bent, A.C. 1932. Life histories of North American gallinaceous birds. Bull. U.S. Natl. Mus. 162:1-490.

Campbell, H. 1950. Note on the behavior of marsh hawks toward lesser prairie chickens. J. Wildl. Manage. 14:477-478.

_____. 1972. A population study of lesser prairie chickens in New Mexico. J. Wildl. Manage. 36:689-699.

Cannon, R.W., and F.L. Knopf. 1979. Lesser prairie chicken responses to range fires at the booming ground. Wildl. Soc. Bull. 71:44-46.

Coats, J. 1955. Raising lesser prairie chickens in captivity. Kansas Fish and Game 13:16-20.

Copelin, F.F. 1958a. Evaluation of the lesser prairie chicken habitat management program (food plots). Oklahoma Dep. Wildl. Conserv., Fed. Aid in Wildl. Res. Proj. W-062-R-02. 12pp.

_____. 1958b. Welfare status of the lesser prairie chicken in Oklahoma. M.S. Thesis. Oklahoma State Univ., Stillwater. 45pp.

_____. 1959a. Notes regarding the history and current status of the lesser prairie chicken in Oklahoma. Proc. Oklahoma Acad. Sci. 37:158-161.

_____. 1959b. Evaluation of the lesser prairie chicken habitat management program (plots). Oklahoma Dep. Wildl. Conserv., Fed. Aid in Wildl. Res. Proj. W-062-R-03. 5pp.

_____. 1960. Evaluation of lesser prairie chicken food. Oklahoma Dep. Wildl. Conserv., Fed. Aid in Wildl. Res. Proj. W-062-R-04. 4pp.

_____. 1963. The lesser prairie chicken in Oklahoma. Oklahoma Wildl. Conserv. Dep. Tech. Bull. 6. 58pp.

Crawford, J. A. 1974. The effects of land use on lesser prairie chicken populations in west Texas. Ph.D. Thesis. Texas Tech Univ., Lubbock. 63pp.

_____. 1978. Morphology and behavior of greater x lesser prairie chicken hybrids. Southwestern Nat. 23:591-596.

_____, and E. G. Bolen. 1973 Spring use of stock ponds by lesser prairie chickens. Wilson Bull. 85:471-472.

_____, and _____. 1975. Spring lek activity of the lesser prairie chicken in west Texas. Auk 92:808-810.

_____, and _____. 1976a. Effects of land use on lesser prairie chickens in Texas. J. Wildl. Manage. 40:96-104.

_____, and _____. 1976b. Fall diet of lesser prairie chickens in west Texas. Condor 78:142-144.

_____, and _____. 1976c. Effects of lek disturbances on lesser prairie chickens. Southwestern Nat. 21:238-240.

Davis, C.A., T.Z. Riley, R.A. Smith, H.R. Suminiski, and M.J. Wisdom. 1979. Habitat evaluation of lesser prairie chickens in eastern Chaves County, New Mexico. New Mexico State Univ. Agric. Exp. Stat., Las Cruces. 141pp.

Davison, V.E. 1940. An 8-year census of lesser prairie chickens. J. Wildl. Manage. 4:55-62.

Donaldson, D.D. 1966. Brush control and the welfare of lesser prairie chickens in western Oklahoma. Proc. Oklahoma Acad. Sci. 46:221-228.

_____. 1969. Effect on lesser prairie chickens of brush control in western Oklahoma. Ph.D. Thesis. Oklahoma State Univ., Stillwater. 80pp.

Duck, L.G., and J.B. Fletcher. 1944. A survey of the game and furbearing animals of Oklahoma. Oklahoma Game and Fish Comm. Bull. 3. 144pp.

Fisher, H. 1951. The avifauna of Niihau Island, Hawaiian Archipelago. Condor 53:31-42.

Frary, L.G. 1955. Rodent-predator relationships as a factor on prairie chicken habitat and reproduction. New Mexico Dep. Game and Fish, Fed. Aid in Wildl. Res. Proj. W-077-R-01. 3 pp.

_____. 1957. Prairie chicken food habits investigation. New Mexico Dep. Game and Fish, Fed. Aid in Wildl. Res. Proj. W-077-R-03. 7 pp.

_____. 1959. Lesser prairie chicken food habits investigations. New Mexico Dep. Game and Fish, Fed. Aid in Wildl. Res. Proj. W-077-R-04. 12pp.

Grange, W. B. 1940. A comparison of the displays and vocal performance of the greater prairie chicken, lesser prairie chicken, sharp-tailed grouse, and sooty grouse. Passenger Pigeon 2:127-133.

Hamerstrom, F.N., and F. Hamerstrom. 1961. Status and problems of North American grouse. Wilson Bull. 73:284-294.

Hjorth, I. 1970. Reproductive behavior in Tetraonidae. Viltrevy 7:184-596.

Hoffman, D.M. 1963. The lesser prairie chicken in Colorado. J. Wildl. Manage. 27:726-732.

Holmes, E.B. 1963. Variation in the muscles and nerves of the leg in two genera of grouse (Tympanuchus and Pedioecetes). Ph.D. Thesis. Univ. Kansas, Lawrence. 213pp.

Hubbard, J.P. 1973. Avian evolution in the aridlands of North America. Living Bird 12:155-196.

Jackson, A.S., and R. DeArment. 1963. The lesser prairie chicken in the Texas Panhandle. J. Wildl. Manage. 27:733-737.

Johnsgard, P.A. 1973. Grouse and quails of North America. Univ. Nebraska Press, Lincoln. 553pp.

Jones, R.E. 1963a. A comparative study of the habitats of the lesser and greater prairie chicken in Oklahoma. Ph.D. Thesis. Oklahoma State Univ., Stillwater. 160pp.

_____. 1963b. Identification and analysis of lesser and greater prairie chicken habitat. J. Wildl. Manage. 27:757-778.

_____. 1964a. The specific distinctness of the greater and lesser prairie chickens. Auk 81:65-73.

_____. 1964b. Habitat used by lesser prairie chickens for feeding related to seasonal behavior of plants in Beaver County, Oklahoma. Southwestern Nat. 9:111-117.

Judd, S.D. 1905. The grouse and wild turkeys of the United States and their economic values. U.S. Dept. Agric. Biol. Surv. Bull. 24. 55 pp.

Lee, L. 1950. Kill analysis for the lesser prairie chicken in New Mexico, 1949. J. Wildl. Manage. 14:475-477.

Ligon, J.S. 1951. Prairie chickens, highways, and power lines. New Mexico Mag. 29:29.

_____. 1954. The lesser prairie chicken and its propagation. Modern Game Breeding and Hunting Club News 24:10-11.

Litton, G.W. 1978. The lesser prairie chicken and its management in Texas. Texas Parks and Wildl. Dept. Booklet 700 0-25. 22pp.

Oberholser, H.C. 1974. The bird life of Texas. Vol. 1. Univ. Texas Press, Austin. 503pp.

Pence, D.B., and D.L. Sell. 1979. Helminths of the lesser prairie chicken, Tympanuchus pallidicintus [sic] (Ridgway) (Tetraonidae), from the Texas Panhandle. Proc. Helminthol. Soc. 46:146-149.

Ridgway, R. 1873. A new variety of prairie chicken. Bull. Essex Inst. 5:199.

_____. 1885. Some emended names of North American Birds. Proc. U.S. Natl. Mus. 8:354-356.

_____, and H. Friedmann. 1946. The birds of North and Middle America. Part X (Galliformes). Bull. U.S. Natl. Mus. 50:1-484.

Sands, J.L. 1968. Status of the lesser prairie chicken. Audubon Field Notes 22:454-456.

Sharpe, R.S. 1968. The evolutionary relationships and comparative behavior of prairie chickens. Ph.D. Thesis. Univ. Nebraska, Lincoln. 230pp.

_____. 1969. A revision of the taxonomy of prairie grouse based on behavioral characters. Proc. Nebraska Acad. Sci. 78:50. (Abstract).

Short, L.L., Jr. 1967. A review of the genera of grouse (Aves, Tetraoninae). Am. Mus. Novit. 2289:1-39.

Summars, V.C. 1956. Lesser prairie chicken census. Oklahoma Game and Fish Dep., Fed. Aid in Wildl. Res. Proj. W-062-R-1. 2pp.

Sutton, G.M. 1964. On plumages of the young lesser prairie chicken. Southwestern Nat. 9:1-5.

_____. 1968. The natal plumage of the lesser prairie chicken. Auk 85:679.

_____. 1977. The lesser prairie chicken's inflatable neck sacs. Wilson Bull. 89:521-522.

Suminski, H.R. 1977. Habitat evaluation for lesser prairie chickens in eastern Chaves County, New Mexico. M.S. Thesis, New Mexico State Univ., Las Cruces. 49pp.

Taylor, M.A. 1978. Fall and winter movements and habitat use of lesser prairie chickens. M.S. Thesis. Texas Tech. Univ., Lubbock. 52pp.

_____. 1980. Lesser prairie chicken use of manmade leks. Southwestern Nat. 24:706-707.

_____, and F.S. Guthery. 1980. Status, ecology, and management of the lesser prairie chicken. U.S. Forest Service, Gen. Tech. Rep. (In Press).

Tiemeier, O.W. 1941. Repaired bone injuries in birds. Auk 58:350-359.

U.S. Fish and Wildlife Service. 1966. Rare and endangered fish and wildlife of the United States. U.S. Fish and Wildl. Serv. Res. Publ. 34. 166pp.

_____. 1973. Threatened wildlife of the United States. U.S. Fish and Wildl. Serv. Res. Publ. 114. 289pp.

Waddell, B., and B. Hanzlick. 1978. The vanishing sandsage prairie. Kansas Fish and Game 35:17-23.

GREATER PRAIRIE CHICKEN STATUS AND MANAGEMENT--1968 - 1979[1]

Ronald L. Westemeier, Illinois Natural History Survey, Effingham, IL 62401

Abstract: The population status of greater prairie chickens (*Tympanuchus cupido pinnatus*) continued downward during 1968-79 in 11 of 12 states surveyed, to about 500,000 birds, or fewer. Chickens became extinct in Indiana but increased by 84% in Wisconsin. Harvest estimates for the 4 states with hunting seasons showed an average decline of 28% to some 61,000 chickens bagged annually. Lack of grassland suitable for nesting due to conversion to cropland, overgrazing, annual burning, annual haying, irrigation, and pesticides continued as the primary limiting factors to prairie chickens in most states. In 1979, the area on which prairie chickens were given some management consideration totaled 71,165 ha, an increase of 637% since 1968. The Nature Conservancy continues to play a major role in habitat acquisition for prairie chickens in 5 states. Prescribed burning, limited grazing, rotational haying, winter food patches, and various methods of brush control were common management practices for prairie chickens in most states. Active research on prairie chickens has increased since 1968. Hunting was regulated by season length, opening and closing dates, bag limits, closed areas, light hunting pressure, and by the wildness of the species. Maintenance of current populations of greater prairie chickens will depend upon reversing adverse land-use trends by substituting ecologically sound land use and continuing acquisition and stewardship of prairies and other grassland habitat.

More than a decade has passed since the last rangewide appraisal of the status and management of the greater prairie chicken by Christisen (1969). Rapidly intensifying land use can cause great losses of habitat and wildlife in such a time span. Conversely, much can be accomplished in a decade to mitigate losses of wildlife resources. This report updates Christisen's work and attempts to determine the rangewide needs required to maintain the species at its current level. Both endangered nonhunted populations and hunted populations are considered.

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Arkansas	Robert G. Leonard, Arkansas Game & Fish Commission
Colorado	Gary C. Miller, Colorado Department of Natural Resources
Illinois	Ronald L. Westemeier, Illinois Natural History Survey
Indiana	Robert D. Feldt, Indiana Department of Natural Resources
Iowa	Ronnie R. George, Iowa Conservation Commission
Kansas	Gerald J. Horak, Kansas Fish & Game
Kentucky	Joe Bruna, Kentucky Department of Fish & Wildlife Resources
Michigan	Herbert E. Johnson, Michigan Department of Natural Resources
Minnesota	W. Daniel Svedarsky, University of Minnesota, Crookston Terry Wolfe, Minnesota Department of Natural Resources
Missouri	Donald M. Christisen, Missouri Department of Conservation
Nebraska	Ken Robertson, Nebraska Game & Parks Commission
North Dakota	Jerry Kobriger, North Dakota Game & Fish Department
Ohio	Steven H. Cole, Ohio Department of Natural Resources

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Oklahoma	Dale Curry, Oklahoma Department of Wildlife Conservation Steven A. Martin, Oklahoma Cooperative Wildlife Research Unit
South Dakota	Larry F. Fredrickson, South Dakota Dept. of Game, Fish & Parks
Texas	Nova J. Silvy, Texas A & M University, College Station
Wisconsin	Raymond K. Anderson, University of Wisconsin, Stevens Point Bruce Gruthoff, Wisconsin Department of Natural Resources Frederick N. Hamerstrom, University of Wisconsin, Stevens Point

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METHODS

Much of the information in this report was provided by responses to a questionnaire by 21 biologists from the 17 states queried, including 6 states that once had greater prairie chickens, 7 states that today have fewer than 10,000 birds, and the 4 states where the species is still hunted. Some of the population estimates are based on spring counts of cocks, whereas other estimates are of fall populations. If a spring count of cocks was given, a 50:50 ratio of cocks and hens was assumed in deriving the estimate, an assumption that may not be valid.

RESULTS AND DISCUSSION

Population Changes

Six reporting states (Arkansas, Indiana, Iowa, Kentucky, Ohio, and Texas) that once had greater prairie chickens (Aldrich 1963) reported no birds (Indiana had reported chickens on the 1968 survey). Indiana, Iowa, and Ohio have some hope for reintroductions.

Michigan reported fewer than 50 chickens (Table 1 and Fig. 1). Illinois had an estimated 230 birds in 1979 based on the spring count of cocks. (The spring 1980 count for Illinois was up 55% to an estimated 334 chickens.) Wisconsin and Minnesota each had populations of approximately 2,000 chickens, also based on the spring (1979) count of cocks. Missouri's spring count was estimated at 9,600 greater chickens. Since Christisen's (1969) report, population levels of prairie chickens in the eastern tall-grass prairies have declined 17% overall--an estimated 13,722 birds remaining--despite closed seasons for at least 24 years, and in 1 state for 73 years. In the decade ending in 1979, chickens became extinct in Indiana and perilously close to extirpation in Michigan, the future remains uncertain in Illinois, the population trend was reported down in Minnesota, and abundance of chickens was essentially unchanged in Missouri. The most positive change since 1968 was the increase of at least 84% in Wisconsin flocks.

Table 1. Estimated populations of greater prairie chickens, 1968 and 1979.

State	1968[a]	1979
Indiana	10	0
Michigan	200	50
Illinois	300	230
Wisconsin	1,000	1,842
Minnesota	5,000	2,000
Missouri	10,000	9,600
E. Tall-Grass Prairie	16,510	13,722
Oklahoma	130,000	8,400-80,000
Kansas	750,000	200,000
Nebraska	100,000	75,000-200,000
South Dakota	80,000	40,000
North Dakota	1,800	1,000
Colorado	7,600	300-3,000
Great Plains	1,069,400	324,700-524,000
Grand Total	1,085,910	378,422-537,742

[a]Data from Christisen (1969).

The current distribution and numbers of chickens was most uncertain in the 6 western states (Table 1 and Fig. 1). Although general downward trends were reported since 1968, prairie chicken numbers have remained sufficiently high for wildlife departments to justify hunting seasons in Oklahoma, Kansas, Nebraska, and South Dakota. The season has remained closed in Colorado and North Dakota.

Comparison of the most liberal estimates available for 1968 and 1979 revealed a drop from 1,069,400 to 524,000 chickens--a loss of 51% in 11 years. However, data from the western states are only rough estimates. Particularly, the estimate of 750,000 birds for Kansas in 1968, which was probably high, would distort the true magnitude of population change. In fact, since 1968 some local expansions in numbers and distribution were reported for Oklahoma, Kansas, and North Dakota, and substantial increases in the populations and harvests for 1978 and 1979 were reported for Nebraska. Nevertheless, it seems unlikely that any local gains have offset the general rangewide losses since 1968. The most recent harvest estimates for the 4 states with hunting seasons show an average decline of 28% in harvest since the fall of 1967 (Table 2).

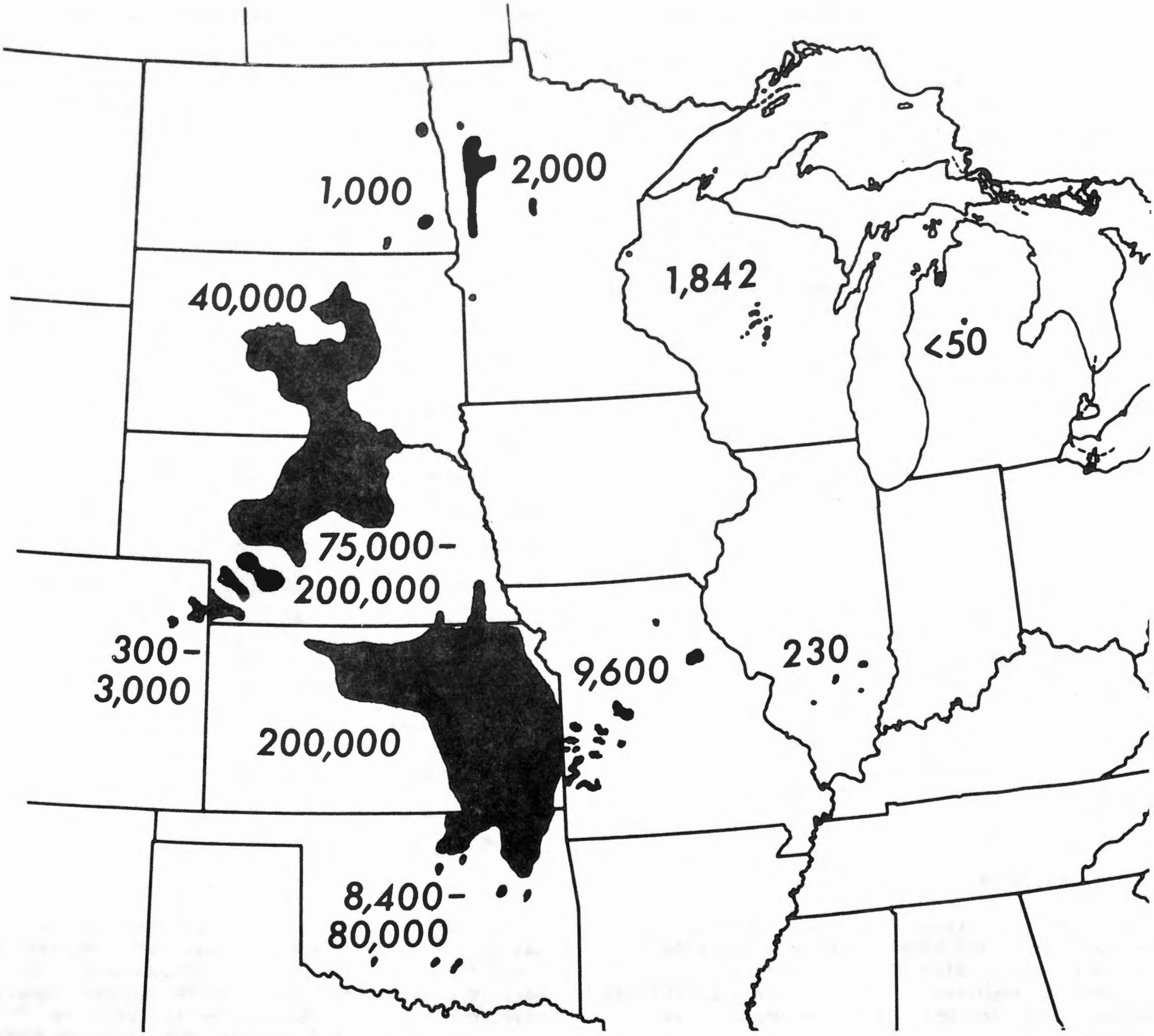

Fig. 1. Range and estimated populations of greater prairie chickens in 1979.

Recent estimates of the kill of chickens by hunters total some 61,000. Up to 2/3 of the legal harvest of chickens may be made in Kansas.

The national population of greater prairie chickens in 1979 was estimated at between 378,000 and 538,000 birds. Since 1968, downward trends were evident for all states except Wisconsin. The 25-year reported outlook in the 11 states still sustaining flocks of greater prairie chickens ranged from "bleak" to "good--with reservations." Continued declines were expected in 4 states, and relative stability was cautiously forecast for 7 states. Six of the 17 states surveyed no longer have greater prairie chickens.

Habitat Acquisition

Almost without exception, the limiting factor for greater prairie chickens continues to be a lack of suitable grassland--principally for nesting, but also for brooding and roosting. Continued conversion of grassland to cropland was reported in several states, and increases in intensity of land use were evident for all states. One western state, Oklahoma, reported an imbalance in the ratio of cropland to rangeland (in this instance extensive prairie unbroken by grain fields), high grazing intensity, mowing, haying, and herbicide spraying of native pastures, as limiting to chicken populations. Thus, the basic

Table 2. Estimated harvests of greater prairie chickens in the 4 states with hunting seasons.

State	Harvest 1967[a]	Harvest Current
Oklahoma	14,000	8,000 (1979)
Kansas	46,000	40,000 (1979)
Nebraska	15,000	8,200 (1977)
South Dakota	10,000	5,233 (1978)
Total	85,000	61,433

[a]Data from Christisen (1969).

land-use problems cited by Hamerstrom and Hamerstrom (1961, 1963), Christisen (1969), and Kirsch (1974) have not changed. Fortunately, the problem of inadequate grassland habitat has not only been recognized, but the remedial action taken in 5 states in the tall-grass prairie region and 2 western states has been impressive.

Land control via acquisition has generally been the 1st step in action programs. The questionnaire asked for the acreage acquired specifically for prairie chickens. Such a question may appear narrow in scope because grasslands suitable for chickens are beneficial to a diverse array of wildlife species; yet the greater prairie chicken is often the key or main "selling point" in decisions for acquisition. The total habitat purchased principally for chickens, partially benefiting chickens, or otherwise managed for chickens, at least in part, currently totals 71,165 ha (Table 3)--up 637% since 1968. Except for 259 ha in Indiana and 1,821 ha in Colorado, all of this area has chickens.

Minnesota leads all states in the tall-grass prairie region with 20,745 ha managed at least in part for greater prairie chickens. A small portion of that land has been acquired specifically for the greater prairie chicken, but the species benefits additionally from the general state program of wildlife land acquisition, the federal wetlands acquisition program, and a prairie preservation program of the Minnesota Chapter, The Nature Conservancy. However, land area data used here are only for the primary chicken range and not for outlying populations.

A 1977 reintroduction on the Lac Qui Parle Wildlife Management Area that appears successful extends the Minnesota chicken range some 112 km south of the primary range (Outdoor News Bulletin 1979). Minnesota's capital investment in land for chickens totals a minimum $12,810,250--assuming a current land value of $250 per acre. The breakdown in this investment by state, federal, and private agencies is 63%, 24%, and 13%, respectively.

Wisconsin, a pioneer in prairie chicken research and management, began land acquisition in 1954 (Hamerstrom et al. 1957) with 32 ha. Currently, 10,023 ha are managed for chickens in central Wisconsin (Berkhahn 1973, Dane County Conservation League 1976). In contrast to the low point of 250 cocks in 1969, the population in Wisconsin had increased to some 900 cocks in 1979. In addition, there is hope for the successful establishment of prairie chickens reintroduced between 1974 and 1977 on the 12,141-ha Crex Meadows Wildlife Area in northwestern Wisconsin (Toepfer 1979).

Land for prairie chickens in central Wisconsin is currently valued at about $10,000,000. Some 2,428 ha are in State ownership, and an additional 7,689 ha have been acquired privately by the Society of Tympanuchus Cupido Pinnatus, the Dane County Conservation League, and others.

Missouri began acquiring land for prairie chickens in 1959 with the State purchase of the 551-ha Taberville Prairie for $133,000. Currently, 2,834 ha are being managed for prairie chickens in Missouri. The Nature Conservancy, the Missouri Department of Conservation, and the Missouri Prairie Foundation cooperate in this range acquisition and habitat preservation effort. Department management of Taberville Prairie has been a success with counts of prairie chicken cocks ranging from 2.4 to 27.0 per km^2 on that area since its' acquisition (Christisen 1977). Presently, Missouri has 21 prairies totaling 2,227 ha in public ownership, varying from 15 to 550 ha in size, with prairie chickens using 14 of those prairies. The prairies not being used by chickens are the smaller tracts, but all 21 have potential for use by chickens, particularly if additional, nearby acreage can be acquired.

In Illinois, the 1st acquisition (early 1940's) for prairie chickens was the 567-ha Green River Conservation Area (Yeatter 1943), later expanded to 943 ha. This area supported the last major flock of prairie chickens in northern Illinois. Unfortunately, that flock did not survive the multiple use program developed for the area (Sanderson and Edwards 1966).

In southern Illinois, acquisition of a scatter pattern of sanctuaries was begun in 1962 by the Prairie Chicken Foundation of Illinois; acquisitions by The Nature Conservancy began in 1965, and in 1970 the Illinois Department of Conservation purchased 166 ha from The Nature Conservancy to expedite further acquisitions by the Conservancy. Currently in Illinois, 664 ha are being managed for native remnant flocks of chickens in Jasper (405 ha) and Marion (259 ha) counties. The purchase price of this land was $678,124; its current estimated value

Table 3. Summary of land on which greater prairie chickens (GPC) were given management consideration in 1979.

State	Areas purchased primarily for GPC (ha)	Areas managed all or partly for GPC (ha)	Investment in land for GPC ($)	Need to acquire more land	
				for Hunting	for Preservation
Indiana	259	259	9,600[a]		yes
Michigan	405	405	36,000+[a]	no	yes
Illinois	664	769	678,124[a]	no	yes
Wisconsin	10,023	10,023	10,000,000[b]	yes	yes
Minnesota	20,745[c]	20,745[c]	12,810,250[cb]	no	yes
Missouri	714	2,834	133,000[a]	yes	yes
E. Tall-Grass Prairie	32,810	35,035			
Oklahoma	65	130	30,000	yes	yes
Kansas	none	4,372	none	no	no
Nebraska	none	130	none	yes	yes
South Dakota	none	[d]	none	no	no
North Dakota	1,275	29,677	225,882	no	no
Colorado	none	1,821	none	no	yes
Great Plains	1,340	36,130			

[a]Purchase price.

[b]Estimated current value.

[c]Wetlands with some prairie chicken habitat are included.

[d]An undetermined area of national grasslands, national wildlife refuges, waterfowl production areas, and other public land benefiting or managed, at least in part, for prairie chickens.

is $3,282,000. Except for one 16-ha remnant tract of prairie vegetation, sanctuaries in Illinois had been under cultivation for over a century prior to acquisition.

Redtop (Agrostis alba) and timothy (Phleum pratense), usually mixed in seedings, are the grasses commonly seeded in habitat management for chickens in Illinois, although recent emphasis involves the seeding of brome (Bromus inermis) and prairie grasses (Andropogon gerardi, A. scoparius, Panicum virgatum, and Sorghastrum nutans). Initial response to sanctuary development in Illinois was dramatic as the main flock near Bogota, Jasper County, increased 415% from the low point of 40 cocks in 1968 to 206 cocks in 1972. Population density reached the phenomenal level of 136 cocks on the largest tract of 94 ha in the spring of 1972. However, heavy predation on nests, particularly by striped skunks (Mephitis mephitis), beginning in 1973 (Westemeier 1979) and increasing harassment and nest parasitism by pheasants (Phasianus colchicus) (Vance and Westemeier 1979) were considered important factors in reducing the population level to 68 cocks in Jasper County by spring 1979.

Ninety-three percent of the booming grounds active in 1980 in Illinois were located either on, or within, 0.8 km of sanctuaries. The density of cocks on or near the Jasper County sanctuaries averaged 16.5 per 40 ha of nest cover over the 14-year period of 1967 to 1980. In Marion County, densities have averaged 10.4 cocks per 40 ha of nest cover on sanctuaries since 1971 (10 years). Although responses to management have been encouraging, the intensity of land use on private lands surrounding the sanctuaries is increasing. Thus, it is uncertain if the present acreage under management will be adequate for the long-term preservation of the Illinois chicken.

Management for Illinois chickens has just recently been expanded to a 105-ha portion of the electrical power generating complex owned by Central Illinois Public Service Company in Jasper County. Also, The Nature Conservancy continues ready to act promptly should any additional suitable land for native Illinois chickens become available for sanctuaries, particularly in Marion County.

The Illinois Department of Conservation and Southern Illinois University are currently attempting to establish greater prairie chickens on reclaimed surface-mined land, using wild stock livetrapped in Kansas and released in southwestern Illinois (Sparling 1979).

Michigan's land acquisitions for prairie chickens, begun in 1970, now total 405 ha in northeast Osceola County. Private contributions to the Michigan Nature Association totaled over $36,000 by 1974, but most prairie chicken land in Michigan has been acquired by the Department of Natural Resources (Anonymous 1974). Although Michigan's last remnant flock of greater prairie chickens totaled fewer than 50 in spring 1979, and the prognosis is bleak, there is hope that preservation efforts are not too little too late. Long range plans made in 1971 called for an area of 21 to 26 km^2 under Department of Natural Resources control acquired within a 51 km^2 block (Ammann 1971).

Prairie chickens were last reported in Indiana in 1972--a 100% loss in 60 years from an estimated population of 100,000 birds in 1912. The acquisition of the 259-ha Beaver Lake Refuge in Newton County, purchased for $9,600 of Izaak Walton League and Pittman-Robertson funds in 1945, did not prevent the loss of chickens from the Hoosier State. It is unclear what cover types and management practices were provided for chickens on the Beaver Lake Refuge, or to what extent chickens responded to management. On private land, steady losses of grassland suitable for nesting, brooding, and roosting were associated with the decline of Indiana chickens; plowing of booming grounds was considered an important cause for desertion of display grounds (Mumford 1955, Ginn 1968, and W.B. Barnes 1979, Connorsville, Ind., pers. commun.). This latter observation is curious because plowed fields, disked ground, soybean stubble, or new grass seedings, each about 4 ha in size, are regularly used as sites for display and booming on Illinois sanctuaries. A preference for plowed fields was also noted in Wisconsin (Westemeier 1971). The plowing referred to in Indiana probably included sizeable tracts of critical nest cover.

In North Dakota, 28,401 ha of public land administered by the U.S. Forest Service supports most of the greater prairie chickens in the state. These lands are not managed specifically for chickens, but greater chickens have increased on U.S. Forest Service lands--particularly on the Sheyenne National Grasslands, and there is some expectation that the increases will continue, if overgrazing and drought are not factors. Conversely, on private lands, population declines in North Dakota have been the rule. Lands purchased specifically for prairie chickens in North Dakota total 1,275 ha, an investment of $225,882 in state funds and $11,500 in private funds.

South Dakota has no acreage purchased or managed specifically for prairie chickens, but chickens occur on the Fort Pierre National Grasslands and on several national wildlife refuges and waterfowl production areas.

At least 7 tracts of prairie were acquired in the 1970's by The Nature Conservancy in South Dakota, with the Samuel H. Ordway, Jr. Memorial Prairie being the largest--3,076 ha in McPherson County. Others include Altamont Prairie, 25 ha in Deuel County; Sioux Prairie, 81 ha in Moody County; Clovis Prairie, 63 ha in Brown County; Vermillion Prairie, 9 ha in Clay County; Aurora Prairie, 12 ha in Brookings County; and Makoce Washte Prairie, 16 ha in Minnehaha County. Sharptails (Pedioecetes phasionellus jamesi) occur on Ordway Prairie (Searle 1975), but there are probably no chickens on any of these prairie tracts. Pheasants may contribute to low densities and absence of chickens on some South Dakota grasslands.

Except for the 130-ha Pawnee Prairie in the southeastern corner (Pawnee County) of the state, Nebraska has no acreage purchased or managed specifically for prairie chickens. Pawnee Prairie was acquired by The Nature Conservancy in 1971 to provide habitat for a remnant flock of greater prairie chickens (Anonymous 1971). Willa Cather Memorial Prairie, 247 ha in Webster County, was acquired by the Conservancy in 1974 (Bennett 1975), but prairie chickens may not be present on this southcentral Nebraska site.

Kansas has no areas purchased specifically for chickens. However, sizable tracts of native prairie totaling 4,372 ha are now managed for greater chickens. These include Konza Prairie, 3,487 ha in Riley County, and Flint Hills Prairie, 885 ha in Butler and Greenwood counties; both prairies were acquired by The Nature Conservancy in the 1970's. Lesser prairie chickens (Tympanuchus pallidicinctus) may inhabit Big Basin, 728 ha of short-grass prairie in Clark County, purchased by the Conservancy in 1972.

Oklahoma, like the 3 other Great Plains states with hunting seasons on the greater prairie chicken, manages relatively few acres (130 ha) for greater chickens. Large expanses of unbroken grassland with little or no cropland is typical of much of the chicken range in Oklahoma. The available acreage is managed mostly for public hunting by planting grain sorghum to concentrate chickens so that they are more readily accessible to hunters.

Although Colorado has not purchased land for prairie chickens, current plans call for some

1,820 ha of the Colorado Division of Wildlife's South Platte Management Area to be restored to support greater prairie chickens (Miller 1979). Historically, overgrazing was typical on the area, but grazing was terminated in 1978. The plan includes interseeding native grasses, control of sand sage (Artemisia filifolia), interseeding of depression areas, and reintroduction of greater chickens to the restored habitat.

Areas acquired and dollar sums provided in Table 3 can only be viewed as a meaningful gesture toward the welfare of the prairie chicken; the job is by no means done. All 6 eastern states and 3 of the 6 western states indicated a need to acquire additional land, particularly for preservation of greater prairie chickens. Wisconsin and Missouri consider that the hunting of chickens may be ecologically feasible if more land can be acquired. Oklahoma and Nebraska hope to provide additional public hunting opportunity if more land can be acquired.

Research

As Christisen (1969) noted, acquisition of land for prairie chickens usually determines if there shall be research and management. Seven of the 11 states with greater chickens are conducting research (Table 4), a gain of 4 and a loss of 1 state since 1968. Two of the states with no current research on chickens plan to initiate projects. When asked if present research information is sufficient for good prairie chicken management, 6 of the 12 states indicated yes, an increase of 3 since 1968. However, 3 of the 6 states qualified their yes answer by stating that better research information is desirable. One state indicated emphatically that research information was adequate and that "more action" was "needed in the form of management." Another responded "there will always be questions to answer, but we have an excellent start."

Table 4. Response to questions regarding research on greater prairie chickens in 1968 and 1979.

State	Research underway		Research planned	Research sufficient for management	
	1968	1979	1979	1968	1979
E. Tall-Grass Prairie					
Indiana	no	no	no	?	
Michigan	no	no	yes	no	no
Illinois	yes	yes		no	yes
Wisconsin	yes	yes		yes	yes
Minnesota	no	yes		no	yes
Missouri	no	yes		yes	yes
Great Plains					
Oklahoma	no	yes		yes	no
Kansas	yes	yes		no	yes
Nebraska	no	no	yes	no	no
South Dakota	yes	no	no	no	yes
North Dakota	no	no	yes?	no	no
Colorado	no	yes		no	no

Habitat Management

Because of the substantial increases in land acquired or managed for greater prairie chickens over the past decade, the present questionnaire included inquiries on management practices and problems. After land has been acquired, sustained annual management of the habitat can become a major burden. The old ecological adage, "Nothing succeeds like succession" is particularly appropriate in the comparatively high rainfall prairie-forest transition zones of southern Missouri, southern Illinois, central Wisconsin, and northwestern Minnesota. Depreciation of habitat from the invasion of introduced grasses or native prairie by woody vegetation can become serious in as few as 3 or 4 years in the absence of fire, grazing, mowing, or chemical treatment.

Prescribed burning was mentioned by more states, and indicated more often as having particular merit in chicken management, than any other practice. All 6 eastern states and 2 western states used fire in managing grassland for chickens. Details of prescribed burning for prairie chickens have been discussed by Kirsch and Kruse (1973), Westemeier (1973), and Kirsch (1974).

Grazing was considered beneficial in 4 eastern states and in 1 western state, but the elimination of both grazing and haying improved nest cover in Minnesota. Rotational haying, however, was considered a beneficial practice on the prairie chicken ranges of Wisconsin, Missouri, and Illinois where average annual precipitation is between 76 and 102 cm.

A long history of annual grazing (usually overgrazing), or annual haying, or both, has degraded the prairies of northwestern Minnesota and the western states, where annual precipitation averages less than 76 cm. In southwestern Missouri, Drobney and Sparrowe (1977) found high use and high nest success by chickens in light to moderately grazed prairie pasture. A relatively high density of 26 cocks per 2.6 km^2 was present on Drobney's study area. In northern and eastern Missouri, Skinner (1975:176) found "the greatest number of species and individuals" in "a grazing system of management which maintained an average height of 20.3 - 30.4 cm." Although prairie chickens were not included in the study, Skinner (1975:179) suggested a combination of proper grazing and fire on both virgin and seeded stands of prairie grass for "birds, beef, and beauty."

Seed harvesting of redtop and timothy grasses by combine continues to be the basic approach to grassland management on Illinois sanctuaries. This practice, which results in weather-resistant stubble, 25-40 cm in height, is described by Westemeier (1973) and Sanderson et al. (1973). Data on over 700 prairie chicken nests found since 1963 continue to show that hens prefer to nest near some abrupt change in habitat configuration (edge). Thus, field size is held to about 4 ha, with disked firelanes or close mowing identifying the field boundaries on the Illinois sanctuaries.

Provision of winter food patches is practiced by 6 states. Kirsch (1974) advised against expending management funds to provide winter cover or food, and Kirsch and Kruse (1973) provided convincing evidence that prairie chickens were present on the prairies of the Dakotas and Montana after the great reduction in grazing by big game herds, especially buffalo, but well ahead of the introduction of grain farming.

Winter food and cover have never been provided by the management program on Illinois sanctuaries because waste grain on nearby private land has been readily available and used by chickens. Wisconsin management, however, has emphasized a consistent, dependable, and well-distributed system of winter food patches. Hamerstrom et al. (1957) and Westemeier (1971) in Wisconsin, Korschgen (1962) in Missouri, and Baker (1953) in Kansas, all attest to the importance of the availability of high-energy grains for chickens in winter. I agree that management funds should not be spent for winter food, since sharecropping can generally provide it. Sharecropping may not be feasible in situations like Wisconsin's Buena Vista Marsh where summer frosts may preclude the growing of corn and, therefore, preclude sharecropping for winter food for chickens.

Other management practices mentioned by several states included plowing and reseeding grasslands; mowing for weed and woody-sprout control; and woodland reduction by bulldozing, chainsawing, timber sales, and chemical control. Use of picloram pellets (Tordon 10K or Amdon 10K) as described by McCaffery et al. (1974) has been effective for control of multiflora rose (Rosa multiflora) and other woody invaders on sanctuaries in Illinois and for brush control on prairie chicken land in Wisconsin (R.K. Anderson and B. Gruthoff, 1979, Wisconsin Rapids, WI, pers. commun.).

The 1979 questionnaire included an inquiry as to management problems on and near land managed for greater prairie chickens. Problems with weed and brush invasion were indicated for 5 of the 6 eastern states. Predation by avian species was mentioned for Michigan, and by mammals, principally skunks, for Illinois. Competition by pheasants was indicated for Indiana, Michigan, and Illinois. Deer were an additional problem in Michigan. Lack of sufficient manpower and equipment was mentioned for 1 state. Establishment of grass cover on land with a high water table was a problem in North Dakota.

There was unanimity that intensifying land use is ubiquitous and in some cases, insidious. Both drainage and irrigation are serious threats on Wisconsin's Buena Vista Marsh (Hamerstrom and Hamerstrom 1973, and Hamerstrom 1977) as are pesticides and pesticide drift on grassland reserves. Pesticide problems were also indicated for Oklahoma and South Dakota. Irrigation and grain farming are making ominous inroads into the grasslands of the water-rich Nebraska Sandhills, with falling water tables and nitrate contamination showing up as attendant problems (Farrar 1980). In Missouri, intensification of land use and irrigation are the greatest problems near lands managed for chickens. Overgrazing and annual burning continue to be primary problems in the Kansas grasslands. Herbicide spraying of native pastures, which eliminates the forb component of the prairie, is a primary problem in Oklahoma. Herbicide spraying, a shift to fescue, more reservoirs, heavy industry, and energy complexes with radiating transmission lines were also listed by Farney (1980) as factors that will soon destroy large portions of prairie habitat in the Flint Hills of Kansas.

Hunting

The questionnaire inquired about safeguards taken to prevent overharvest and how excessive mortality by hunting would be detected. Three of the 4 states with seasons indicated that they regulated the season length, opening and closing dates, and bag limits. In Nebraska, some areas are closed to all grouse hunting. In Oklahoma, most prairie chickens are found on private lands where little or no hunting is allowed, thus providing, in effect, refuges.

Overharvesting was reported as unlikely in Kansas because of light hunting pressure and feed-field hunting traditions. In South Dakota, overharvest was thought impossible because of the large area of sparsely inhabited range and because of the birds tendency to flock and get wary shortly after hunting begins. In Nebraska, a declining population would be detected by spring breeding ground surveys and by a changing ratio of chickens to sharptails in hunter bag checks.

Hunting continues to be the primary management consideration for greater prairie chickens in the 4 states with seasons. No fears were expressed that hunting endangered the species. Indeed, 2 states that have no seasons, Missouri and North Dakota, indicated the dual goal in their management efforts of preservation and the hope of future hunting. Hunting promotes the advantages from increased support by sportsmen and this facilitates management efforts by State conservation agencies.

MAINTAINING CURRENT POPULATIONS

The population trend for greater prairie chickens was reported down in 8 states, static in 2, and up in only 2, in the decade preceeding Christisen's (1969) report. The present report revealed a continuation of the same downward trend. It is unlikely that land use in the remaining range of the greater prairie chicken will change significantly for the better. The last bastions of huntable populations appear most likely to persist in Kansas and Nebraska. Chicken hunting may also persist in Oklahoma and South Dakota, but with increased restrictions. Perpetuation of greater chickens appears likely, and perhaps even limited trophy hunts are feasible for Wisconsin, Minnesota, Missouri, and North Dakota. Uncertainty about preservation persists in Colorado, Illinois, and particularly Michigan.

Curtailment of the downward trend in chicken abundance over the past 2 decades will depend on stemming adverse trends in land use. More conservative range management, i.e., light to moderate grazing instead of overgrazing, periodic prescribed burning instead of annual burning (or fire exclusion), and selective brush control instead of broad-spectrum use of herbicides that kill both woody plants and prairie forbs, must become common practice in the Great Plains range. Increased irrigation and use of pesticides must be halted if current populations of chickens are to be maintained. Perhaps the rising cost of energy needed to operate irrigation pumps will halt or slow the conversion of rangeland that is better suited for prairie and beef, rather than corn and milo.

Land acquisition must continue and be accompanied by good stewardship of habitat for greater prairie chickens and associated species. In the past decade The Nature Conservancy has spent some $10,000,000 on prairie preservation (Farney 1980), a superb effort by private individuals that is continuing. Other organizations, and particularly state and federal governments, must follow such example. Establishment of a National Tallgrass Prairie Park or other suitable preserve should secure the future for greater chickens in the Great Plains.

However, we should ask if present federal (and state) lands potentially suitable for chickens are being managed near their potential? The current upswing of chickens on the Sheyenne National Grasslands in North Dakota following a program of deferred rotational grazing, prescribed burning, and mowing is 1 Federal program showing positive results. The midwest prairie conferences beginning in 1968 have sparked much interest in prairie. Prairie restoration is currently much in vogue throughout the Midwest. The work of George et al. (1979) in Iowa offers an excellent approach to establishment of prairie grass pastures as nest cover in states where prairie has long disappeared. Kirsch (1974) suggested a goal of 100 cocks per 1.6 km^2 of managed habitat that was based largely on responses by chickens in Illinois. This goal continues to appear realistic, as the densities for 14 years in Jasper County and 10 years in Marion County, by 1980, average 93.5 cocks per 1.6 km^2 of nest cover on sanctuaries in Illinois. Although the Illinois data include 2 years of "abnormal" population highs, they also include 2 years of low density. Also, several sanctuaries received relatively little use by chickens, and have potential for use, thus even higher densities may be possible in the future.

Application of proven and published findings on habitat preservation and management, continually refined at symposia such as the present one and at the biennial meetings of the Prairie Grouse Technical Council, offer the greatest hope for the future of our prairie grouse resource.

LITERATURE CITED

ALDRICH, J.W. 1963. Geographic orientation of American Tetraonidae. J. Wildl. Manage. 27:529-545.

AMMANN, G.A. 1971. Prairie chicken management. Mich. Dep. of Nat. Resour. 5pp. Mimeo.

ANONYMOUS. 1971. New projects. The Nature Conservancy News. 21(4):5.

_____. 1974. Theater wanted for grassland players. Mich. Nat. Resour. 43(3):6-9.

BAKER, M.F. 1953. Prairie chickens of Kansas. Univ. Kansas Museum Nat. Hist. Lawrence. State Biol. Survey, Misc. Pub. No. 5. 68pp.

BENNETT, M.R. 1975. Willa Cather and the prairie. The Nature Conservancy News. 25(1):8-11.

BERKHAHN, J.R. 1973. Wisconsin's prairie chicken management program. Pages 47-55 in W.D. Svedarsky and T. Wolfe, eds. The Prairie Chicken in Minnesota. Univ. of Minnesota, Crookston. 102pp.

CHRISTISEN, D.M. 1969. National status and management of the greater prairie chicken. Trans. North Am. Wildl. Conf. 34:207-217.

_____. 1977. Prairie preservation: salvation for the greater prairie chicken in Missouri. Presented at the 12th Prairie Grouse Technical Council, Pierre, S.D. 12pp. Mimeo.

DANE COUNTY CONSERVATION LEAGUE. 1976. Buena Vista Marsh Wildlife Area. D.C.C.L. Newsletter. Nov. 1976.

DROBNEY, R.D., and R.D. SPARROWE. 1977. Land use relationships and movements of greater prairie chickens in Missouri. Trans. Mo. Acad. Sci. 10&11:146-160.

FARNEY, D. 1980. The tallgrass prairie: can it be saved? National Geographic. 157(1):37-61.

FARRAR, J. 1980. Sandhills Alive! Outdoor Life. June 1980. pp. 54-61.

GEORGE, R.R., A.L. FARRIS, C.C. SCHWARTZ, D.D. HUMBURG, and J.C. COFFEY. 1979. Native prairie grass pastures as nest cover for upland birds. Wildl. Soc. Bull. 7:4-9.

GINN, W.E. 1968. No prairies, no chickens. Outdoor Indiana 33(7):16-19.

HAMERSTROM, F.N. 1977. New threat to Buena Vista chickens. Wis. Nat. Resour. 1(1):6-7.

_____, O.E. MATTSON, and F. HAMERSTROM. 1957. A guide to prairie chicken management. Wis. Conserv. Dep. Tech. Bull. 15. 128pp.

_____, and F. HAMERSTROM. 1961. Status and problems of North American grouse. Wilson Bull. 73:284-294.

_____. 1963. The grouse symposium in review. J. Wildl. Manage. 27:868-887.

_____. 1973. The prairie chicken in Wisconsin: highlights of a 22-year study of counts, behavior, movements, turnover and habitat. Wis. Dep. of Nat. Resour. Tech. Bull. 64. 52pp.

KIRSCH, L.M. 1974. Habitat management considerations for prairie chickens. Wildl. Soc. Bull. 2:124-129.

_____, and A.D. KRUSE. 1973 (1972). Prairie fires and wildlife. Proc. Annual Tall Timbers Fire Ecol. Conf. 12:289-303.

KORSCHGEN, L.J. 1962. Food habits of greater prairie chickens in Missouri. The Am. Midl. Nat. 68:307-318.

MCCAFFERY, K.R., L.D. MARTOGLIO, and F.L. JOHNSON. 1974. Maintaining wildlife openings with picloram pellets. Wildl. Soc. Bull. 2:40-45.

MILLER, G.C. 1979. Development of a preservation program for three species of prairie grouse. Colo. Div. of Wildl. Job Progress Rep. SE-3-3. 19pp. Mimeo.

MUMFORD, R.E. 1955. Prairie chicken. In Ind. Pittman-Robertson Wildlife Restoration 1939-1955, John M. Allen ed., Ind. P-R Bull. 3, pp. 18-35.

OUTDOOR NEWS BULLETIN. 1979. Prairie chickens booming in Minnesota. Wildlife Management Inst. 33(13):6. June 29, 1979.

SANDERSON, G.C., and W.R. EDWARDS. 1966. Efforts to prevent the extinction of the prairie chicken in Illinois. Trans. Ill. Acad. Sci. 59(4): 326-333.

_____, R.L. WESTEMEIER, and W.R. EDWARDS. 1973. Acquisition and management of prairie chicken sanctuaries in Illinois. Pages 59-79 in W.D. Svedarsky and T. Wolfe, eds. The Prairie Chicken in Minnesota. Univ. of Minnesota, Crookston. 102pp.

SEARLE, N. 1975. Listen to the prairie. The Nature Conservancy News. 25(4):16-19.

SKINNER, R.M. 1975. Grassland use patterns and prairie bird patterns in Missouri. Pages 171-180 in M.K. Wali, ed. Prairie: a multiple view. 1975. (1974) Univ. of North Dakota Press, Grand Forks. 433pp.

SPARLING, D.W. 1979. Restoration of the greater prairie chickens in southwestern Illinois. Coop. Wildl. Research Lab., Southern Illinois Univ., Carbondale. 20pp. Mimeo.

TOEPFER, J.E. 1979. Reintroduction of prairie chickens into the Crex Meadows Wildlife Area, Burnett County, Wisconsin. Univ. of Wisconsin, Stevens Point. 5pp. Mimeo.

VANCE, D.R., and R.L. WESTEMEIER. 1979. Interactions of pheasants and prairie chickens in Illinois. Wildl. Soc. Bull. 7:221-225.

WESTEMEIER, R.L. 1971. The history and ecology of prairie chickens in central Wisconsin. Univ. of Wisconsin, Res. Div. Res. Bull. 281. 66pp.

_____. 1973 (1972). Prescribed burning in grassland management for prairie chickens in Illinois. Proc. Annual Tall Timbers Fire Ecol. Conf. 12:317-338.

_____. 1979. Illinois prairie chicken ecology and management investigations. Ill. Dept. Conserv. P-R Rept., Project W-66-R-19. 42pp. Mimeo.

YEATTER, R.E. 1943. The prairie chicken in Illinois. Ill. Nat. Hist. Survey Bull. 22:377-416.

STATUS OF SHARP-TAILED GROUSE IN NORTH AMERICA

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Abstract: Populations, past and current distributions, and predicted trends of 6 subspecies of sharp-tailed grouse (*Pedioecetes phasianellus*) in North America were ascertained through a questionnaire and literature review. Sharptails once occurred in at least 29 provinces and states of Canada and the United States; they now are found in 21, having been extirpated from 8 states at the periphery of their historical range. Distributional losses usually have been accompanied by intensive grazing or conversion of native vegetation to cropland. Fifteen questionnaire respondents predicted distributional losses over the next 10 years and 16 predicted stability. None foresaw distributional gains.

The northern 3 subspecies of sharp-tailed grouse, *P. p. phasianellus* (northern), *P. p. kennicotti* (northwestern), and *P. p. caurus* (Alaskan) have received little management or research, although increased human activities are expected in parts of their ranges. Of the southern 3 subspecies, Columbian sharptails (*P. p. columbianus*) are fewest in number (60,000 to 170,000), occurring as isolated populations throughout most of their range. They have undergone range reductions exceeding 90% in 7 of 10 political subdivisions of their historic range. Prairie sharptails (*P. p. campestris*) number between 600,000 and 2,000,000 exclusive of Ontario and Saskatchewan. They have been extirpated from 2 states and future distributional losses are expected, even in the center of their range. Plains sharp-tailed grouse (*P. p. jamesi*) number between 600,000 and 3,000,000, exclusive of peripheral populations in British Columbia and Manitoba. They have been extirpated from 3 states and are classified as "endangered" in Colorado, but are expected to remain fairly stable in the center of their range.

Among North American prairie grouse the sharp-tailed grouse occupies the largest geographical area and contains the greatest number of subspecies. The broad distribution and taxonomic variety are reflective of the many ecological conditions in which sharptails exist: brushy openings within extensive boreal forests (Aldrich 1963); savannahs of midwestern prairies where woody vegetation may comprise 20% to 50% of the ground cover (Grange 1948, Ammann 1957); extensive tall and mid-grasslands of the west where shrub cover comprises as little as 5% of the ground cover (Edminster 1954); and sagebrush-grassland communities of the Rocky Mountain and intermountain regions (Aldrich 1963). Because the sharptail evolved into a number of subspecies, each adapted to distinct ecological conditions, environmental changes potentially can affect the separate subspecies differently.

Changes in sharptail distribution have been noted periodically, but reports by McClanahan (1940), Aldrich and Duvall (1955), Aldrich (1963) Johnsgard and Wood (1968), and Johnsgard (1973) have been somewhat inconsistent. The population status of the 6 subspecies has not been treated in published reports, although Johnsgard (1973) presented hunter harvest data by political units. A review of sharp-tailed grouse management problems was last accomplished in 1961 (Hamerstrom and Hamerstrom 1961). The most recent summary of research and management needs was a literature review by Evans (1968).

This paper updates distributional changes of sharp-tailed grouse by subspecies, identifies the apparent reasons for those changes, and clarifies past inconsistencies in the literature. Population and hunter harvest estimates are given, as are predictions of distributional trends over the next 10 years. Summaries of recent and ongoing activities are presented to identify the most pressing research and management needs and to promote economies in future work.

We thank the wildlife professionals who provided much of the information contained herein. Clait E. Braun's critical review of the manuscript is appreciated. This study was conducted through Federal Aid Project SE-3.

METHODS

We distributed questionnaires to wildlife professionals in 32 states and provinces of the United States and Canada in September 1979 and received 41 replies. Respondents characterized present distributions and populations of subspecies as a percentage of past maximums (extirpated, <10%, 10%-50%, >50%-90%, >90%) and numerically ranked suspected reasons for those changes. They predicted trends of subspecies over the next 10 years (increase, decrease, or stable). Estimates of present populations by subspecies (≤ 1,000, 1,001 to 10,000, 10,001 to 50,000, 50,001 to 100,000, 100,001 to 500,000 and > 500,000) and annual hunter harvests were provided. Respondents summarized current management and research activities.

We ascertained past and present distributions for the 6 subspecies of sharp-tailed grouse recognized by the American Ornithologists' Union (1957). For the United States, we compared reasons given for changes in distribution with the findings of Klopatek et al. (1979) which, based on 1967 data, quantified man-induced changes to natural vegetation described by Küchler (1964). Respondents' predictions of distributional changes over the next 10 years were summarized. Minimum and maximum population estimates were summed for each subspecies.

RESULTS

Distribution

Inconsistencies exist in the literature concerning the historical distribution of sharp-tailed grouse in Oklahoma. Although McClanahan (1940), Aldrich and Duvall (1955), American Ornithologists' Union (1957), and Aldrich (1963) omitted Oklahoma as historic range, Johnsgard and Wood (1968) and Johnsgard (1973) included it. Specimens are lacking, but sharptails, probably P. p. jamesi, were apparently resident in northwestern Oklahoma (Nice and Nice 1924, Ridgway and Friedmann 1946, Sutton 1967).

Another inconsistency concerns the subspecies once occurring in New Mexico. Aldrich and Duvall (1955) showed both P. p. jamesi and P. p. columbianus as ranging into New Mexico, while the American Ornithologists' Union (1957) listed only P. p. columbianus for the state, and Aldrich (1963) showed only P. p. jamesi. The only specimens from New Mexico of which we know are 1 taken by Ligon near the Colorado border in eastern New Mexico in 1926 (Bailey 1928), and 4 taken by A. P. Smith at Folsom, in the same area, in 1918 (Am. Mus. Nat. Hist. catalog #353690-353694. The sharptails in eastern New Mexico were considered an extension of the eastern Colorado population (Bailey 1928, Ligon 1961).

The New Mexico specimens were assigned to P. p. columbianus, in agreement with the American Ornithologists' Union (1910) check-list current at the time. Later, the subspecies P. p. jamesi was accepted by the American Ornithologists' Union (1947), based on Lincoln's (1917) eastern Colorado specimen. Even though the New Mexico sharptails were adjacent to populations of the newly-named P. p. jamesi subspecies in Colorado and presumably Oklahoma, and were roughly 200 km from the nearest known P. p. columbianus location, New Mexico was still listed as within the range of P. p. columbianus, and omitted from the range of P. p. jamesi by the American Ornithologists' Union (1947). Recently, personnel of the Museum of Vertebrate Zoology, University of California, Berkeley, examined the Ligon specimen but were unable to assign it unequivocally to either subspecies (V. M. Dziadosz, pers. comm.). For these reasons, we have included New Mexico within the former range of P. p. jamesi, and omitted the state from the former range of P. p. columbianus.

Indiana and Texas have not been considered historical sharptail range, but sharptails may have occurred in both states. Ridgway and Friedmann (1946) listed 1 Indiana occurrence, and in Texas, Sutton (1967) states "records of U.S. Fish and Wildlife Service indicate that species was formerly not uncommon in northwestern part of Texas Panhandle." Lacking substantive documentation, however, we did not include these states within historical ranges.

The past, present, and predicted distributional trends (over the next 10 years) of sharp-tailed grouse in North America were summarized (Table 1). Sharptails once occurred in at least 8 Canadian provinces and 21 states. They now occur in 8 provinces and 13 states. The 8 states from which they have been extirpated are at the periphery of their historical range: Oregon, California, Nevada, New Mexico, Oklahoma, Kansas, Iowa, and Illinois. Fifteen respondents in states or provinces now containing sharptails predicted further distributional losses over the next 10 years; 16 predicted stability.

Population Status

There was a lack of population information for the northern 3 subspecies. For the southern 3 subspecies, estimates were obtained for all states and provinces except Ontario. In the case of plains sharptails in Montana and South Dakota, however, the estimates were extrapolated from published studies (Brown 1964, Hillman and Jackson 1973). Population and harvest estimates are given in the subspecies accounts. As indicated in these accounts, some respondents were unable to provide estimates for all subspecies in their political subdivisions. Several respondents noted the cyclic nature of grouse populations, and many were unable to relate past population changes or predict future population trends.

Table 1. Past, present, and predicted trend (over the next 10 years) of sharp-tailed grouse distribution in North America, 1979.

	States or Provinces In Range		Respondents Predicting		
Subspecies	Past	Present	Decrease	Stable	Increase
P. p. phasianellus	3	3	0	2	0
P. p. kennicotti	1	1	0	1	0
P. p. caurus	5	5	1	4	0
P. p. columbianus	10	7	5	2	0
P. p. campestris	8	6	6	2	0
P. p. jamesi	13	10	3	6	0
TOTALS	29[a]	21[a]	15	16	0

[a]Less than sum of states and provinces, since some political units contain more than 1 subspecies.

P. p. phasianellus, kennicotti, and caurus. The 3 sharp-tailed grouse subspecies of northern North America occupy 9 political subdivisions (Table 1) -- see Aldrich (1963) for a distribution map. P. p. phasianellus ranges through the Hudson Bay lowlands from west-central Quebec through northern Ontario and western Manitoba. P. p. kennicotti is found in the southwestern part of the Northwest Territories (Mackenzie), and P. p. caurus occurs from central Alaska through the Yukon Territory, the Northwest Territories south of Great Slave Lake, into northeastern British Columbia and northern Alberta. We found no clarification of the subspecies occurring in central Alberta, Saskatchewan, and Manitoba, the "race unknown" portion of Aldrich's (1963) map. Distributions are patchy throughout the northern regions and generally are associated with forest openings (Edminster 1954).

We received 8 responses regarding the status of these subspecies. Distributions of P. p. caurus in Yukon Territory were > 50-90% of the past maximum. Ontario, Quebec (P. p. phasianellus), and Northwest Territories (P. p. kennicotti) respondents believed that occupied ranges were at least 90% of past ranges. P. p. caurus populations in Alaska appeared to be more restricted (unspecified) than the peaks of distribution in the 1920's and 30's, primarily because of fire suppression (Weeden and Ellison 1968, J. D. McGowan, pers. comm.). The concensus for all the northern subspecies was that ecological succession, promoted by fire suppression, was most responsible for reductions in sharptail distribution.

Range reductions over the next 10 years were predicted for P. p. caurus in British Columbia (W. T. Munro, pers. comm.). Throughout the remainder of the range of these 3 subspecies, however, stable distributions were predicted (Table 1).

Population estimates generally were not available for these subspecies. P. p. caurus in Yukon Territory probably numbered between 1,001 and 10,000 (D. Mossop, pers. comm.). Respondents generally noted that these sharptails were lightly hunted. About 1,000 P. p. kennicotti are bagged annually in Northwest Territories (S. Miller, pers. comm.), and 300-400 P. p. caurus are taken in the Yukon Territory. Spring hunting at leks (legal for Native Peoples) may be reducing some flocks in the Yukon Territory (D. Mossop, pers. comm.).

We found no indication of ongoing research or management specifically for P. p. phasianellus or P. p. kennicotti. Alaska and Yukon Territory personnel inventory P. p. caurus populations by lek counts, and some ecological study and habitat restoration work are conducted in the Yukon Territory (D. Mossop, pers. comm.). Human activities noted by respondents as potentially influencing sharptail welfare in the northern regions included: increasing agriculture, oil field and tar sands development, logging, wild-fire suppression, and mining of sandy lek sites for road materials.

P. p. columbianus. Of the 3 southern subspecies Columbian sharptails have experienced the most severe distributional losses. They once occurred in 10 states and provinces (Fig. 1). They were last known in California in the 1920's (Starkey and Schnoes 1976), Nevada in 1952 (Wick 1955), and Oregon in 1968 or 1969 (Olsen 1976).

This subspecies now occurs in 6 states and British Columbia, existing as isolated populations through the southern 2/3's of its range (Fig. 1). Respondents felt that Columbian sharptails occupied less than 10% of their former range in Idaho, Montana, Utah, and Wyoming, 10-50% in Colorado and Washington, and 80% or more in British Columbia. The consensus was that intensive grazing was most responsible for losses, followed by conversion of rangeland to cropland (see Buss and Dziedzic 1955), and ecological succession. In Washington, Zeigler (1979) noted losses of 10.6-51.4% of sharptail winter "budding" habitat to agriculture over a 32 year period.

For the most part, the present distribution of Columbian sharptails coincides with Kuchler's (1964) sagebrush steppe (Artemisia - Agropyron) type which Klopatek et al. (1979) estimated had been reduced by 15%. In Washington, however, sharptail distribution corresponds with Kuchler's (1964) fescue-wheatgrass (Festuca-Agropyron) type, of which 73% had been lost, primarily to cropland (Klopatek et al. 1979).

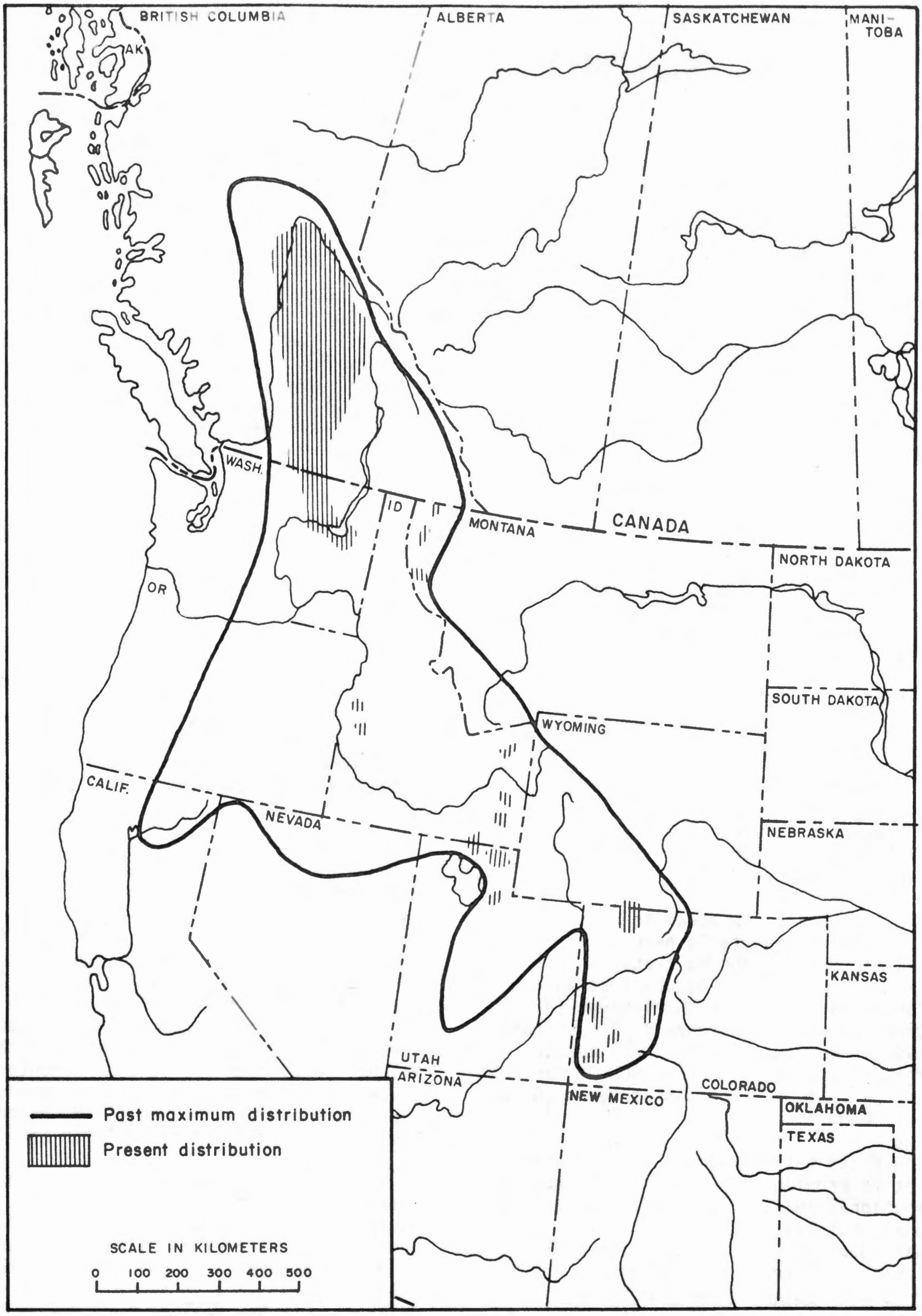

Fig. 1. Past and present distribution of P. p. columbianus in North America, 1979.

Further range reductions over the next 10 years were predicted in 4 states and British Columbia (Table 1). Respondents in Utah and Wyoming, which contain few P. p. columbianus, felt distribution would remain stable (D. Bunnell, D. Moody, pers. comm.).

Columbian sharp-tailed grouse numbers were estimated to be between 60,000 and 170,000, with 60-80% in British Columbia. They are hunted in Colorado, Idaho, Utah, Washington, and British Columbia, with 13,000 to 15,000 taken annually. Montana and Wyoming do not have seasons for Columbian sharptails, but some are killed illegally in Wyoming during the sage grouse (Centrocercus urophasianus) season (D. Moody, pers. comm.). Columbian sharp-tailed grouse were classified as "status-undetermined" by the U.S. Fish and Wildlife Service (U.S. Dept. Interior 1973). Brown (1971) considered them endangered in Montana, and they have been classified endangered in Oregon (Marshall 1969).

Colorado, Utah, Washington, and Wyoming state personnel inventory their P. p. columbianus populations. Ecological studies are ongoing in Idaho and Utah, and planned in Colorado (D. Norell, D. Bunnell, C. E. Braun, pers. comm.). Surveys of potential sites for reintroduction are planned in Oregon (R. R. Denney, pers. comm.). Reintroductions to Lava Beds National Monument, California, and the National Bison Range, Montana, have been proposed (Starkey and Schnoes 1976, W. Kessler, pers. comm.). No respondents knew of any habitat restoration or acquisition activities.

P. p. campestris. Prairie sharp-tailed grouse once ranged through 8 states and provinces (Fig. 2). They were extirpated from Illinois in the early 1900's (J. H. Kebe, pers. comm.) and from Iowa in 1934 (Grant 1963).

Prairie sharptails now occur in 6 states and provinces (Fig. 2). Sharptails have acquired new range in eastern Ontario due to transplants (H. G. Lumsden, pers. comm.). They occupy less than 10% of their former maximum range in Michigan (H. E. Johnson, pers. comm.) and Wisconsin (E. J. Frank, M. W. Gratson, pers. comm.); 30% in Minnesota (W. E. Berg, pers. comm.); and >50-90% in Manitoba (G. Collins, pers. comm.) and Saskatchewan (G. W. Pepper, pers. comm.).

The consensus was that conversion of sharptail habitat to cropland has been most responsible for distributional losses. By 1967, cropland had pre-empted all but 17% of Küchler's (1964) oak-savannah (Quercus - Andropogon) type, the historical sharptail habitat in Wisconsin and Minnesota. Other reasons given for range reductions were ecological succession (enhanced by fire suppression) in the lake states, intensive grazing in Canada, and housing developments in Michigan.

Respondents predicted range reductions in Minnesota, Michigan, Wisconsin, and Manitoba over the next 10 years. Sharptail distribution in Ontario and Saskatchewan should remain stable (Table 1). A detailed account of sharptail distribution in Wisconsin has been given by Vanderschaegen (1977).

Prairie sharptails number between 600,000 and 2,000,000 birds, exclusive of Ontario and Saskatchewan. Michigan and Wisconsin probably have no more than 5,000 combined (H. E. Johnson, M. W. Gratson, pers. comm.). They are hunted in all states and provinces in which they occur, with annual harvests of 60,000 to 140,000 birds, again exclusive of Ontario and Saskatchewan.

Inventories of prairie sharptails are conducted in all provinces and states except Ontario. Habitat restoration work is ongoing in Michigan, Minnesota, and Wisconsin, utilizing, in part, prescribed burning (Evrard 1977). In Wisconsin land-use planning with incentives to local governments and private landowners has been identified as instrumental in preventing further losses of sharptail habitat (F. Strand, pers. comm.). Ecological studies of prairie sharptails are underway at the University of Minnesota and University of Wisconsin - Stevens Point (W. E. Berg, M. W. Gratson, F. N. Hamerstrom, pers. comm.).

P. p. jamesi. Plains sharp-tailed grouse once ranged into 13 political subdivisions, but no longer occur in the 3 states along the southern extent of their range (Fig. 3). Plains sharptails disappeared from Kansas in the early 1900's (K. Montei, pers. comm.), were last seen in Oklahoma in 1932 (Sutton 1974), and have not been reported in New Mexico since 1961 (Ligon 1961).

Plains sharptails occur peripherally in eastern British Columbia and southwestern Manitoba (Fig. 3), but respondents provided no recent distributional data on this subspecies in those areas. Plains sharptails occur in Colorado as a relict population, occupying less than 10% of their former range (Miller 1979). They occupy 10-50% of their former range in Alberta (A. B. Rippin, pers. comm.), North Dakota (L. Kirsch, pers. comm.), and Wyoming (J. Nemick, R. Wilson, pers. comm.); >50-90% in Montana (J. Weigand, pers. comm.), Nebraska (K. Robertson, pers. comm.), Saskatchewan (G. W. Pepper, pers. comm.), and South Dakota (Hillman and Jackson 1973).

Conversion of rangeland to cropland and intensive grazing ranked about equally as reasons given for distributional losses of P. p. jamesi. Klopatek et al. (1979) estimated that 40-80% of Küchler's (1964) natural vegetation types had been lost in those parts of Kansas, Oklahoma, and New Mexico where plains sharptails once occurred. The wheatgrass-needlegrass (Agropyron-Stipa) type, indicative of sharptail habitat in the Dakotas, had decreased by 36%, primarily from conversion to cropland. Grama - needlegrass - wheatgrass (Bouteloua - Stipa - Agropyron) grasslands, associated with plains sharptails in eastern Montana (Yde 1977),

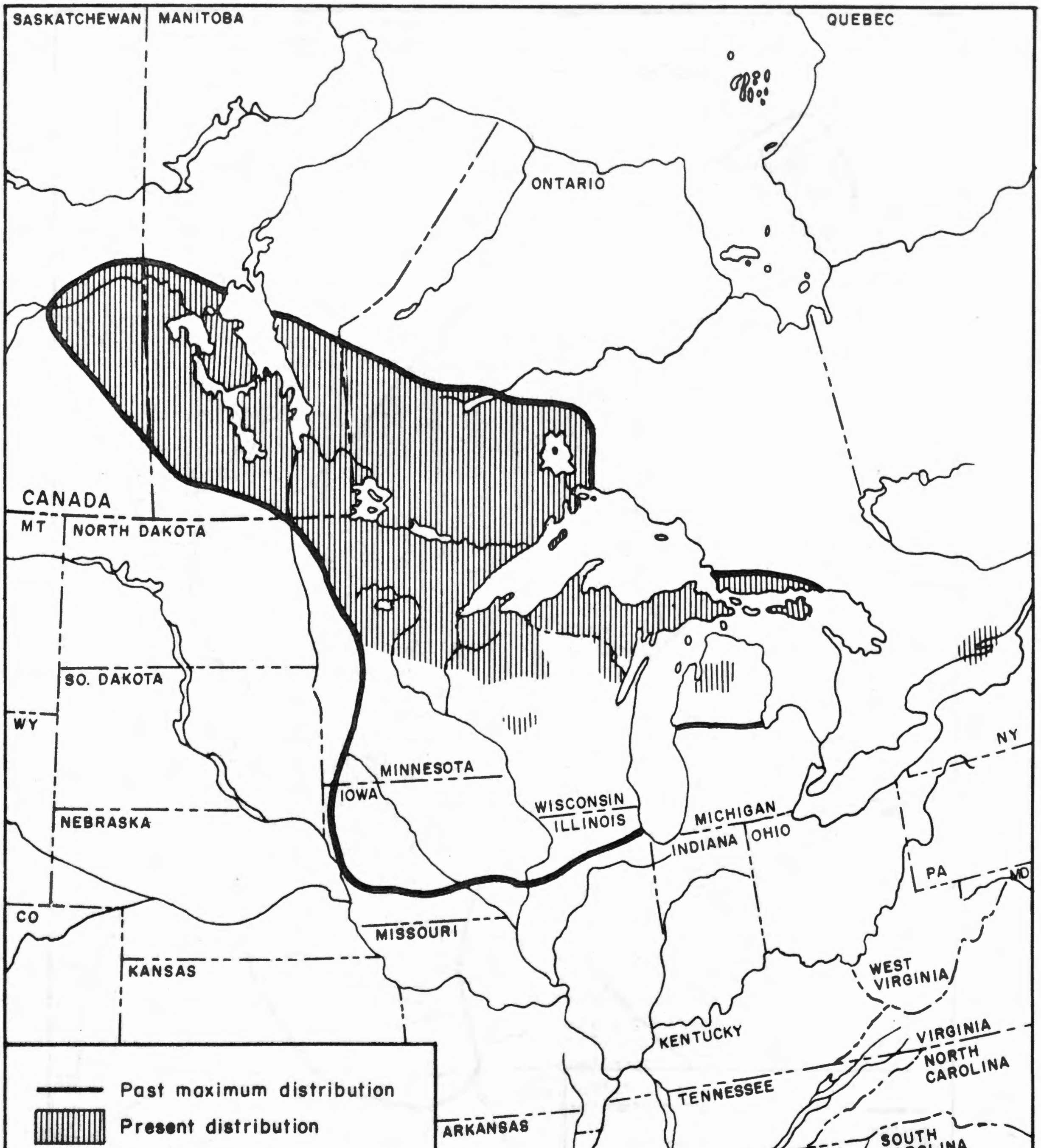

Fig. 2. Past and present distribution of P. p. campestris in North America, 1979.

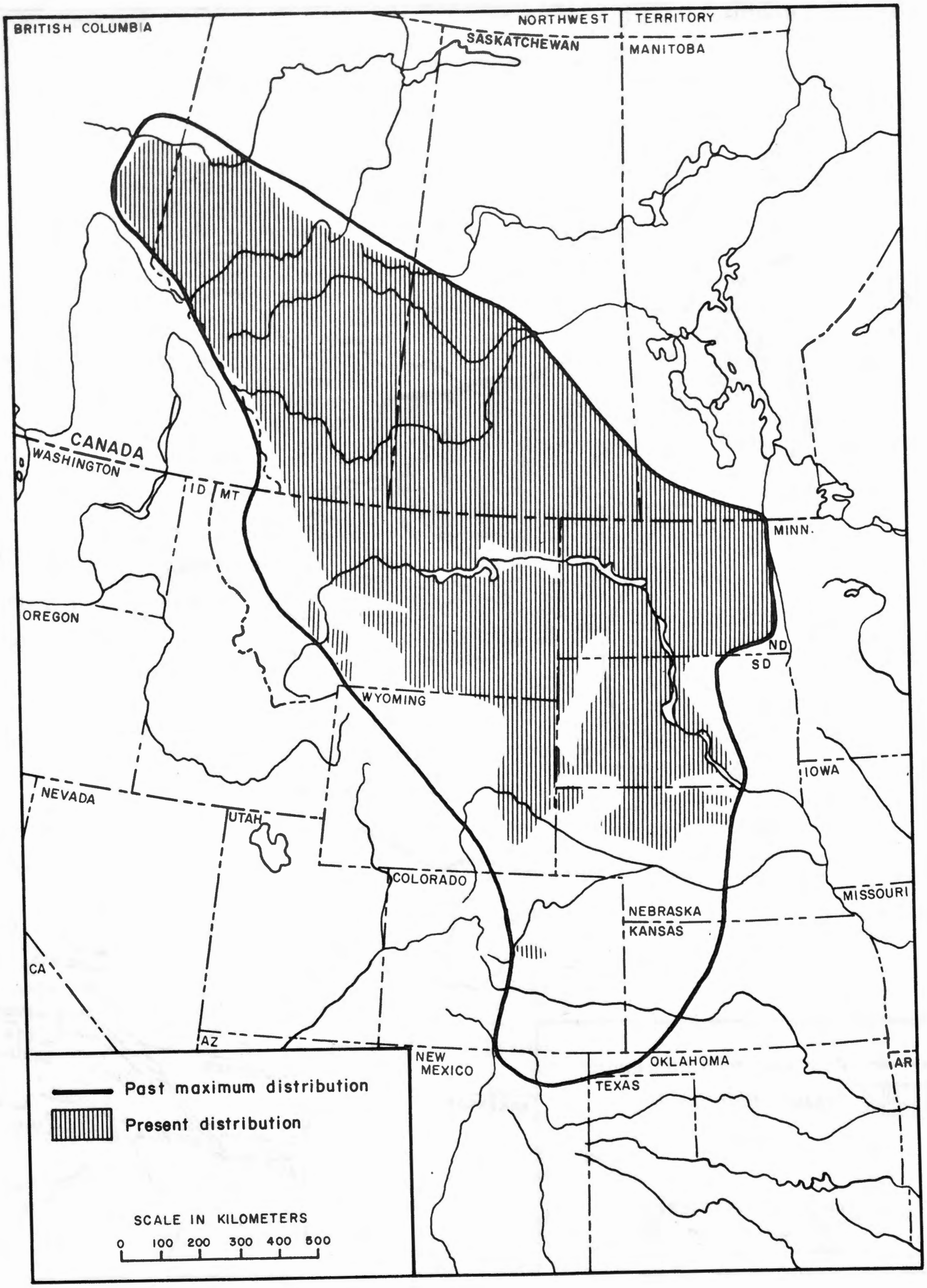

Fig. 3. Past and present distribution of P. p. jamesi in North America, 1979.

had decreased by 24%, primarily due to cultivation. In Colorado this subspecies no longer occurs in the sandsage-bluestem prairie (Artemisia - Andropogon) areas which, overall, showed a 58% decline. Their remaining range in Colorado, in the plains - foothills ecotone south of Denver, is severely threatened by subdivisions and "ranchette" housing developments, and intensive grazing (Miller 1979). Küchler's (1964) Nebraska sandhills prairie (Andropogon - Calamovilfa) vegetation, the habitat of sharp-tails in Nebraska and southern South Dakota, had decreased by 6% as of 1967.

Colorado and Wyoming respondents predicted further range reductions as did 1 North Dakota respondent. All others felt that P. p. jamesi distribution would be stable for the next 10 years (Table 1). However, 7 of 9 P. p. jamesi respondents predicted population decreases in the next 10 years.

Numbers of plains sharptails were estimated at 600,000 to 3,000,000, exclusive of Manitoba and British Columbia where they occur peripherally. The lower value appears to be an artifact of the questionnaire categories, since the annual harvest was estimated at 505,000 to 640,000. They are hunted in all the states and provinces in which they occur except Colorado, where they are listed as an endangered species by the Colorado Wildlife Commission.

Management activities for P. p. jamesi include inventory in all states and provinces, habitat acquisition in North Dakota and Saskatchewan, and habitat restoration in Saskatchewan. South Dakota has done a limited amount of transplanting and ecological studies are underway in Montana and Saskatchewan.

DISCUSSION

Although major distributional changes in the northern 3 subspecies of sharp-tailed grouse were not detected, there was a paucity of published information, with the exception of P. p. caurus in Alaska (Weeden 1965, Weeden and Ellison 1968). Regarding the southern 3 subspecies, however, our findings and those of Johnsgard and Wood (1968) indicated that the most severe distributional losses have occurred in the southern portions of past ranges. Distributional losses have been associated primarily with intensive grazing in western ranges and with vegetation type conversions, primarily to cropland, in eastern ranges. These findings generally support Klopatek et al. (1979)--type conversions have been most extensive in the eastern Great Plains of the United States.

Population estimates of the northern 3 subspecies of sharp-tailed grouse generally were unavailable. Estimates for the southern subspecies were broad-ranged (due, in part, to the questionnaire's structure), but may have provided a framework within which to view more local conditions. We did not ask the basis of population estimates, but several respondents volunteered that estimates were based on spring counts of leks (dancing grounds) and numbers of leks. Such counts are poor measures of population levels due to many variables such as time of year, time of day, weather, and non-territorial males (Rogers 1969, Rippin and Boag 1974, Sisson 1976, R. J. Robel, pers. comm.). In fact, Sisson (1976) has argued that such counts, as generally practiced, are inadequate for setting hunting seasons and bag limits, and an alternative census method needs to be developed.

Based upon population estimates (60,000-170,000), distributional losses (over 90% in 7 of 10 political subdivisions), and predicted trends (5 of 7 respondents predicted further losses) the future of Columbian sharptails appears insecure. Starkey and Schnoes (1976) estimated 15,000-20,000 Columbian sharptails in the United States, roughly the lower limit of estimates we received from U.S. respondents, and argued for consideration of "threatened" status for this subspecies.

Some research on Columbian sharptails has begun, but there has been little management of the subspecies beyond inventory and the regulation of hunting. The best hope for Columbian sharptails probably lies in gaining consideration in multiple-use management of public lands, especially in regard to livestock grazing.

Prairie sharptails are more numerous than Columbian sharptails, but also have undergone severe distributional reductions (over 90% in 4 of 8 states and provinces). Unfortunately, continued range reductions are predicted in the center of prairie sharptail range. Habitat restoration and maintenance techniques are well-known for this subspecies, however (Hamerstrom et al. 1952, Hamerstrom 1963, Ammann 1963, Evrard 1977, Vanderschaegen 1977).

Plains sharptails appear most secure of the southern 3 subspecies. Unlike Columbian and prairie sharptails, plains sharptails occur as large, contiguous populations through most of their range, and distributional stability is predicted in the center of the range. The prediction of population declines, however, is a cause for concern.

The plains sharptail is the most extensively researched subspecies of sharp-tailed grouse. Since Evans' (1968) literature review, publications on plains sharptails have been produced by Rogers (1969) in Colorado, Bernhoft (1969) and Christenson (1970) in North Dakota, Pepper (1972) in Saskatchewan, Hillman and Jackson (1973) in South Dakota, and Sisson (1976) in Nebraska. Population dynamics have been investigated by Rippin and Boag (1974), Caldwell (1976), and Sisson (1976). The energetics of plains sharptails, and the resulting management implications, have been addressed by Evans and Dietz (1974) and Caldwell (1976). Habitats have been described and often quantified (Brown 1968, Christenson 1970, Pepper 1972, Twedt 1974, Kohn

1976). Exploration of ways in which land use practices can be made more compatible with sharp-tail management has begun (Miller 1972, Kirsch et al. 1973, Kohn 1976, Yde 1977, Mattise 1978). Through much of their range, plains sharp-tailed grouse are of prime importance in wildlife management considerations.

It is difficult to generalize about the 6 subspecies of sharp-tailed grouse. They differ widely in their habitats, the degree to which their distributions and populations are known, and in the types and intensities of research and management activities directed at them. Perhaps the greatest need is to elevate our knowledge of the northern 3 subspecies and Columbian sharp-tails to the level presently existing for prairie and plains sharp-tailed grouse.

LITERATURE CITED

Aldrich, J. W. 1963. Geographic orientation of North American tetraonidae. J. Wildl. Manage. 27:529-545.

_____, and A. J. Duvall. 1955. Distribution of American gallinaceous game birds. U.S. Fish Wildl. Serv. Circ. 34. 30pp.

American Ornithologists' Union. 1910. Check-list of North American birds. 3rd ed. (Revised). American Ornithologists' Union, New York. 430pp.

_____. 1947. Twenty-second supplement to the American Ornithologists' Union check-list of North American birds. Auk 64:445-452.

_____. 1957. Checklist of North American birds. 5th ed. The Lord Baltimore Press, Inc., Baltimore, Maryland. 691pp.

Ammann, G. A. 1957. The prairie grouse of Michigan. Michigan Dept. Conserv. Tech. Bull. 200pp.

_____. 1963. Status and management of sharp-tailed grouse in Michigan. J. Wildl. Manage. 27:802-809.

Bailey, F. M. 1928. Birds of New Mexico. New Mexico Dept. Game, Fish, Albuquerque. 807pp.

Bernhoft, L. S. 1969. Reproductive ecology of female sharp-tailed grouse (Pedioecetes phasianellus jamesi Lincoln) and food habits of broods in southwestern North Dakota. M.S. Thesis, Univ. of North Dakota, Grand Forks. 96pp.

Brown, R. L. 1964. Sharp-tailed grouse population study. Small Game Research Project Job Completion Rep., Proj. W-91-R-5, Montana Fish Game Dept., Helena. 8pp.

_____. 1968. Effects of land-use practices on sharptail grouse. P-R Job Completion Rep., Proj. W-91-R-9, Montana Fish Game Dept., Helena. 11pp.

_____. 1971. Sharp-tailed grouse. Pages 129-133 in T. W. Mussehl and F. W. Howell, eds. Game management in Montana. Montana Fish Game Dept., Helena.

Buss, I. O., and E. S. Dziedzic. 1955. Relation of cultivation to the disappearance of the Columbian sharp-tailed grouse from south-eastern Washington. Condor 57:185-187.

Caldwell, P. J. 1976. Energetic and population considerations of sharp-tailed grouse in the aspen parklands of Canada. Ph.D. Thesis, Kansas State Univ., Manhattan. 109pp.

Christenson, C. D. 1970. Nesting and brooding characteristics of sharp-tailed grouse (Pedioecetes phasianellus jamesi Lincoln) in southwestern North Dakota. M.S. Thesis, Univ. of North Dakota, Grand Forks. 88pp.

Edminster, F. C. 1954. American game birds of field and forest: their habits, ecology, and management. Charles Scribner's Sons, New York. 490pp.

Evans, K. E. 1968. Characteristics and habitat requirements of the greater prairie chicken and sharp-tailed grouse - a review of the literature. U.S. Dept. Agric. For. Serv. Conserv. Rep. 12. 32pp.

_____, and D. R. Dietz. 1974. Nutritional energetics of sharp-tailed grouse during winter. J. Wildl. Manage. 38:622-629.

Evrard, J. O. 1977. Habitat management on a Wisconsin prairie grouse area. Proc. Prairie Grouse Tech. Council 12:13.

Grange, W. B. 1948. Wisconsin grouse problems. Wisconsin Conserv. Dept., Madison. 318pp.

Grant, M. L. 1963. A checklist of Iowa birds, coded with status symbols. Iowa Bird Life 33:50-62.

Hamerstrom, F. N., Jr. 1963. Sharptail brood habitat in Wisconsin's northern pine barrens. J. Wildl. Manage. 27:793-802.

Hamerstrom, F., and F. Hamerstrom. 1961. Status and problems of North American grouse. Wilson Bull. 73:284-294.

_____, _____, and O. E. Mattson. 1952. Sharp-tails into the shadows? Wisconsin Wildl. 1. Wisconsin Conserv. Dep., Madison. 35pp.

Hillman, C. N., and W. W. Jackson. 1973. The sharp-tailed grouse in South Dakota. South Dakota Dept. Game Fish Parks Tech. Bull. 3. 63pp.

Johnsgard, P. A. 1973. Grouse and quails of North America. Univ. of Nebraska Press, Lincoln. 553pp.

_____, and R. E. Wood. 1968. Distributional changes and interaction between prairie chickens and sharp-tailed grouse in the mid-west. Wilson Bull. 80:173-188.

Kirsch, L. M., A. T. Klett, and H. W. Miller. 1973. Land use and prairie grouse population relationship in North Dakota. J. Wildl. Manage. 37:449-453.

Klopatek, J. M., R. J. Olson, C. J. Emerson, and J. L. Joness. 1979. Land-use conflicts with natural vegetation in the United States. Environ. Conserv. 6(3):191-199.

Kohn, S. C. 1976. Sharp-tailed grouse nesting and brooding habitat in southwestern North Dakota. M.S. Thesis, South Dakota State Univ., Brookings. 123pp.

Küchler, A. W. 1964. Potential natural vegetation of the conterminous United States. Am. Geogr. Soc. Spec. Publ. 36. 39pp.

Ligon, J. S. 1961. New Mexico birds and where to find them. Univ. of New Mexico Press, Albuquerque. 360pp.

Lincoln, F. C. 1917. A review of the genus Pedioecetes in Colorado. Proc. Biol. Soc. Washington 30:83-86.

Marshall, D. B. 1969. Endangered plants and animals of Oregon. III. Birds. Oregon State Univ. Agric. Exp. Sta. Spec. Rep. 278. 23pp.

Mattise, S. N. 1978. Effects of grazing systems on sharp-tailed grouse habitat. M. S. Thesis, South Dakota State Univ., Brookings. 46pp.

McClanahan, R. C. 1940. Original and present breeding ranges of certain game birds in the United States. Wildl. Leafl. BS-158. USDI Bur. Biol. Surv. 21pp.

Miller, G. C. 1979. Development of a preservation program for three species of prairie grouse. Job Prog. Rep., Proj. SE-3-3, Colorado Div. Wildl.,Denver. 19pp.

Miller, H. W. 1972. Review of changing wildlife habitat and requirements for maintaining key species. North Dakota Outdoors 35(5): 2-9.

Nice, M. M., and L. B. Nice. 1924. The birds of Oklahoma. Univ. of Oklahoma Bull. 20, Univ. Studies 286. 122pp.

Olsen, B. 1976. Status report: Columbian sharptailed grouse. Oregon Wildl. 31(4):10.

Pepper, G. W. 1972. The ecology of sharp-tailed grouse during spring and summer in the aspen parklands of Saskatchewan. Saskatchewan Dept. Nat. Resour. Wildl. Rep. 1. 56pp.

Ridgway, R., and H. Friedmann. 1946. The birds of North and Middle America. U.S. National Mus. Bull. 50, Pt. 10. 484pp.

Rippin, A. B., and D. A. Boag. 1974. Recruitment to populations of male sharp-tailed grouse. J. Wildl. Manage. 38:616-621.

Rogers, G. E. 1969. The sharp-tailed grouse in Colorado. Colorado Game Fish Parks Div. Tech. Publ. 23. 94pp.

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

Starkey, E. E., and R. A. Schnoes. 1976. The Columbian sharp-tailed grouse: with special reference to their potential reintroduction to Lava Beds National Monument. Pages 497-500 in R. M. Linn, ed. Proc. First Conf. on Scientific Research in the National Parks. National Park Serv. Trans. Proc. Ser. 5.

Sutton, G. M. 1967. Oklahoma birds: their ecology and distribution with comments on the avifauna of the southern Great Plains. Univ. of Oklahoma Press, Norman. 674pp.

_____. 1974. A check-list of Oklahoma birds. Stovall Mus. Sci. and Hist., Univ. of Oklahoma. 48pp.

Twedt, C. M. 1974. Characteristics of sharp-tailed grouse display grounds in the Nebraska Sandhills, Ph.D. Dissertation, Univ. of Nebraska, Lincoln. 78pp.

U.S. Dept. Interior. 1973. Threatened wildlife of the United States. U.S.D.I. Bur. Sport Fish Wildl. Resour. Publ. 114. 289pp.

Vanderschaegen, P. V. 1977. Status of sharp-tailed grouse in Wisconsin, 1975. Wisconsin Dept. Nat. Resour. Res. Rep. 95. 10pp.

Weeden, R. B. 1965. Grouse and ptarmigan in Alaska. Federal Aid in Wildl. Restoration Rep., Proj. W-6-R-5, Alaska Dept. Fish Game, Juneau. 110pp.

Weeden, R. B., and L. N. Ellison. 1968. Upland game birds of forest and tundra. Wildl. Bklt. Ser. 3, Alaska Dept. Fish Game, Juneau. 45pp.

Wick, W. Q. 1955. A recent record of the sharp-tailed grouse in Nevada. Condor 57:243.

Yde, C. A. 1977. Distribution and movements of sharp-tailed grouse during spring and summer in relation to rest - rotation grazing. P-R Job Final Rep., Proj. W-120-R, Montana Fish Game Dep. Helena. 70pp.

Zeigler, D. L. 1979. Distribution and status of the Columbian sharp-tailed grouse in eastern Washington. Upland Game Investigations Completion Rep. Proj. W-70-R-18, Washington Dept. Game. 26pp.

STATUS OF THE ATTWATER'S PRAIRIE CHICKEN–AN UPDATE[1]

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Abstract: The number of Attwater's prairie chickens *(Tympanuchus cupido attwateri)*, an endangered subspecies, decreased from an estimated 8,700 birds in spring 1937 to 1,584 birds in spring 1980. An apparently stable population of 1,500 to 2,250 birds had existed since the last major status report in 1968. During spring 1980, isolated groups of chickens inhabited an estimated 120,410 ha in 10 counties; over 78% of the total population occurred in Austin, Colorado, and Refugio counties. Habitat loss was the greatest threat to these populations. The Attwater Prairie Chicken National Wildlife Refuge and the Tatton Unit of Aransas National Wildlife Refuge were the only areas where the Attwater's was managed. Increased chicken numbers without acquisition of additional public lands must come through management of private lands. Control of brush and establishment of food plots on lands in Victoria and Goliad counties presented the greatest potential for increasing Attwater's numbers. A relatively stable chicken population was anticipated for the next 10 years, but a gradual, long-term decline in numbers was predicted as suitable habitat is lost.

The Attwater's prairie chicken presently occupies areas of the Gulf Coastal Prairie in Texas. Its original range extended from the Nueces River in Texas to Abbeyville, Louisiana (Lehmann 1971), but population numbers and distribution have declined since the early 1900's. The population was estimated to approach 1 million individuals on 2.4 million ha during peak years (Lehmann 1941). The population had declined to 8,700 individuals on 182,250 ha when the first life history work (Lehmann 1941) on the subspecies was published. A decline in population numbers was recorded with censuses in 1950 (Jennings 1950), 1963 (Lehmann and Mauermann 1963), and 1967 (Lehmann 1968), yielding population estimates of 4,200; 1,335; and 1,070, respectively (Fig. 1). In 1967, the subspecies occupied approximately 94,770 ha, a reduction of 50% since 1937 (Lehmann 1968). The distribution in 1967 was limited to 12 counties: Austin, Calhoun, Chambers, Colorado, Fort Bend, Galveston, Goliad, Harris, Jefferson, Refugio, Victoria, and Wharton. The most important factor in the population decline of Attwater's prairie chicken was change in land use. Conversion of coastal prairie to crop production and urban-industrial development plus the invasion of woody plant species into large tracts of coastal prairie reduced suitable habitat (Lehmann 1968).

Management programs for Attwater's prairie chickens began in the mid-1960's with the purchase of chicken range in Colorado County by the World Wildlife Fund, and the donation of chicken habitat adjoining Aransas National Wildlife Refuge to the U.S. Fish and Wildlife Service. The bird was placed on the Federal Endangered Species List in 1967.

This paper updates the status of the Attwater's prairie chicken since 1967 and presents current population and habitat trends, and research and management activites.

[1]Texas Agricultural Experiment Station, Technical Article 16055.

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CURRENT STATUS

The 1980 population estimate for the Attwater's prairie chicken of 1,584 individuals was higher than the 1967 estimate (Table 1). The lower value for 1967 might have been due to imprecision in census techniques and/or the effects of Hurricane Beulah. Estimates of population numbers during the 1970-80 period ranged from 1,500-2,250 during yearly (excluding 1978) population censuses (Fig. 1).

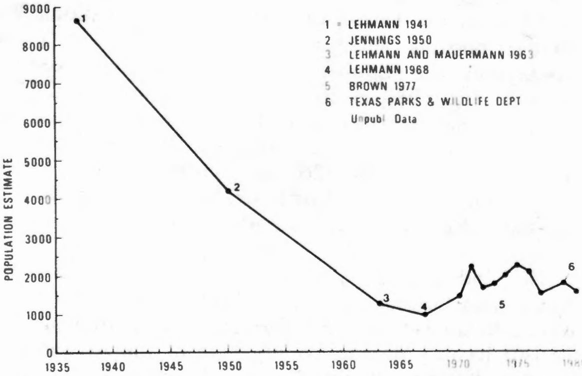

Fig. 1. Population estimates for the Attwater's prairie chicken, 1937-80.

Table 1. Population estimates, percent of total, and percentage change, by county (1967 and 1980) and estimated potential range by county (1980) of the Attwater's prairie chicken in Texas.

County	1967 Population estimate[a]	1967 Percent of total	1980 Population estimate[b]	1980 Percent of total	Percentage change (1967-80)	1980 Estimated Potential Range (ha)
Aransas	0	0.0	76	4.8	–	3,390
Austin	200	18.7	326	20.6	+63.0	15,590
Brazoria	0	0.0	20	1.3	–	1,010
Calhoun	10	0.9	0	0.0	-100.0	0
Chambers	10	0.9	0	0.0	-100.0	0
Colorado	175	16.4	186	11.8	+6.3	15,140
Fort Bend	35	3.3	54	3.4	+54.3	400
Galveston	130	12.2	96	6.1	-26.2	2,710
Goliad	75	7.0	34	2.1	-54.7	23,780
Harris	120	11.2	2	0.1	-98.3	200
Jefferson	10	0.9	0	0.0	-100.0	0
Refugio	175[c]	16.4	726	45.8	+314.8	49,540
Wharton	40	3.7	0	0.0	-100.0	0
Victoria	90	8.4	64	4.0	-28.9	8,650
TOTAL	1,070	100.0	1,584	100.0	+48.0	120,410

[a]landowner interviews and aerial census
[b]aerial census and ground counts
[c]low population following Hurricane Beulah

Lehmann (1968) estimated that the Attwater's prairie chicken occupied 94,770 ha in 1967. Because of the difficulty in determining distance traveled from leks, we have included all open grassland habitat surrounding known leks in our 1980 estimate of 120,410 ha. We have included these areas because we feel that a more accurate estimate of potential chicken range results (Fig. 2).

Fifty-three percent of Attwater's prairie chickens occurred on a continuous area in Aransas, Goliad, and Refugio counties. This population had been the largest each year except in 1967 following Hurricane Beulah. Lehmann (1968) estimated pre- and post-hurricane levels at 1,200-1,500 and 250 individuals, respectively. Chickens were reported in Aransas County in 1970, 1971, and 1976-80. The 1980 population estimate was 76 birds on 3,390 ha (Table 1). Habitat management initiated in 1974 on the Tatton Unit of the Aransas National Wildlife Refuge possibly aided in the establishment of a resident population. The population in Goliad County peaked in 1974 at 486. The 1980 estimate was 34 chickens on 23,780 ha. Land-use had remained consistent during this period and the reason for this decline is unknown. The 1980 estimate for Refugio County was 726, an increase of 315% since the decimating effects of Hurricane Beulah. Estimated chicken habitat in Refugio County was 49,540 ha.

The 2nd largest population (32% of total) occurred in Austin and Colorado counties (Table 1). The 1980 estimates were 326 chickens on 15,590 ha in Austin County and 186 on 15,140 ha in Colorado County (site of the Attwater Prairie Chicken National Wildlife Refuge). Peak population for these 2 counties was 990 in 1975. Development of a crop-rotation system between rice and soybeans in the mid-1970's possi-

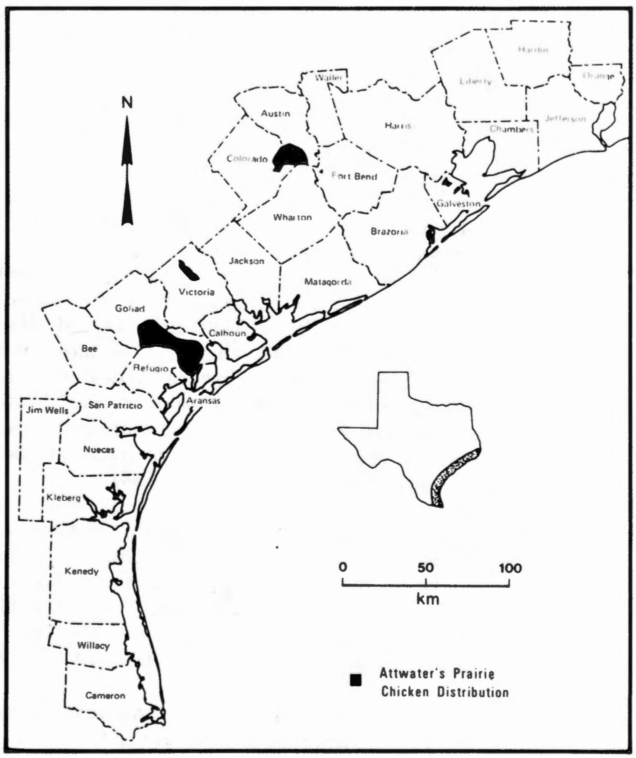

Fig. 2. 1980 distribution of the Attwater's prairie chicken.

bly contributed to this decrease. Formerly, chickens utilized fallow rice fields for nesting and brood cover. Although soybeans provide a potential fall-winter food source, the absence of grass cover in these fields may have affected population numbers.

The 1980 estimate for Galveston County was 96 birds (6% of total) on 2,710 ha (Table 1). Most of this population occurred on a 700-ha ranch near Texas City. One male was reported in adjoining Harris County, but urban-industrial development associated with the growth of Houston has eliminated most chicken habitat.

Victoria County contained an estimated 64 (4% of total) Attwater's prairie chickens, a decline of 29% since 1967 (Table 1). Potential range in this county was 8,650 ha. Numbers are decreasing, presumably due to the invasion of prairie by running live oak *(Quercus virginiana)* and increased rice cultivation. Chickens were last observed in adjoining DeWitt County during the 1977 census.

Two other counties contained 5% of the total population. Fort Bend County had 54 birds on 400 ha (Table 1). Grassland areas have recently been planted into cotton or soybeans eliminating most of the remaining habitat. Twenty birds were recorded on 1,010 ha in Brazoria County during 1980, whereas no birds were observed during the 1967 census.

No sightings had been recorded in Calhoun and Jefferson counties since 1967 (Table 1). The last sighting in Chambers County was in 1976. Chickens were reported in Waller County in 1970-77, but none were reported in 1967 or 1980. Chickens were last reported in Wharton County in 1977. Disappearance of the chicken in Waller and Wharton counties was probably related to the planting of soybeans in fallow rice fields.

MANAGEMENT

Several efforts to manage Attwater's prairie chicken populations and habitat have been undertaken since the last status paper. Two refuges currently have management programs for the chicken. The Attwater Prairie Chicken National Wildlife Refuge was purchased by the U.S. Fish and Wildlife Service from the World Wildlife Fund in 1977. Recent land acquisition has increased the Refuge to 3,240 ha with an estimated population of 124 chickens. Management programs include burning, mowing, herbicide treatments, controlled grazing, cultivation of food plots, and construction of drainage ditches. The 2,833 ha Tatton Unit of the Aransas National Wildlife Refuge was donated to the U.S. Fish and Wildlife Service by Mr. and Mrs. J. M. Tatton in 1967 (Lehmann 1968). This area contains approximately 76 chickens on 810 ha of coastal prairie habitat. Current management programs include controlled grazing and burning. Kessler (1979) summarized the value of the agricultural and range management practices utilized at the 2 refuges. In addition, at the Attwater Prairie Chicken National Wildlife Refuge, ditching helped to reduce flooding which could be a serious problem during nesting and brood-rearing seasons (Lehmann and Mauermann 1963) and herbicide treatments were used to control invading brush species.

Attwater's prairie chickens were transplanted from 2 areas where their range was appropriated for urban development. Seventy chickens were transplanted from Ellington Air Force Base (Harris County) in 1967, and an additional 44 were moved in 1970 (McCune 1970). Sixty-one of these birds were released in Refugio and Goliad counties, and 53 were taken into captivity at Texas A&M University (Lehmann 1971). Fate of the released birds is unknown and propagation efforts proved unsuccessful due to poultry diseases and lack of proper facilities. In 1979, 34 birds were transplanted from Gulf Airport in Galveston County to the 2,430 ha Gonzales Ranch in Victoria County. Success of this transplant is currently being evaluated using radio-telemetry.

The Attwater's Prairie Chicken Recovery Team was formed in 1975 to prepare a recovery plan and provide technical advice to the U.S. Fish and Wildlife Service. The recovery plan will identify needed research, identify essential habitat, and stimulate agencies and organizations to program funds for recovery actions.

RESEARCH

Several research projects aimed at determining habitat requirements and management techniques for the Attwater's prairie chicken have been undertaken since 1968. The Texas Parks and Wildlife Department instituted a series of studies from 1968-77 examining ranges, activities, vegetative requirements, and population numbers (Brown 1968, Brownlee 1971-74, 1973-74, 1974, 1977). Current activities consist of censuses at 3-year intervals and the publication of a bulletin on the bird.

The Patuxent Wildlife Research Center Field Station (U.S. Fish and Wildlife Service) located in Victoria, Texas, surveyed pesticide use near the Attwater Prairie Chicken National Wildlife Refuge and examined a few specimens from this area (U.S. Fish and Wildlife Service 1979). The pesticides used had little or no toxicity for birds, and the specimens had only low levels (usually less than 1 ppm) of DDE.

Effects of agricultural and range management practices on prairie chicken habitat have been examined by the Range Science Department at Texas A&M University. Chamrad (1971) and Chamrad and Dodd (1972) studied the effects of prescribed burns and grazing management on prairie chicken habitat. They noted that controlled grazing was beneficial to prairie chicken habitat, but prescribed burns could be favorable where grazing was restricted or absent. Kessler (1978) and Kessler and Dodd (1978) examined the response of coastal prairie vegetation to fall and winter prescribed burns and mowing treatments. They noted that ungrazed pastures were characterized by deteriorating range condition and were not used by the chickens. Fall burns or mowing stimulated forb growth providing a winter food source and open areas for possible lek sites. They recommended a management program of grazing, burning, and mowing to provide cover diversity for the chickens.

Dodd et al. (1975) determined the proper application rate of the herbicide 2,4–D to increase grass herbage production and Attwater's prairie chicken use of fallow rice fields. Attwater's use appeared to be a function of the herbicide's ability to accelerate plant succession, thereby providing more cover.

The Department of Wildlife and Fisheries Sciences at Texas A&M University initiated a series of research projects in 1975 on the ecology of the Attwater's prairie chicken in Refugio County. Cogar et al. (1977) and Horkel (1979) examined the vegetative preferences and cover requirements. They recognized 8 cover types on this study area and determined through radio-telemetry that 90% of all chicken locations were in a single cover type. Lutz (1979) found that petroleum development had no major detrimental effects on the birds. Horkel et al. (1979), studying both Attwater's and dummy nests, determined that the density of nests, distance from development, and date of initiation influenced nest success. Current studies are addressing food habits, the effects of predator control on nest success, and effectiveness of the 1979 transplant.

Several research projects appear needed. The biological effects and economics of application of various herbicides for controlling brush invasion should be examined. There is a need to determine if properly spaced food plots within the prairie would increase or maintain chicken populations where seasonal food availability is suspected to be the limiting factor. The function of agricultural lands adjoining the Attwater Prairie Chicken National Wildlife Refuge as brood-rearing cover and as a food source should be examined. Other research should examine the effects of genetic isolation and mortality factors of the Attwater's.

FUTURE OUTLOOK

The long-term outlook for the Attwater's prairie chicken is dim, for the habitat is decreasing. If the Attwater's is going to survive, large blocks of native prairie must be preserved. Chicken populations in Galveston, Harris (they are probably already gone), and Brazoria counties will disappear due to urbanization and industrial expansion associated with the growth of Houston. Chickens will probably disappear in Fort Bend County due to the recent conversion of the remaining grassland areas into cropland. In the near future there will be only 3 areas that will provide habitat for this subspecies (Austin and Colorado counties; Aransas, Goliad, and Refugio counties; and Victoria County). In many counties petroleum production has provided the funds to allow large cattle operations to successfully compete with row crops. However, we doubt that the large cattle operations which now support many of the Attwater's will be economical when the oil reserves are exhausted.

Increasing the population of Attwater's prairie chickens without the acquisition of additional public lands would have to come through management on private lands. Victoria and Goliad counties offer the greatest opportunity for increasing Attwater's through such management. Control of running live oak and mesquite *(Prosopis* spp.) would open large tracts of prairie. Food plots might be established in these counties to compensate reduced forb production on sandy soils during dry years. Economic or other incentives to landowners are needed to help control brush and provide food sources. If new habitat can be developed for the Attwater's, then transplants of prairie chickens to these areas should be considered.

Flooding due to adverse weather conditions remains a constant threat to Attwater's prairie chicken populations. This was exemplified by the effects of Hurricane Beulah. The Attwater's Prairie Chicken Recovery Team is recommending the establishment of another refuge in Victoria County to provide managed populations of Attwater's at geographically separated locations. The additional refuge could act as a buffer when populations in 1 area are reduced to adverse weather conditions.

Considering the recent trends in Attwater's prairie chicken numbers, we predict that Attwater's populations will remain relatively stable for the next 10 years, given no unpredictable catastrophes. However, a long-term downward trend is expected unless land management and/or land purchases are implemented.

LITERATURE CITED

Brown, D. L. 1968. Prairie chicken range appraisal. Texas Parks and Wildlife Dept., Job Prog. Rept., W-92-R-4. 12pp.

Brownlee, W. C. 1971-74. Seasonal territorial ranges of Attwater's prairie chicken. Texas Parks and Wildl. Dept., Job Prog. Repts., W-100-R-2, 3, 4, and 5. 13pp.

—. 1973-74. Activities of the prairie chicken within its seasonal range. Texas Parks and Wildl. Dept., Job Prog. Rept., W-100-R-4 and 5. 6pp.

—. 1974. Vegetative requirements of the Attwater's prairie chicken. Texas Parks and Wildl. Dept., Job Prog. Rept., W-100-R-5. 2pp.

—. 1977. Attwater's prairie chicken population census. Texas Parks and Wildl. Dept., Job Prog. Rept., W-100-R-8. 6pp.

Chamrad, A. D. 1971. Effects of fire and grazing on coastal prairie rangeland and Attwater's prairie chicken habitat. Ph.D. Thesis, Texas A&M Univ., College Station. 120pp.

—, and J. D. Dodd. 1972. Prescribed burning and grazing for prairie chicken habitat manipulation in the Texas coastal prairie. Proc. Tall Timbers Fire Ecol. Conf. 12:257-276.

Cogar, V. F., J. D. Horkel, and N. J. Silvy. 1977. Vegetation type preference of Attwater's prairie chicken in coastal prairie. Proc. Southeastern Assoc. Fish and Wildl. Agencies. 31:41-50.

Dodd, J. D., R. Jurries, and A. T. Weichert. 1975. Stimulating native forage production for livestock and wildlife on fallow riceland. Progress Rept., Texas Agri. Exp. Stat. 8 pp.

Horkel, J. D. 1979. Cover and space requirements for Attwater's prairie chicken *(Tympanuchus cupido attwateri)* in Refugio County, Texas. Ph.D. Thesis, Texas A&M Univ., College Station. 96pp.

—, R. S. Lutz, and N. J. Silvy. 1978. The influence of environmental parameters on nesting success of upland game birds. Proc. Southeastern Assoc. Fish and Wildl. Agencies. 32:234-241.

Jennings, W. S. 1950. Abundance, distribution, and present status of Attwater's prairie chicken, Final Rept. to the Texas Coop. Wildl. Unit, Texas A&M Univ., College Station. 37pp. (mimeogr.)

Kessler, W. B. 1978. Attwater's prairie chicken ecology in relation to agricultural and range management practices. Ph.D. Thesis, Texas A&M Univ., College Station. 158pp.

—. 1979. The Attwater's greater prairie chicken: endangered grouse of the Texas coastal prairie. Proc. Welder Wildlife Found. Symp. 1:189-198.

—, and J. D. Dodd. 1978. Responses of coastal prairie vegetation and Attwater prairie chicken to range management practices. Proc. International Rangeland Congress. 1:473-476.

Lehmann, V. M. 1941. Attwater's prairie chicken, its life history and management. U.S. Dept. Interior, Fish and Wildl. Serv., Washington, D.C. N. Am. Fauna 57. 63pp.

—. 1968. The Attwater's prairie chicken, current status and restoration opportunities. Trans. N. Am. Conf. 33:398-407.

—. 1971. Attwater's prairie chicken. Nat. Parks and Conserv. Mag. 45:1-4.

—, and R. G. Mauermann. 1963. Status of the Attwater's prairie chicken. J. Wildl. Manage. 27:713-725.

Lutz, R. S. 1979. The response of Attwater's prairie chicken to petroleum development. M.S. Thesis, Texas A&M Univ., College Station. 82pp.

McCune, R. A. 1970. Prairie chicken moving days. Texas Parks and Wildl. 18(7):12-15.

U.S. Fish and Wildlife Service. 1979. Attwater's prairie chickens have low pesticide residues. Pages 34-35 *in* T. G. Scott et al., eds. Fisheries and Wildlife Research, 1978.

CURRENT AND FUTURE RESEARCH NEEDS FOR PRAIRIE GROUSE

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Abstract: Research on prairie grouse during the last 20-30 years has concentrated on (1) descriptive studies of lekking behavior, (2) surveys of spring populations, and (3) evaluating quantitative aspects of habitat. Little biologically-oriented research has been conducted on prairie grouse. To enable scientific management of prairie grouse populations, long term biologically-oriented research must be initiated on viable populations in good habitats in central portions of their ranges. These studies need to focus on population dynamics, nutrient requirements, behavioral aspects of population regulation, and disease, parasitism, and predation.

Research needs for the prairie grouse are difficult to discuss without 1st reviewing the status of past and current research. To review all research on prairie grouse would involve a massive review of literature, and a concomitant reduction in time for me to focus on future research needs. In this paper I review pertinent past and present research on prairie grouse primarily to highlight areas that should receive more attention if we are to manage this native wildlife resource scientifically. Because of the thrust of the program theme and the expertise represented among the invited speakers, I shall focus my attention on research needs for 3 prairie grouse species: the greater prairie chicken (*Tympanuchus cupido pinnatus*), the lesser prairie chicken (*T. pallidicinctus*), and the sharp-tailed grouse (*Pedioecetes phasianellus*). Many of my comments will apply equally to sagegrouse (*Centrocercus urophasianus*) and Attwater's prairie chicken (*T. c. attwateri*).

Much of our knowledge of prairie grouse originated 20 to 30 years ago from natural history studies or from later publications based on data collected many years earlier. Today's biologists working on greater prairie chickens are at a distinct disadvantage without having reviewed in detail such classics as Ammann (1957), Baker (1953), Grange (1948), Hamerstrom (1939), Hamerstrom and Hamerstrom (1949, 1955 1973), Hamerstrom et al. (1957), Jacobs (1959), Schwartz (1945), and Yeatter (1943). Likewise a biologist working on lesser prairie chickens will be disadvantaged if unfamiliar with such noteworthy reports as Copelin (1963) and Jones (1963), while those working on sharp-tailed grouse should be conversant with the works of Aldous (1943), Ammann (1957), Folker (1964), Hart et al. (1950), Hamerstrom (1939), Hamerstrom and Hamerstrom (1951), Hillman and Jackson (1973), Peterle (1954), and Rogers (1969), to mention only a few. Pertinent sections of the grouse management issue of the Journal of Wildlife Management (Scott 1963) contain useful information for scientists working with prairie grouse.

Some biologists fail to familiarize themselves with the literature and thus reinvent the wheel over and over again. Much useful prairie grouse information has already been collected and published. Today's researchers should build on the current data base, not create a duplicate one.

POPULATION STATUS

Biologists, especially those with management orientations, have spent most of their time determining the status of grouse populations. That effort is especially evident within states containing remnant prairie grouse populations; consider, for example, reports by Partch (1970), Evans (1963), Christisen (1969, 1979), Stempel and Rodgers (1961), Will (1979), and those of many other biologists. Though basic surveys to determine the population status of prairie grouse are rarely considered as research, the data are needed to develop management strategy, to formulate hypotheses for research emphasis, and to set annual harvest seasons. Most states with prairie grouse populations use spring surveys of leks (booming grounds and dancing grounds) as indicators of populations. Both lek activity and numbers of birds on a lek are used as indices to prairie grouse populations (Horak 1977, 1978). Neither the precision nor the accuracy of these techniques has been carefully analyzed. At times, the spring lek survey data are supplemented with bits of data from counts by rural mail carriers or summer brood counts. I doubt that the techniques currently used to census prairie grouse are sufficiently sensitive to detect a 20% change in a prairie grouse population from 1 spring or fall to another. The need for a scientifically valid census technique for prairie grouse is obvious.

HABITAT-POPULATION RELATIONSHIPS

It is difficult to separate studies of habitat change and population trends because they are normally conducted concurrently. Normally a declining trend in prairie grouse populations stimulates the effort to evaluate the habitat (Podoll 1961, Kirsch 1974). Recently, researchers in New Mexico (Davis et al. 1979, Smith 1979) have attempted to develop methods to evaluate lesser prairie chicken habitat, and thereby to develop a set of management recommendations that should result in a secure population of lesser prairie chickens in eastern New Mexico. In an attempt to preserve greater prairie chicken habitat in Colorado, Graul (1977) surveyed and recommended that certain state school lands be managed for greater prairie chicken habitat. In Oklahoma, there has been a long-time interest in evaluating habitat for greater and lesser prairie chickens, and is reflected in the early efforts of Jacobs (1959), Jones (1963), and Copelin (1963). Oklahoma's current effort focuses on studies correlating various land-use practices and vegetative characteristics with the prairie chicken's population density (Cannon 1978, 1979). Taylor (1978) developed habitat management recommendations from a 1-year telemetry-assisted study in Texas, much like an earlier 5-year telemetry-assisted study in Kansas (Robel et al. 1970). Generally, short-term habitat studies are conducted in conjunction with short-term population surveys; the results are then interpreted as cause and effect, i.e., habitat changes cause changes in population numbers of prairie grouse. Correlation studies using short-term data sets may provide misleading conclusions.

Studies of habitat requirements of greater prairie chickens in Illinois (Westemeier 1979) are more appropriately designed to answer habitat questions than some of the previously mentioned studies. Although the early studies of biologists in Illinois focused on land-use changes and population declines (Yeatter 1963, Sanderson et al. 1973, Vance 1976), more recent efforts have involved experimental manipulation of habitats as well (Westemeier 1972, 1977, 1978, 1979). During recent years, Missouri has initiated some experimental habitat management efforts as well (Christisen 1975, 1976, 1977). The experimental habitat manipulations in Missouri and Illinois most likely will provide useful management information for those specific areas, but additional studies in other geographical areas are needed before results can be considered applicable over the entire range of the greater prairie chicken.

Studies of habitat preferences of sharp-tailed grouse have been conducted for several years in North Dakota (Bernhoft 1967, 1968, 1969, Christenson 1971), primarily to determine preferred nesting and brood cover. More recent studies in North Dakota have correlated various pasture management systems with sharp-tailed grouse nesting and brooding habitat (Kohn 1976, Mattise 1978). Studies in Montana (Brown 1968) were unsuccessful in correlating annual changes in vegetative cover with changes in sharp-tailed grouse population density, however Yde (1977) did report increased usage of pastures with patches of denser vegetative cover. In Minnesota, Artmann (1970) discovered seasonally-related correlations in usage of habitat types of sharp-tailed grouse, a relationship also reported by Pepper (1972) in Saskatchewan and by Sisson (1976) in Nebraska.

NON-POPULATION HABITAT STUDIES

I believe there is less than 1 non-population habitat study for every 50 studies of population status or habitat relationships in the prairie grouse. That in itself is not surprising because we tend to focus on the obvious, i.e., the perceived causes or results of a situation. We have been programmed to look at land-use changes and/or habitat losses when populations exhibit declines. In most cases, the focus is correct; however, efforts to modify the environment to counteract a downward trend in a wild population are often hit-and-miss or trial-and-error affairs. Few studies have been initiated to study the <u>biology</u> of prairie grouse and prairie grouse populations, and without such studies, the biological <u>causes</u> of population fluctuations will not be understood. The need for biologically-oriented studies is great.

POPULATION DYNAMICS

Although many short-term studies report bits of population dynamics data, only the major effort in South Dakota resulted in a firm appraisal of the annual mortality of sharp-tailed grouse (Robel et al. 1972). However, that study was not designed to answer specific questions on prairie grouse population dynamics. Where are intensive studies being conducted on prairie grouse to collect data necessary for analyses such as conducted by den Boer (1971), Chitty (1967), Dorney and Kabat (1960), Errington (1945), Jenkins et al. (1963), Krebs et al. (1969), Watson (1965), and Watson and Moss (1972)? Until long-term research is initiated specifically to gain a better understanding of population dynamics of prairie grouse, we will have to be content with comparisons of annual mortality rates, (e.g., Robel et al. 1972, Hamerstrom and Hamerstrom 1973).

NUTRITIONAL REQUIREMENTS

Even though the literature is sprinkled with short-term food habits studies of prairie grouse, those studies provide little in the way of annual nutritional requirements of prairie grouse. With few exceptions, food habits studies on prairie grouse focus on birds collected in fall or consist of sample sizes inadequate for meaningful conclusions. Even where the weaknesses of single-season collections and inadequate sample sizes are overcome, data on food abundance are not available to determine food preferences.

Although some elementary studies have been conducted on energetics of sharp-tailed grouse (Caldwell 1976, Evans 1971, Evans and Dietz 1974, Evans and Moen 1975), those data are not adequate to provide a thorough understanding of energy needs of prairie grouse. Studies such as those by Case and Robel (1974), Case (1973a, b), Davis (1955), Kendeigh (1969), West (1960), and Zimmerman (1965) are needed to gain insight into energy needs of prairie grouse under various environmental conditions. Determination of metabolizable energy in the foods consumed is needed to assess the energy value of various foods to prairie grouse (e.g., Robel et al. 1979a, b, Browning and Robel 1980) to evaluate energetic consequences of habitat manipulations (Robel et al. 1974).

In addition to determining energetic requirements, biologists need to know general nutrient requirements (vitamins, minerals, etc.) of prairie grouse to interpret grouse-habitat interactions. We also need to know if prairie grouse select for nutritive value in foods, as proposed for other grouse by Gardarsson and Moss (1970) and Savory (1978).

HABITAT REQUIREMENTS IN TERMS OF QUALITY

To date, biologists in North America have concentrated on evaluating prairie grouse habitat on quantitative features, such as vegetative type, composition, height, density, and aspect. We have not included measurements of food quality (energetics and nutrient content) because those requirements are not known for prairie grouse. Once we determine the energetic and nutritional requirements of prairie grouse, habitats can be evaluated on a qualitative as well as quantitative basis. I expect this qualitative-quantitative evaluation to provide a much more useful and thorough index to the suitability of the habitat for prairie grouse than does our current quantitative approach.

An understanding of energetic-nutritional requirements of prairie grouse, coupled with the ability to measure these parameters in the habitat, will permit an insight into the probable causes of population responses to habitat changes (Moss et al. 1974, 1975). We will then have the tools to understand the outcome of experimental habitat manipulations similar to those conducted in Europe (e.g., Miller et al. 1970, Watson et al. 1977, Watson and O'Hare 1973, 1979).

BEHAVIORAL IMPLICATIONS

Other than descriptive studies of breeding behavior associated with leks (Scott 1950, Evans 1961, Lumsden 1965, Robel 1964, 1966, 1967), little attention has been given to the impacts of behavior on prairie grouse populations. Robel (1972), Robel and Ballard (1974), and Ballard and Robel (1974) discuss the potential role of lek social organization on breeding success in greater prairie chickens, and Robel (1970) offers some tentative suggestions of how social organization might cause nonbreeding and thus influence population regulation. Bowman and Robel (1977) report data on behaviorally-related mortality during the dispersal of juvenile greater prairie chickens. Comparable studies have not been conducted on lesser prairie chickens or sharp-tailed grouse.

Current evidence indicates that North American prairie grouse are not territorial (except some males during breeding season), and therefore not all of the vast body of data from the red grouse (*Lagopus lagopus scoticus*) and ptarmigan (*L. mutus*) can be applied to our prairie grouse populations. However, some aspects may well be applicable to certain situations in prairie grouse. To believe that our prairie grouse populations are not influenced somewhat (directly or indirectly) by social behavior would reflect biological naivete. No doubt there are differences and fluctuations in aggressive levels within any grouse population as have been documented by Robel (1972), Watson (1970), Moss et al. (1979), and Watson and Moss (1970). If these behavioral traits are genetically controlled as in red grouse (Moss and Watson 1980) and poultry (Craig et al. 1965, Guhl et al. 1960, Komai et al. 1959), strong environmental selection could shift aggressive levels in prairie grouse populations within 3 to 4 generations. Such general shifts in aggressive levels in prairie grouse populations could be reflected in changes in vulnerability to predation and other natural mortality of the sort reported by Fretwell (1968), Watson and Moss (1972), Wellington (1960), and others.

DISEASES, PARASITISM, AND PREDATION

Generally, studies of disease, parasitism, and predation in grouse have been conducted coincidental to other studies, or have included birds collected primarily for other purposes. Berger et al. (1963), Morgan and Hamerstrom (1941), Harper et al. (1967), Boddicker (1969, 1972), and Pence and Sell (1979) indicate that parasitism and predation probably have little effect on adults within prairie grouse populations.

However, few hard data are available to measure the role of diseases, predation, or parasitism on population dynamics of prairie grouse. Experimental studies have shown that juvenile mortality might be severe if grouse chicks are even lightly parasitized. Even if the chicks do not die, they may be so weakened as to be predisposed to predation or other diseases (Duncan et al. 1978).

Myrberget (1970, 1972) has presented some rather convincing information that indicates a potentially significant role of predation in fluctuations of willow grouse (L. lagopus) in Norway. Data from several studies including those of Robel (1970) and Bowen et al. (1976), disclose significant reductions in nesting success of greater prairie chickens due to predators, and Bowman and Robel (1977) verified at least a 24% annual mortality of full grown greater prairie chickens due to predators.

Based on fragmentary studies, here mentioned, one cannot discount the impact of diseases, parasites, or predation on prairie grouse populations. The interactions of disease, predators, and parasites have not been studied in prairie grouse populations, but if the results of McEwen and Brown (1966) and Gesell et al. (1979) are any indication of what can occur under natural conditions, these variables and their interactions could be important in regulating prairie grouse populations.

OBSTACLES TO RESEARCH PROGRESS

Strange as it may seem, prairie grouse populations are negatively correlated with research efforts, i.e., little research is conducted in those portions of the prairie grouse range where populations are high and stable, whereas more intensive habitat-related research efforts are associated with remnant flocks or areas of marginal or isolated habitat. Where huntable populations exist (Kansas and Nebraska, for example) state wildlife agencies appear to be satisfied with cursory surveys of spring populations and gathering fall harvest information; more intensive efforts are indicative of states with remnant populations (Illinois and Missouri, for example). Long term biologically-oriented research on remnant and/or isolated prairie grouse populations may not produce data representative of viable prairie grouse populations in central portions of their ranges. Results of research from remnant and/or isolated populations may reflect abnormally stressful conditions or an ecotypically different population, or they could be simply artifacts of a particular habitat-population situation.

Good prairie grouse populations coupled with stable habitats of high quality cause ambivalence in the research divisions of state game agencies. With plenty of grouse to hunt, why worry about doing much biologically-oriented basic research so long as the grouse population holds up? Such an attitude results in little meaningful research being conducted in central portions of the grouse range, the very place where research should be conducted to understand the basic biology of prairie grouse populations. When remnant populations exist, little basic biologically-oriented research is initiated by state game agencies because of the low probability of the grouse population developing into a huntable resource. These psychological obstacles to research efforts must be overcome if we are to make substantial progress in understanding the biology of prairie grouse populations. Perhaps the Prairie Grouse Technical Council can deliberate on the problem and identify a solution.

SUMMARY AND CONCLUSIONS

Much research remains to be done before we can scientifically manage prairie grouse populations. Quantitative aspects of habitat are important and must continue to receive the attention of biologists working with prairie grouse. Continued efforts must be made to census grouse populations accurately and/or precisely. Of utmost importance, however, is that research horizons must be expanded and efforts must be increased to initiate basic studies of grouse biology and grouse-habitat relationships. These new research efforts should focus on the following areas:

1. year-round nutritional and energetic requirements of juvenile and adult prairie grouse;
2. development of qualitative habitat measurement techniques to dovetail into the preceding area of focus;
3. intensive review of behavioral aspects within prairie grouse populations, primarily those aspects capable of influencing population regulation;
4. individual studies of disease, parasites, and predation and an assessment of their combined impact on prairie grouse populations; and
5. long-term population dynamics of prairie grouse in the central portion of their range where good quality habitat exists, to gain an insight into population fluctuations under natural conditions.

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LITERATURE CITED

Aldous, S. E. 1943. Sharp-tailed grouse in the sand dune country of north-central North Dakota. J. Wildl. Manage. 7:23-31.

Ammann, G. A. 1957. The prairie grouse of Michigan. Michigan Dept. Conserv., Fed. Aid Proj. 5-R, 37-R, and 70-R. 200pp.

Artmann, J. 1970. Study of the sharp-tailed grouse with emphasis on habitat relationships. Minnesota Game Research 30:161-193.

Baker, M. F. 1953. Prairie chickens of Kansas. Univ. Kansas Biol. Surv., Misc. Publ. 5. 68pp.

Ballard, W. B., and R. J. Robel. 1974. Reproductive importance of dominant male greater prairie chickens. Auk 91:75-85.

Bernhoft, L. S. 1967. Habitat preferences of the sharp-tailed grouse. North Dakota Game and Fish Dept., Fed. Aid Proj. W-67-R-7. 9pp.

Bernhoft, L. S. 1968. Habitat preferences of the sharp-tailed grouse. North Dakota Game and Fish Dept., Fed. Aid Proj. W-67-R-8. 18pp.

Bernhoft, L. S. 1969. Habitat preferences of the sharp-tailed grouse. North Dakota Game and Fish Dept., Fed. Aid Proj. W-67-R-9. 38pp.

Berger, D. D., F. Hamerstrom, and F. N. Hamerstrom, Jr. 1963. The effect of raptors on prairie chickens on booming grounds. J. Wildl. Manage. 37:778-791.

Boddicker, M. L. 1969. Characteristics of parasite infestations in sharp-tailed grouse. Rept., Dept. Ento.-Zool., South Dakota State Univ. 8pp.

Boddicker, M. L. 1972. Parasites of sharp-tailed grouse in South Dakota. Unpubl. Rept. cited in Hillman and Jackson (1973).

den Boer, P. J. 1971. Stabilization of animal numbers and the heterogeneity of environment: The problem of the persistence of sparse populations. Pages 77-97 in P. J. den Boer and G. R. Gradwell (eds.), Dynamics of Populations. Wageningen.

Bowen, D. E., R. J. Robel, and P. G. Watt. 1976. Habitat and investigators influence artificial ground nest losses: Kansas. Trans. Kansas Acad. Sci. 79:141-147.

Bowman, T. J., and R. J. Robel. 1977. Brood break-up, dispersal, mobility, and mortality of juvenile prairie chickens. J. Wildl. Manage. 41:27-34.

Brown, R. L. 1968. Effects of land-use practices on sharp-tailed grouse. Montana Fish and Game Dept., Fed. Aid Proj. W-91-R-9. 11pp.

Browning, N. G., and R. J. Robel. 1980. Metabolizable energy in four seeds fed to cardinals. Auk 97: (In Review).

Caldwell, P. J. 1976. Energetics and population considerations of sharp-tailed grouse in the Aspen Parkland of Canada. Ph.D. Thesis, Kansas State Univ. 114pp.

Cannon, R. 1978. Distribution and status of the lesser prairie chicken in western Oklahoma. Oklahoma Dept. Wildl., Fed. Aid Proj. W-125-R-1. 7pp.

Cannon, R. 1979. Distribution and status of the lesser prairie chicken in western Oklahoma. Oklahoma Dept. Wildl., Fed. Aid Proj. W-125-R-1. 8pp.

Case, R. M. 1973a. Energetic requirements for egg laying bobwhites. Pages 205-212 in J. A. Morrison and J. C. Lewis (eds.), Proc. 1st Natl. Bobwhite Quail Symp. Oklahoma State Univ.

Case, R. M. 1973b. Bioenergetics of a covey of bobwhites. Wilson Bull. 85:52-59.

Case, R. M., and R. J. Robel. 1974. Bioenergetics of the bobwhite. J. Wildl. Manage. 38:638-652.

Chitty, D. 1967. The natural selection of self-regulatory behaviour in animal populations. Proc. Ecol. Soc. Aust. 2:51-78.

Christenson, C. D. 1971. Habitat preferences of the sharp-tailed grouse. North Dakota Game and Fish Dept., Fed. Aid Proj. W-67-R-11. 53pp.

Christisen, D. M. 1969. National status and management of the greater prairie chicken. Trans. N. Amer. Wildl. Nat. Res. Conf. 34:207-217.

Christisen, D. M. 1975. Prairie chicken inventory; mobility and transplant investigation; and habitat improvement Missouri Dept. Conserv., Fed. Aid Proj. W-13-R-29. 14pp.

Christisen, D. M. 1976. Prairie chicken inventory; mobility and transplant investigation; and habitat improvement. Missouri Dept. Conserv., Fed. Aid Proj. W-13-R-30. 15pp.

Christisen, D. M. 1977. Annual prairie chicken inventory. Missouri Dept. Conserv., Fed. Aid Proj. W-13-R-31. 8pp.

Christisen, D. M. 1979. Annual prairie chicken inventory. Missouri Dept. Conserv., Fed. Aid Proj. W-13-R-33. 8pp.

Copelin, F. F. 1963. The lesser prairie chicken in Oklahoma. Oklahoma Wildl. Conserv. Dept., Tech. Bull. 6. 58pp.

Craig, J. V., L. L. Ortman, and A. M. Guhl. 1965. Genetic selection for social dominance ability in chickens. Anim. Behav. 13:114-131.

Davis, C. A., T. Z. Riley, R. A. Smith, H. R. Suminski, and M. J. Wisdom. 1979. Habitat evaluation of lesser prairie chickens in eastern Chaves County, New Mexico. Dept. Fish and Wildl. Sci., New Mexico State Univ. 141pp.

Davis, E. A., Jr. 1955. Seasonal changes in the energy balance of the English sparrow. Auk 72:385-411.

Dorney, R. S., and C. Kabat. 1960. Relation of weather, parasitic disease and hunting to Wisconsin ruffed grouse populations. Wisconsin Conserv. Dept., Tech. Bull. 20. 64pp.

Duncan, J. S., H. W. Reid, R. Moss, J. D. P. Phillips, and A. Watson. 1978. Ticks, louping ill and red grouse on moors in Speyside, Scotland. J. Wildl. Manage. 42:500-505.

Errington, P. L. 1945. Some contributions of a fifteen-year local study of the northern bobwhite to a knowledge of population phenomena. Ecol. Monogr. 15:1-34.

Evans. K. E. 1963. Inventory of greater prairie chickens. Colorado Game, Fish and Parks Div., Fed. Aid Proj. 14pp.

Evans, K. E. 1971. Energetics of sharp-tailed grouse during winter in western South Dakota. Ph.D. Thesis, Cornell Univ. 169pp.

Evans, R. M. 1961. Courtship and mating behavior of sharp-tailed grouse (Pedioecetes phasianellus jamesi, Lincoln). M.S. Thesis, Univ. Alberta. 134pp.

Evans, K. E., and D. R. Dietz. 1974. Nutritional energetics of sharp-tailed grouse during winter. J. Wildl. Manage. 38:622-629.

Evans, K. E., and A. N. Moen. 1975. Thermal exchange between sharp-tailed grouse, Pedioecetes phasianellus, and their winter environment. Condor 77:160-168.

Folker, R. V. 1964. A study of sharp-tailed grouse on the Gibbs study area, Saskatchewan. Saskatchewan Dept. Nat. Res. 30pp.

Fretwell, S. 1968. Dominance behavior and winter habitat distribution in juncos (Junco hyemalis). Bird Banding 40:1-25.

Gardarsson, A., and R. Moss. 1970. Selection of food by Icelandic ptarmigan in relation to its availability and nutrient value. Symp. Brit. Ecol. Soc. 10:47-69.

Gesell, G. G., R. J. Robel, A. D. Dayton, and J. Frieman. 1979. Effects of dieldrin on operant behavior of bobwhites. J. Environ. Sci. Health B14:153-170.

Grange, W. B. 1948. Wisconsin grouse problems. Wisconsin Conserv. Dept., Publ. 328, A-1948. 318pp.

Graul, W. D. 1977. Analysis of state school lands in Yuma County as greater prairie chicken habitat. Colorado Game, Fish and Parks Div., Unpubl. Rept. 6pp.

Guhl, A. M., J. V. Craig, and C. D. Mueller. 1960. Selective breeding for aggressiveness in chickens. Poultry Sci. 39:970-980.

Hamerstrom, F. N., Jr. 1939. A study of Wisconsin prairie chickens and sharp-tailed grouse. Wilson Bull. 51:105-120.

Hamerstrom, F. N., Jr., and F. Hamerstrom. 1949. Daily and seasonal movements of Wisconsin prairie chickens. Auk. 66:313-337.

Hamerstrom, F. N., Jr., and F. Hamerstrom. 1951. Mobility of the sharp-tailed grouse in relation to its ecology and distribution. Amer. Midl. Nat. 46:174-226.

Hamerstrom, F. N., Jr., and F. Hamerstrom. 1955. Population density and behavior in Wisconsin prairie chickens (Tympanuchus cupido pinnatus). Proc. Int. Ornithol. Congr. 11:459-466.

Hamerstrom, F. N., Jr., and F. Hamerstrom. 1973. The prairie chicken in Wisconsin. Wisconsin Dept. Nat. Res. Bull. 64. 52pp.

Hamerstrom, F. N., Jr., O. E. Mattson, and F. Hamerstrom. 1957. A guide to prairie chicken management. Wisconsin Conserv. Dept., Tech. Wildl. Bull. 15. 128pp.

Harper, G. R., R. J. Robel, and M. F. Hansen. 1967. Helminths of greater prairie chickens in Kansas. J. Wildl. Manage. 31:265-269.

Hart, C. M., O. S. Lee, and J. B. Low. 1950. The sharp-tailed grouse in Utah: its life history, status and management. Utah Dept. Fish and Game, Publ. 3. 79pp.

Hillman, C. N., and W. W. Jackson. 1973. The sharp-tailed grouse in South Dakota. South Dakota Dept. Game, Fish and Parks, Tech. Publ. 3. 62pp.

Horak, G. J. 1977. Development of a greater prairie chicken survey method. Kansas Fish and Game Comm., Fed. Aid Proj. W-42-R-3. 14pp.

Horak, G. J. 1978. Development of a greater prairie chicken survey method. Kansas Fish and Game Comm., Fed. Aid Proj. W-42-R-4. 15pp.

Jacobs, K. F. 1959. Restoration of the greater prairie chicken. Oklahoma Dept. Wildl. 42pp.

Jenkins, D., A. Watson, and G. R. Miller. 1963. Population studies on red grouse, Lagopus lagopus scoticus (Lath.) in north-east Scotland. J. Anim. Ecol. 32:317-376.

Jones, R. E. 1963. A comparative study of habitats of the lesser and greater prairie chicken in Oklahoma. Ph.D. Thesis, Oklahoma State Univ. 160pp.

Kendeigh, S. C. 1969. Energy responses of birds to their thermal environments. Wilson Bull. 81:411-449.

Kirsch, L. M. 1974. Habitat management considerations for prairie chickens Wildl. Soc. Bull. 2:124-129.

Kohn, S. C. 1976. Sharp-tailed grouse nesting and brooding habitat in southwestern North Dakota. M.S. Thesis, South Dakota State Univ. 123pp.

Komai, T., J. V. Craig, and S. Wearden. 1959. Heritability and repeatability of social aggressiveness in the domestic chicken. Poultry Sci. 38:356-359.

Krebs, C. J., B. L. Keller, and R. H. Tamarin. 1969. Microtus population biology: demographic changes in fluctuating populations of M. orchogaster and M. pennsylvanicus in southern Indiana. Ecology 50:587-607.

Lumsden, H. G. 1965. Displays of the sharp-tailed grouse. Ontario Dept. Lands and Forests, Res. Rept. 66. 68pp.

Mattise, S. N. 1978. Effects of grazing systems on sharp-tailed grouse habitat. M.S. Thesis, South Dakota State Univ. 46pp.

McEwen, L. C., and R. L. Brown. 1966. Acute toxicity of dieldrin and malathion to wild sharp-tailed grouse. J. Wildl. Manage. 30:604-611.

Miller, G. R., A. Watson, and D. Jenkins. 1970. Responses of red grouse populations to experimental improvement of their food. Symp. Brit. Ecol. Soc. 10:323-334.

Morgan, B. B., and F. N. Hamerstrom, Jr. 1941. Notes on endoparasites of Wisconsin pinnated and sharp-tailed grouse. J. Wildl. Manage. 5:194-198.

Moss, R., H. H. Kolb, M. Marquiss, A. Watson, B. Treca, D. Watt, and W. Glennie. 1979. Aggressiveness and dominance in captive cock red grouse. Agress. Behav. 5:59-84.

Moss, R., and A. Watson. 1980. Inherent changes in the aggressive behavior of a fluctuating red grouse (Lagopus lagopus scoticus) population. Ardea (In Press).

Moss, R., A. Watson, and R. Parr. 1974. A role of nutrition in the population dynamics of some game birds (Tetraonidae). Trans. Int. Congr. Game Biologists 14:193-201.

Moss, R., A. Watson, and R. Parr. 1975. Maternal nutrition and breeding success in red grouse (Lagopus lagopus scoticus). J. Anim. Ecol. 44:233-244.

Myrberget, S. 1970. The part played by predation in short-term variations in the population of willow grouse, Lagopus lagopus, in Norway. Trans. Int. Congr. Game Biologists 9:458-464.

Myrberget, S. 1972. Fluctuations in a north Norwegian population of willow grouse. Proc. Int. Ornithol. Congr. 15:107-120.

Partch, M. 1970. Prairie chicken exodus: notes on the prairie chicken in central Minnesota. The Loon 42:5-19.

Pence, D. B., and D. L. Sell. 1979. Helminths of the lesser prairie chicken, Tympanuchus pallidicinctus (Ridgway) (Tetraonidae), from the Texas Panhandle. Proc. Helminthol. Soc. Wash. 46:146-149.

Pepper, G. W. 1972. The ecology of sharp-tailed grouse during spring and summer in the aspen parklands of Saskatchewan. Saskatchewan Dept. Nat. Res., Wildl. Rept. 1. 56pp.

Peterle, T. J. 1954. The sharp-tailed grouse in the Upper Peninsula of Michigan. Unpubl. Ph.D. Thesis, Univ. Mich. 260pp.

Podoll, E. B. 1961. Characteristics of the Great Plains prairie chicken range. Soil Conserv. Serv. (Bismarck, ND). 24pp.

Robel, R. J. 1964. Quantitative indices of booming Tympanuchus cupido pinnatus. Trans. Kansas Acad. Sci. 67:702-712.

Robel, R. J. 1966. Booming territory size and mating success of the greater prairie chicken (Tympanuchus cupido pinnatus). Anim. Behav. 14:328-331.

Robel, R. J. 1967. Significance of booming grounds of greater prairie chickens. Proc. Amer. Philosophical Soc. 111:109-114.

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

Robel, R. J. 1972. Possible function of the lek in regulating tetraonid populations. Proc. Int. Ornithol. Congr. 15:121-133.

Robel, R. J., and W. B. Ballard. 1974. Lek social organization and reproductive success in the greater prairie chicken. Amer. Zool. 14:121-128.

Robel, R. J., A. R. Bisset, T. M. Clement, Jr., A. D. Dayton, and K. L. Morgan. 1979a. Metabolizable energy of important foods of bobwhites in Kansas. J. Wildl. Manage. 43:982-987.

Robel, R. J., A. R. Bisset, A. D. Dayton, and K. E. Kemp. 1979b. Comparative energetics of bobwhites on six different foods. J. Wildl. Manage. 43:987-992.

Robel, R. J., J. N. Briggs, J. J. Cebula, N. J. Silvy, C. E. Viers, and P. G. Watt. 1970. Greater prairie chicken ranges, movements, and habitat usage in Kansas. J. Wildl. Manage. 34:286-305.

Robel, R. J., R. M. Case, A. R. Bisset, and T. M. Clement, Jr. 1974. Energetics of food plots in bobwhite management. J. Wildl. Manage. 38:653-664.

Robel, R. J., F. R. Henderson, and W. W. Jackson. 1972. Some sharp-tailed grouse population statistics from South Dakota. J. Wildl. Manage. 36:87-98.

Rogers, G. E. 1969. The sharp-tailed grouse in Colorado. Colorado Game, Fish and Parks Div., Tech. Publ. 23. 94 pp.

Sanderson, G. C., R. L. Westemeier, and W. R. Edwards. 1973. Acquisition and management of prairie chicken sanctuaries in Illinois. Pages 59-79 in W. D. Svedarsky and T. Wolfe (eds.), The Prairie Chicken in Minnesota, Univ. Minnesota.

Savory, C. J. 1978. Food consumption of red grouse in relation to the age and productivity of heather. J. Anim. Ecol. 47:269-282.

Schwartz, C. W. 1945. The ecology of the prairie grouse in Missouri. Univ. Missouri Studies 20:1-99.

Scott, J. W. 1950. A study of the phylogenetic or comparative behavior of three species of grouse. Ann. N.Y. Acad. Sci. 51:1062-1073.

Scott, T. G. (ed.). 1963. Grouse management symposium. J. Wildl. Manage. 27:525-895.

Sisson, L. 1976. The sharp-tailed grouse in Nebraska. Nebraska Game and Parks Comm. 88pp.

Smith, R. A. 1979. Fall and winter habitat of lesser prairie chickens in southwestern New Mexico. M.S. Thesis, New Mexico State Univ. 71pp.

Stempel, M. E., and S. Rogers, Jr. 1961. History of prairie chickens in Iowa. Iowa Acad. Sci. 68:314-322.

Taylor, M. A. 1978. Fall and winter movements and habitat use of lesser prairie chickens. M.S. Thesis, Texas Tech. Univ. 52pp.

Vance, R. D. 1976. Changes in land use and wildlife populations in southeastern Illinois. Wildl. Soc. Bull. 4:11-15.

Watson, A. 1965. A population study of ptarmigan (Lagopus mutus) in Scotland. J. Anim. Ecol. 34:135-172.

Watson, A. 1970. Territorial and reproductive behaviour of red grouse.J. Reprod. Fert., Suppl. 11:3-14.

Watson, A., and R. Moss. 1970. Dominance, spacing behaviour and aggression in relation to population limitation in vertebrates. Symp. Brit. Ecol. Soc. 10:167-218.

Watson, A., and R. Moss. 1972. A current model of population dynamics in red grouse. Proc. Int. Ornithol. Congr. 15:134-149.

Watson, A., R. Moss, J. Phillips, and R. Parr. 1977. The effects of fertilizers on red grouse stocks on Scottish moors grazed by sheep, cattle, and deer. Pages 193-212 in P. Pesson and M. G. Birkan (eds.), Ecologie du petit gibier. Paris.

Watson, A., and P. J. O'hare. 1973. Experiments to increase red grouse stocks and improve the Irish bogland environment. Biol. Conserv. 5:41-44.

Watson, A., and P. J. O'hare. 1979. Red grouse populations on experimentally treated and untreated Irish bog. J. Appl. Ecol. 16:433-452.

Wellington, W. G. 1960. Qualitative changes in natural populations during changes in abundance. Can. J. Zool. 38:289-314.

West, G. C. 1960. Seasonal variation in the energy balance of the tree sparrow in relation to migration. Auk 77:306-329.

Westemeier, R. L. 1972. Prescribed burning in grassland management for prairie chickens in Illinois. Proc. Ann. Tall Timbers Fire Ecol. Conf. 12:317-338.

Westemeier, R. L. 1977. Illinois prairie chicken ecology and management investigations. Illinois Dept. Conserv., Fed. Aid Proj. W-66-R-17. 38pp.

Westemeier, R. L. 1978. Illinois prairie chicken ecology and management investigations. Illinois Dept. Conserv., Fed. Aid Proj. W-66-R-18. 38pp.

Westemeier, R. L. 1979. Illinois chicken ecology and management investigations. Illinois Dept. Conserv., Fed. Aid Proj. W-66-R-19. 42pp.

Will, B. D. 1979. Lesser prairie chicken survey. Colorado Game, Fish and Parks Div., Fed. Aid Proj. SE-3-2. 20pp.

Yde, C. A. 1977. Distribution and movements of sharp-tailed grouse during spring and summer in relation to rest-rotation grazing. Montana Fish and Game Dept., Fed. Aid Proj. W-120-R-1. 70pp.

Yeatter, R. E. 1943. The prairie chicken in Illinois. Illinois Nat. Hist. Survey Bull. 22:377-416.

Yeatter, R. E. 1963. Population responses to land-use changes in Illinois. J. Wildl. Manage. 27:739-757.

Zimmerman, J. L. 1965. Bioenergetics of the dickcissel, Spiza americana. Physiol. Zool. 38:370-389.

EVOLUTIONARY CONSIDERATIONS IN CREATING ARTIFICIAL LEKS FOR ATTWATER'S PRAIRIE CHICKEN[1]

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Abstract: Booming Attwater's prairie chicken *(Tympanuchus cupido attwateri)* were observed from 1975-77 on a 6,100-ha study site in Refugio County, Texas. The effects of extensive oil field activities on the birds were assessed. Four of 27 leks were in native vegetation while the remaining leks occurred on areas impacted by oil field operations (gravel roads, oil pads, and pipeline right-of-ways). Density of leks exceeded 6/km^2 on 1 area of the study site. Birds were observed to display individually or in groups of up to 23 birds. The behavior of the Attwater's prairie chicken on leks was compared to behavior of the greater prairie chicken *(T. c. pinnatus)* as reported in the literature. The breeding hierarchy on many of the leks appeared unstable due to an apparent breakdown of territoriality related to extreme linearity of the leks. The increase in number of leks due to oil development and the instability of linear leks may lead to greater genetic variability within the population. The possible effect of altered genetic variability within a population should be considered before the number of leks on an area is manipulated.

The Attwater's prairie chicken was once common on the gulf coastal prairie from southwestern Louisiana southward to the Nueces River in Texas (Lehmann 1968). This subspecies is currently designated as endangered, having declined from 8,700 birds in 1939 (Lehmann 1941) to approximately 1,600 at present (Lawrence and Silvy 1980).

Bendire (1894) 1st described the Attwater's prairie chicken as a small, dark subspecies of the greater prairie chicken. Kessler (1978) noted that behavior of the Attwater's prairie chicken on leks was comparable to that described for the greater prairie chicken by Robel (1964).

Robel (1970) observed 121 copulations on leks of greater prairie chickens. Dominant males occurred in the center of a lek and escorted females from the edge to the center of their territories for copulation (Robel 1967). Ballard and Robel (1974) removed 5 dominant males from leks and reported that each vacated territory was filled by a male of lower social status from a peripheral territory. Following removal of dominant males only 5 (13%) of 39 copulations were successful and the 39 attempts were by 7 different males. In direct contrast, during the previous 6 years, the alpha and beta males had accounted for 108 of 121 successful copulations and mating success averaged 92% (Ballard and Robel 1974).

The remaining range of Attwater's prairie chicken overlaps extensive oil-related activities in native gulf coastal prairies. This study assessed effects of oil-related activities in native gulf coastal prairie on natural selection and behavior of Attwater's prairie chicken on leks.

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STUDY AREA

The study was conducted on the 6,100-ha Lake Pasture of the O'Connor Brothers' River Ranch, 28.8 km northeast of Refugio (Refugio County), Texas (Fig. 1). The area is 1 of the few remnants of native gulf-coastal prairie and is also the site of extensive oil-field operations. Slightly rolling coastal grasslands dominate the study area, with 2 small drainages of intermittent flow. Elevation of the area varied from 7.6-15.2 m (U. S. Department of Interior Geological Study Survey Contour Map, 1965). For the past 100 years the Lake Pasture supported a viable Attwater's prairie chicken population. An estimated 250-400 birds were present on the pasture during this study.

Cogar et al. (1977) described the major vegetation types of the study area. Artificially-maintained areas such as mowed roadways, oil pipeline right-of-ways, gravel roads, and oil well pads created areas that differed from the natural vegetation types.

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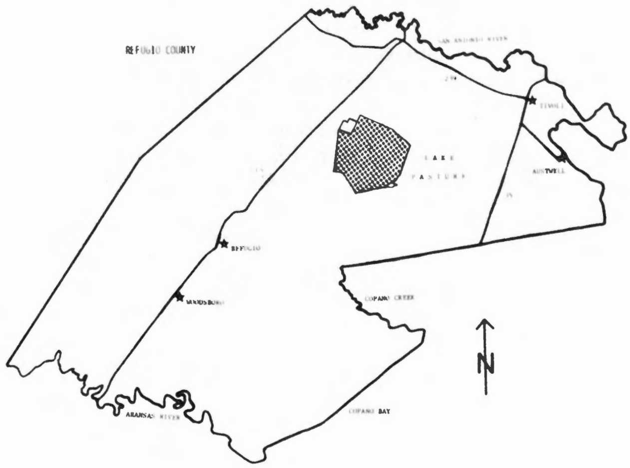

Fig. 1. Refugio County, Texas showing location of the 6,100-ha Lake Pasture of O'Connor Riverside Ranch.

Fig. 2. Location of Attwater's prairie chicken leks on the Lake Pasture for 1975-77, Refugio County, Texas.

METHODS

Leks were located by a systematic search of the Lake Pasture during the springs of 1975-77. No attempt was made to locate all grounds during spring 1975. During 1976 and 1977, searches were made for 2-h periods immediately after sunrise and before sunset. Numbers of male birds present on, and female visitations to, a lek were recorded. The vegetation type of the lek, the proximity of other leks, and the oil-field related structures and activity were noted. Prairie chicken response to the mowing of vegetation on leks was also noted.

Male and female chickens were trapped with mist nets, cannon nets, rocket nets, and a helicopter fitted with a helinet. Selected males and females were radio-tagged, leg banded, and released. Additional birds were leg banded only with color-coded bands and released. Radioed birds were located at least daily at random times. Activities of these birds were recorded when possible. In addition, visual observations were made daily of banded birds on leks.

Behavior of male prairie chickens on several leks was recorded during 30-min observation periods. Behavior was assessed in terms of: (1) Presence of a male dominance hierarchy, (2) daily use of the lek, and, (3) stability of the male territories in the presence of a female on a lek. A stable lek was defined as having (1) a definite male dominance hierarchy, (2) daily use, and (3) stabilized male territories in the presence of a female. An unstable ground was without a male dominance hierarchy when a female was present. Unstable grounds may or may not have been used daily by males.

RESULTS

Twenty-four males and 32 female Attwater's prairie chickens were banded and equipped with radio transmitters. An additional 32 males and 2 females were banded only.

A total of 27 leks was found on the Lake Pasture during 1975-77 (Fig. 2). Of these, 4 were on native shortgrasses (hardpan) and 23 on areas impacted by oil-field operations (along asphalt and gravel roads, oil well pads, under mown high-voltage power lines, and pipeline right-of-ways). In 1 area of the Pasture, the density of leks exceeded $6/km^2$. Leks were highly variable in terms of numbers of males observed and number of female visits each day (Table 1).

Fourteen leks were used during 1976 and 18 were used during 1977 (Table 1). Nine leks used during 1976 were not in use during 1977 and 13 additional leks were established during 1977. Three of the 4 native grassland leks were in use both years. One of the natural grounds was not in use in 1977 because of heavy spring flooding.

Table 1. Leks, number of times males and females were observed on each lek, and maximum number of males and females observed per lek during 1976-77, Lake Pasture, Refugio County, Texas.

	Observations				Maximum numbers			
	1976		1977		1976		1977	
	Male	Female	Male	Female	Male	Female	Male	Female
Silver Well	35	10			14	5		
Powerline	20	2			5	3		
Hardpan	27	8			6	8		
Storage Tank	13	3			6	4		
Crossroad	13	2			6	5		
Cabin Path	5	1			2	2		
Spiny Crossing	3	2			1	3		
Asphalt	26	16			4	3		
Coward Well	9	4			3	4		
Double Well	57	18	30	9	10	8	13	10
Red Well	51	3	3		12	2	5	
Spartina	15	1	2	1	11	2	8	4
Circle	46	24	25	12	15	10	13	10
New Well	15	2	1		13	3	9	
Braman #1			11	4			23	3
Braman #2			5				10	
Braman #3			43	22			23	13
Battery			8	2			10	3
Coward Road			7	2			8	6
New Well Pipeline 1			1				10	
New Well Pipeline 2			2				7	
T			34	7			13	2
Well 21			2				1	
Well 43			10	3			10	3
Well 45			6				5	
Blacktop			7	4			2	6
Circle North			2				12	

The maximum number of males visiting an individual lek on a single day ranged from 1 to 15 during 1976 and from 1 to 23 during 1977 (Table 1). The maximum number of females visiting an individual lek on a single day ranged from 2 to 10 during 1976 and from 2 to 13 during 1977.

Of 3,698 observations of displaying males, 83% were on areas impacted by oil development and 17% were on native hardpan areas. Lek sites were always adjacent to the only vegetation types in which Attwater's prairie chickens nested (Horkel 1979).

The effect of disturbance due to oil development on use of lek sites was also noted. New shortgrass areas within or near good nesting habitat were being established with the construction of new roads (and their mown roadsides), oil well pads, and/or pipeline right-of-ways (Horkel 1979). All new areas offered a potential for the establishment of new leks or a shift in an already established lek as vegetation became too high or dense at old leks. Males displayed on mown pipeline right-of-ways and mown oil well pads and roadsides; however, these sites were abandoned if not mown. For example, during spring 1975, lek A (Fig. 3) was established under a newly established powerline where the right-of-way was mown. This right-of-way was not mown after spring 1975 and was abandoned as a lek during spring 1976. During spring 1976, 3 new leks were established. Two were established at newly constructed oil well pads (leks F and G, Fig. 3) and 1 (lek E, Fig. 3) was established at a newly constructed road. During fall 1976, 3 additional oil well pads were constructed and were used as leks during spring 1977 (leks H, I, and J, Fig. 3). Former leks D and G were abandoned during spring 1977. Vegetation on the oil well pads was not mown and had grown tall and rank.

Fourteen males were observed to use more than 1 lek. One adult male captured on lek B (Fig. 3) during early spring 1976, used consecutively leks E, F, G, C, and G before establishing a territory on lek F. A radio-tagged juvenile male, captured in early spring 1976 on lek B, was radio-located near 10 of the 14 known leks on the study area prior to establishing a territory on lek G.

Nineteen banded males captured during spring 1976 returned to leks in spring 1977, but only 8 returned to the lek of their capture. Four adult males established territories on newly established leks (1st used in 1977) while the other 7 established territories on leks that had been 1st used in 1976. Dominant males were more likely to remain on a lek once the vegetation became dense, whereas subdominant males were more likely to move to newly established leks. Lek B (Fig. 3) had 12 males during spring 1976 when the site was mown by the authors. During 1977, the number of males decreased to 5 when the site was not mown. Two of these 5 males were known breeders during spring 1976. Two nonbreeding males that used lek B during spring 1976, moved to lek F during spring 1977.

Only 1 of 4 hens that survived from spring 1976 to spring 1977 was observed on a lek in 1977. She returned to the same

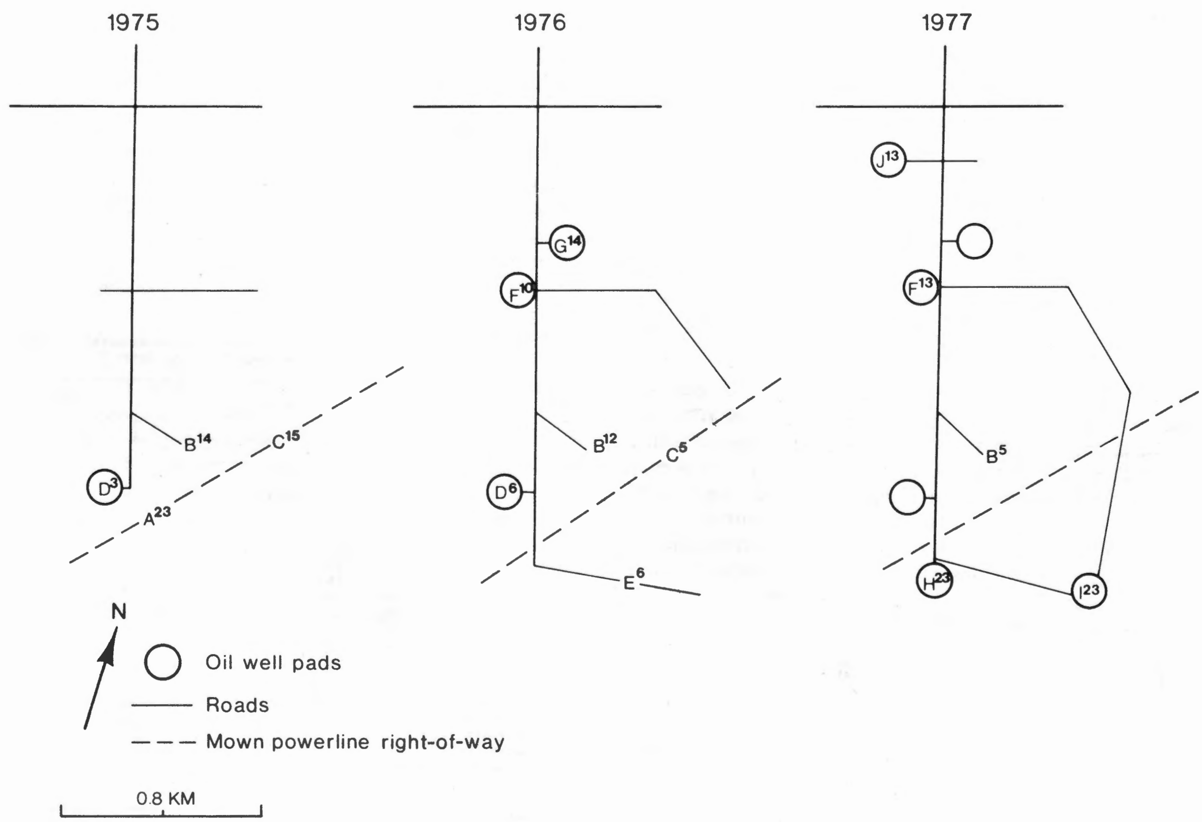

Fig. 3. A portion of the Lake Pasture, Refugio County, Texas showing typical changes in lek site use 1975-77.

lek of her original capture.

Leks varied from circular configurations (up to 22.5 m diameter) on a native grassland site to linear (up to 0.8 km) along a pipeline right-of-way site. Territory stability on the leks also varied. The Double Well lek (a circular site) was highly stable while the T lek (a linear site) was unstable. The arrival of females on the Double Well lek had no discernable effect on the stability of male territories. Females would select 1 of the males with which to mate. However, female arrival on the T lek (unstable) resulted in a breakdown of male territories as males followed females into surrounding territories. On 25 April 1977, 13 unsuccessful mating attempts were made by 6 different males and the same female on the T lek. Inter-male aggression was intense; males were knocked from hens during copulation attempts. A successful mating was observed on this lek the following day; however, it was not known if the same hen was involved. Mating interference was not observed at stable leks such as Double Well.

Successful breeding was observed on only 11 occassions during 1976-77. Successful mating occurred during 10 (12%) of 86 occassions when females were observed on stable (circular) leks and only during 1 (1%) of the 76 occassions when females were observed on unstable (linear) leks. In contrast, unstable leks attracted females on 76 (38%) of 200 observations while stable leks had females present on only 86 (26%) of 335 occassions. Although no observations of successful breeding were observed on a single male lek, the Spiny Crossing lek (Table 1), observed only 3 times, had 3 females present on each of 2 occassions. The number of males present on a lek appeared to have no effect on the number of females attracted to a lek (Table 1).

The linearity of leks along roads or pipeline right-of-ways precluded the establishment of a stable lek. Males only contested with neighbors on 2 sides (Fig. 4). Displaced males flew along the road or pipeline to the end of the lek and established another territory. Females usually arrived on these leks by entering perpendicular to the road or pipeline through the taller vegetation at the sides. Because selected males had neighbors on only 2 sides to help suppress intruders, invading males could easily interfere with matings by approaching perpendicular to the road or pipeline where the selected male had no neighbors to help suppress the interfering males. As noted previously, this lack of stability usually delayed mating of hens on these leks.

The mowing and nonmowing of road and pipeline right-of-ways and well heads also affected the stability of leks. If mown from year to year, a stable lek resulted; however, if mown 1 year and not the next, the lek site was abandoned.

DISCUSSION

The fitness or adaptive value of an individual is measured by its ability to leave adult, fertile offspring (Wallace 1968). The relative Darwinian fitness of a given genotype, its adaptive value, is the average fitness of individuals of the genotype. Much variation occurs in natural populations and may be either genetic or environmental in origin.

Although data on which this paper is based are not strong, results from our study and the literature have led us to the following hypotheses: (1) The dominance hierarchy of prairie chickens on leks leads to decreased genetic variation within the population in constant environments, (2) oil development on our study area has disrupted the dominance hierarchy and has increased the genetic variation within the population of

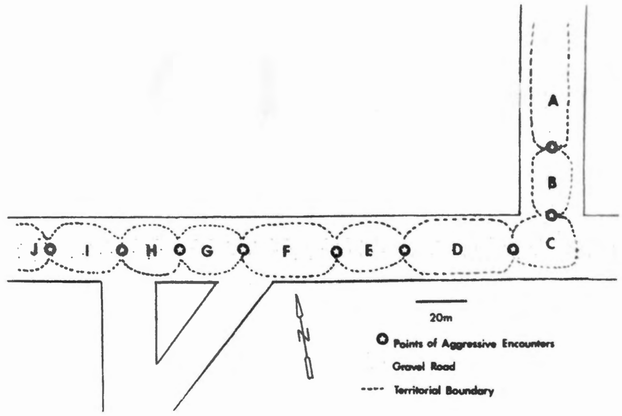

Fig. 4. Male Attwater's prairie chicken territories in 1978 on the Circle Lek, Lake Pasture, Refugio County, Texas (Lutz 1979).

Attwater's prairie chicken, and (3) decreased genetic variation within the chicken population is more beneficial to the population under constant conditions, whereas increased genetic variation within the population is more beneficial to the chickens under changing conditions.

Because of the highly ordered social structure usually observed on prairie chicken leks, the dominant males do most of the breeding. These individuals through the number of offspring they leave may be considered most fit in the Darwinian concept of fitness. Both age and level of aggression (Robel 1970) enhance the probability of mating success in prairie chickens. Alpha and beta males on leks studied by Robel were the oldest males present. In comparison to others in the population, longevity is a measure of adaptiveness to the environment (Fig. 5). If these males are more fit (i.e. leave more offspring) then they enhance the adaptivity of the species to its environment. In unchanging environments, natural selection should favor a species that has genetic traits that favor its adaptability to that environment.

Robel (1970) speculated that the lek system of the greater prairie chicken increased the probability of the most fit individuals (males and females) mating. Not only did dominant (older) males do most of the breeding, but dominant (older?) females were thought to delay or prevent the mating of subordinate (younger?) females. Hamerstrom and Hamerstrom (1953) reported similar aggressive hen behavior and indicated aggression was more pronounced in females about to accept a male in copulation. Horkel (1979) also observed a dominance hierarchy in females arriving on leks of our study area.

Robel (1970) showed that 1st nests had a greater probability of survival and that dominant females were the 1st to nest. Horkel et al. (1978) determined that artificial nests located on our study area were less succeptible to predation if established early than late during the spring. They postulated that predators develop a searching image as nests were found each spring, and once they acquired this image the intensity of predation increased as the season advanced. Early nesting females are considered more fit as they have a greater probability of leaving more offspring. Because Robel (1970) considered dominant females to be older, they would also be more adap-

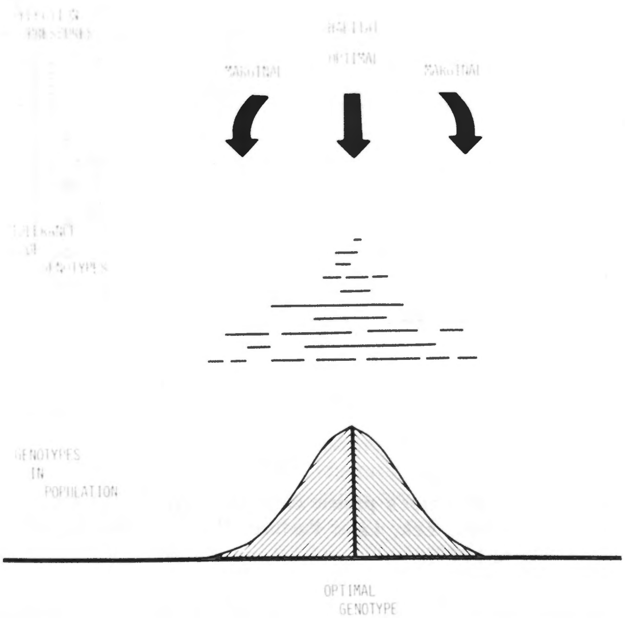

Fig. 5. Selective pressure act through the environment (habitat) on genotypes in the population to produce an average (best fit) individual for that set of environmental conditions.

ted to their environment than would be the young, subdominant hens that nested later. Further research is needed to determine if these subdominant hens are younger; however, even if they are not, the greater adapted older males breeding with any aged female would produce a similar result, but the same degree of decreased variation would take longer.

With males of high adaptability mating with females of high adaptability, the genetic composition of the population would consist of individuals more highly adapted to their unchanging environment. The population present on an area would be the best adapted for the existing conditions and reduced genetic variability in the population would reinforce this adaptation. Such a mating scheme would be perpetuated in an unchanging environment.

In a changing environment, a mating system that maximized for reduced genetic variability of the population would be a disadvantage. For, as the environment changed, different genotypes (selection acting through the phenotype) would be favored. Populations having a genotype favoring less change would then be at a disadvantage. Populations with more genetic variability would be favored as they could "take advantage" of the changing conditions.

Robel (1970) reported that subordinate males were usually driven off leks by dominant males and continued to display on peripheral areas. These males were thought to suffer greater mortality due to their displaying in marginal areas. Berger et al. (1963), Silvy (1968), and Horkel (1979) have reported predation losses of prairie chickens on leks. Wiley (1973) has suggested that sage grouse cocks around the edges of leks were more vulnerable to predation. Adult cocks tended to occupy the center of the lek, younger cocks the periphery. Dominant male prairie chickens are usually located in the center of leks (Robel 1967) and are therefore somewhat protected from predation due to a position that is surrounded by subdominant males. Dominant males on our linear leks shared exposure to predation with all except the end males.

On our study area, the probability of more individual males participating in mating was increased due to oil field disturbance. With greater areas for use as lek sites, more leks were established (Fig. 3). In 1976, there were 14 leks; during 1977 when more sites were available, 19 leks were in use. During 1977, at least 5 additional males were contributing to the genotype of the population (assuming that at least 1 male was breeding at each of the newly established leks). Five males breeding is considered minimal as there appeared to be no dominant males on our linear leks. Lutz (1979) observed 11 males using the Circle lek during 1978 and recorded 2 matings; 1 each by 2 widely separated males (B and G, Fig. 4). Breeding males were attacked while mating but the matings were considered successful. Successful matings are accomplished at these (Circle and T) unstable leks; however, not at the same rate (1 at T lek to 10 at stable leks during our study). It appears that the instability of these leks are delaying mating of hens. This concept was 1st proposed by Robel (1970) and is further supported by the greater percentage (38%) of times females were observed on unstable leks than they were on stable leks (26%). Due to interference of matings on unstable leks, females may have been forced to return several times prior to successful mating. The unstable leks and the numerous incidences of single displaying males on our study area are disrupting the evolutionary process and may lead to increased genetic variability in the population. Horkel (1979) observed females being courted by individual males that displayed on areas other than those considered in our study to be established leks. Because of the greater number of leks in use, more females could be serviced early. In turn, more nests would be early and therefore less susceptible to predation (Robel 1970, Horkel et al. 1978). More females would then have a greater probability of contributing to the gene pool of the population.

Under mating hierarchies as reported by Robel (1970) for the greater prairie chicken and as observed on our stable grounds, genetic variability is reduced. However, with the constant disturbance by oil development, there are numerous areas suitable for use as leks. With more leks in use, more individuals are contributing to the gene pool of the population and greater genetic variability is the result.

Matings of the best fit females with the best fit male may not be occurring. More indiscriminant matings will lead to increased genetic variability in the population. This increased variability is detrimental to a population under constant conditions where genetic variability would be selected against. However, under changing conditions, increased genetic variability would be a positive factor in survival of the population. A population with a high degree of genetic variability would be less affected by changing environmental conditions than would a population with little genetic plasticity. Populations with greater genetic variability have greater genetic material on which natural selection acts.

We theorize that where conditions are not changing, the number of leks can be reduced to decrease the genetic variability in the population and increase the fitness of the species for that environment. In areas where the environment is rapidly changing, the numbers and shapes of leks can be increased and changed respectively, possibly increasing population variability. This will enhance the survival of the population as these areas change.

Prairie chicken managers have always wanted to increase the number of leks for their prairie chickens. More leks would mean more chickens and a better job of management. However, the nature of the management area should be considered. Reduced numbers of leks may be the best management strategy in areas that are environmentally relatively constant. Increased numbers of leks may be a better strategy in areas characterized by change.

LITERATURE CITED

Ballard, W. D., and R. J. Robel. 1974. Reproductive importance of dominant male greater prairie chickens. Auk 91:75-85.

Bendire, C. E. 1894. *Tympanuchus americanus attwateri* Bendire. Attwater's or southern prairie hen. Auk 11:130-132.

Berger, D. D., F. Hamerstrom, and F. N. Hamerstrom, Jr. 1963. The effects of raptors on prairie chickens on booming grounds. J. Wildl. Manage. 27:778-791.

Cogar, V. F., J. D. Horkel, and N. J. Silvy. 1977. Vegetation type preference of Attwater's prairie chicken in coastal prairie. Proc. Ann. Conf. Southeastern Assoc. Fish and Wildl. Agencies. 31:41-50.

Hamerstrom, F. N., Jr., and F. Hamerstrom. 1955. Population density and behavior in Wisconsin prairie chicken *(Tympanuchus cupido pinnatus).* Proc. Internatl. Ornithol. Congr. Basel. 11:459-466.

Horkel, J. D. 1979. Cover and space requirements of Attwater's prairie chicken *(Tympanuchus cupido attwateri)* in Refugio County, Texas. Ph.D. Thesis. Texas A&M Univ. College Station. 96pp.

——, R. S. Lutz, and N. J. Silvy. 1978. The influence of environmental parameters on nesting success of upland game birds. Proc. Ann. Conf. Southeastern Assoc. Fish and Wildl. Agencies 32:234-241.

Kessler, W. B. 1978. Attwater prairie chicken ecology in relation to agricultural and range management practices. Ph.D. Thesis. Texas A&M Univ. College Station. 158pp.

Lehmann, V. M. 1941. Attwater's prairie chicken, its life history and management. U.S. Dept. Interior, Fish and Wildl. Serv., Washington, D. C. N. A. Fauna 57. 63pp.

——. 1968. The Attwater's prairie chicken, current status and restoration opportunities. Trans. N. Am. Wildl. Conf. 33:398-407.

Lutz, R. S. 1979. The response of Attwater's prairie chicken to petroleum development. M.S. Thesis. Texas A&M Univ., College Station. 82pp.

Robel, R. J. 1964. Quantitative indices to activity and territoriality of booming *Tympanuchus cupido pinnatus* in Kansas. Trans. Kansas Acad. Sci. 67:702-712.

——. 1967. Significance of booming grounds of greater prairie chicken. Proc. Am. Phil. Soc. 111:109-114.

——. 1970. Possible role behavior in regulating greater prairie chicken populations. J. Wildl. Manage. 34:306-312.

Silvy, N. J. 1968. Movements, monthly ranges, reproductive behavior, and mortality of radio-tagged greater prairie chickens *(Tympanuchus cupido pinnatus).* M.S. Thesis. Kansas State Univ., Manhattan. 135pp.

Wallace, F. 1968. Topics in population genetics. W. W. Norton & Co., Inc. New York. 481pp.

Wiley, R. H. 1973. Territoriality and non-random mating in sage grouse. Anim. Behav. Monogr. 6:87-169.

PREDATOR RESPONSE TO ARTIFICIAL NESTS IN ATTWATER'S PRAIRIE CHICKEN HABITAT[1]

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Abstract: A study of artificial nests was conducted within Attwater's prairie chicken *(Tympanuchus cupido attwateri)* habitat in Refugio County, Texas, during March-May 1978 and 1979. Few differences were found in the vegetative cover at nests disturbed or undisturbed by predators. Beyond a critical minimum, vegetation surrounding nests had little influence on their susceptibility to predation. Although not statistically significant, 62% less predation of nests occurred in areas of low (<1 scat/km) predator activity than in areas of high (>1 scat/km) predator activity. Duration of nests in the field was not related to susceptibility of nests to predation. Destruction of artificial nests by predators appeared to be area-specific.

Gottfried and Thompson (1978:311) proposed using artificial nests to evaluate the significance of predation on nests. We utilized artificial nests to evaluate the influence of height of, and obstruction of vision by vegetation on the fate of nests in nesting habitat of Attwater's prairie chickens. We also compared the fate of artificial nests in areas developed for petroleum production with fate of artificial nests in undisturbed areas.

STUDY AREA

The study areas were located in the 6,000-ha Lake and 2,500-ha Beef pastures of the O'Connor Brothers' River Ranch, 28.8 km northeast of Refugio, Texas. Vegetation on the Lake Pasture was quantitatively described by Cogar et al. (1977). Continuous grazing of 1 AU/6.5 ha was maintained throughout the study.

Table 1. Petroleum development in the Lake and Beef pastures on the O'Connor Brothers' River Ranch, Refugio County, Texas. Development was defined as gravel roads and rights-of-way having an average width of 20+ m, ranch roads averaging 5+ m, and pipelines averaging 22+ m. Unless otherwise indicated, all values are in hectares.

	Development			
Study area	Gravel roads	Ranch roads	Pipelines	Number of wells
Developed				
Circle	14.2	0.2	25.1	22
Double	11.3	Tr	13.8	14
#45	0.8	0.0	5.7	4
Undeveloped				
Beef	0.0	1.5	0.0	0
New Well	0.0	0.7	2.8	0
Braman 3	1.6	0.7	1.6	1

Within the Lake and Beef pastures, smaller (1 km^2) study areas were delineated in grasslands that were either developed for petroleum production between 1960 and 1965 or undeveloped (Fig. 1, Table 1). Undeveloped study areas were at least 1.6 km from intensive petroleum developments. Both the developed and undeveloped areas were within habitat types that contained all known nests on the study site (Horkel 1979, Lutz 1979). In 1978, the developed study areas included Double Wells and Circle (Fig. 1). The undeveloped study areas in 1978 were the Beef and New Well. In 1979, the developed study areas were Double Well, Circle, and No. 45. Undeveloped study areas in 1979 were Braman 3 and New Well.

MATERIALS AND METHODS

Research occurred during 1978 and 1979. Lines of 10 nests each were placed in Attwater's prairie chicken nesting habitat in each of the study areas. Lines, initiated at the edge of mowed pipelines or roads, angled away from these features. Each nest consisted of 4 domestic chicken eggs. New lines were initiated every 2 weeks, and all lines were terminated in mid-May. In 1978, 6 lines were established in each of the 4 study areas. Initiation dates were 7 April, 20 April, and 4 May. Lines (10 per area) were initiated on 8 March, 1 April, 10 April, and 8 May in the New Well, Double, and Circle in 1979. Four lines each in Braman 3 and No. 45 were initiated 1 April. Nests were examined weekly until destroyed or for a maximum of 4 weeks. The nest was considered "unsuccessful" if 1 or more eggs were either missing or appeared to have been

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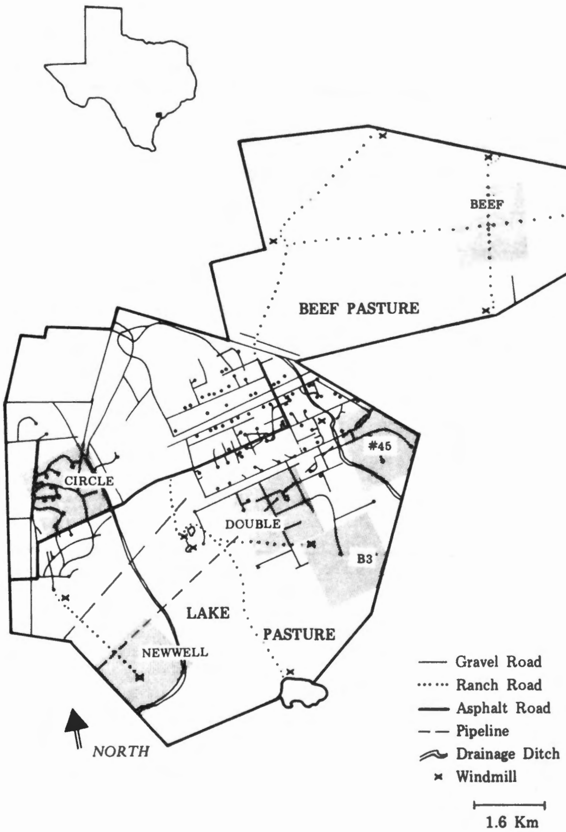

Fig. 1. Study sites (Lake and Beef) and study areas (Beef, Braman 3, #45, Double, Circle, and New Well) on the O'Connor Brothers' River Ranch, Refugio County, Texas.

destroyed by predators. Undisturbed nests were termed "successful."

After establishing status of all nests, vegetation measurements were taken along the lines. Vegetation height (VH) and obstruction of vision (OV) values were recorded at nest location and along the line 10 m before and 10 m after the nest location. VH measurements were the unextended height of standing vegetation (grass or forb) at the sampling points. OV values were obtained by placing an incremented range pole (Robel et al. 1970) at the sampling point. Measurements used in statistical analysis included OV readings (BOV) and height (BHT) 10 m before the nest, OV reading (NOV) and height measurements (NHT) at the nest, OV readings (AV) and height measurements (AHT) 10 m after the nest. "Away" values (AWOV, AWHT) were an average of the before and after values.

Predator scats were collected every 2 weeks to monitor predator activity. Scats were classified as "large" (coyote *Canis latrans*) or "small" (raccoon *Procyon lotor*, skunk *Mephitis mephitis*). Sections of ranch roads, 1.6 km in length, served as transects for scat collections.

Statistical methods follow Ott (1977) unless otherwise indicated. Statistical significance was at the 0.05 level. Chi-square tests were used to determine the relationship between nest fate and (1) study area, (2) the period (weeks) nests survived predation, and (3) nest position along a line. *T*-tests were used to test for differences in vegetation measurements at successful and unsuccessful nests within and between years. Differences in mean number of scats per transect in 1978 and 1979 and mean number of scats per study area were also tested with the *t* statistic. The Spearman correlation coefficient (Conover 1971) was used to measure the strength of the relationship between OV and VH nest success.

RESULTS

Predation on nests was 3 times higher in 1979 than in 1978, and success varied significantly between study areas (Table 2). Although predation rates differed significantly between years, the Double area had the highest (78%) nest predation, the New Well intermediate (51%), and the Circle had few losses (29%). Observed predation on nests was independent of the presence or absence of petroleum development (Table 2).

The relationship between time of nest destruction and the number of weeks a nest had been in the field varied between years. Nest destruction averaged 7.9% per week during 1978 and did not vary significantly between weeks. During 1979, the loss rate was significantly higher (58%/week) during the 1st week than during the 3rd week (17%/week).

The effect of proximity to disturbance (mowed pipelines, roads) was examined indirectly by comparing the fate of nests relative to position along lines. Because nest lines originated at an edge created by disturbance, the 1st nest in these lines could be compared with subsequent nests to evaluate if nests close to the disturbance were more susceptible to predation than were nests further from the disturbance. Distance from disturbance was not related to predation on nests on both developed and undeveloped study areas, and for both years.

The relationship between vegetation measurements and success of nests varied between years. In 1978, there were significant differences between NOV and NHT at successful and unsuccessful nests when data from all lines were combined. Successful nests were characterized by larger (11%) OV and taller (5%) VH measurements. However, if successful and unsuccessful nests were analyzed by individual study areas, no significant differences were found in any of the variables (Table 3). In 1979, when all lines were considered, only AOV differed significantly between successful and unsuccessful nests. In the Circle, BOV, AHT, and AWHT, were signifi-

Table 2. Destruction of artificial nests and predator activity levels in the study areas in the Lake and Beef pastures, O'Connor Brothers' River Ranch, Refugio County, Texas, 1978-79.

Study area	Sample size		% Nest destruction by predators[a]		Predator activity (scats/km)	
	1978	1979	1978	1979	1978	1979
Developed						
Circle	60	100	6	40	0.6 (0.89)[b]	0.3 (0.50)
Double	60	100	51	93	3.4 (2.19)	3.8 (2.22)
#45		40		60		
Undeveloped						
Beef	60		20		4.8 (2.32)	
New Well	60	100	15	72	3.8 (1.79)	2.3 (1.71)
Braman 3		40		59		2.0 (1.15)

[a]Nests available to predators were less those destroyed by cattle.

[b]Numbers in parentheses are ± 1 S.D.

Table 3: Mean vegetation height (VH) and obstruction of vision (OV) measurements at successful and unsuccessful dummy nests on study areas in the Lake and Beef pastures, O'Connor Brothers' River Ranch, Refugio County, Texas, 1978-79.

	Nest fate							
	Successful				Unsuccessful			
	1978		1979		1978		1979	
Study areas	OV	HT	OV	HT	OV	HT	OV	HT
Developed								
Circle	1.7 (0.7)[a]	51.8 (16.8)	1.8 (0.7)	43.1 (14.9)	1.9 (0.8)	53.1 (12.7)	1.9 (0.8)	53.1 (18.5)
Double	1.7 (0.6)	40.1 (21.6)	1.7 (1.0)	41.5 (19.0)	1.4 (0.6)	41.1 (21.6)	1.6 (0.7)	46.3 (16.3)
#45			1.8 (0.7)	38.1 (16.2)			1.9 (0.7)	41.5 (14.5)
Undeveloped								
Beef	1.4 (0.8)	43.4 (20.8)			1.3 (0.5)	38.1 (13.9)		
New Well	2.1 (1.1)	58.8 (21.1)	2.2 (0.9)	48.4 (15.5)	1.6 (0.6)	53.0 (16.4)	2.2 (0.7)	51.6 (15.8)
Braman 3			2.1 (0.9)	41.9 (20.6)			2.3 (0.9)	42.7 (14.5)

[a]Numbers in parentheses are ±1 S.D.

cantly different at successful and unsuccessful nests. AOV was the only vegetation measurement significantly different at successful and unsuccessful nests in the New Well and Braman 3. Nest success in individual study areas (both years) was not correlated with OV ($r = 0.40$) or VH ($r = 0.42$) values.

Although nest success differed between years, predator activity (scats/km) for study areas combined was not significantly different. Predator activity in the individual study areas varied from year to year, but only the Circle showed a significant difference (decreased from 1978 to 1979). When predator activity was averaged for the 2 years, the Double had the most activity, New Well intermediate, and Circle the least activity. The study areas with low predator activity had less nest predation, but the correlation ($r = 0.36$) was not significant.

DISCUSSION

Predation on nests varied significantly between years, and a trend was observed for study areas each year. Although not significant, areas of low predator activity had greater nest success in both years. Lutz (1979) observed that nest success of Attwater's prairie chickens was not significantly correlated with predator activity. Beasom (1973:169) found artificial nests were more successful in an area where predators had been removed than they were in areas where no predators had been removed.

Increased odors produced by deterioration of eggs over time did not result in increased predation. In 1979, nests in the field for the 1st 2 weeks were more likely to be destroyed than were nests that had survived the 3rd week. Our results are contrary to reports by Henry (1969:71) and Baker (1978); they found weekly increases in predation rates on artificial nests and believed the increase was due to predators finding deteriorated eggs more readily.

The paucity of significant differences for vegetation variables associated with artifical nests could indicate several things: (1) predation of nests was based primarily on the probability of predators encountering a nest, (2) beyond a critical minimum, vegetation surrounding a nest had little influence on its susceptibility to predation, (3) vegetation variables measured contributed little to a nest's susceptibility to predation, or (4) our technique was not sufficiently precise to discriminate differences.

The distance of artificial nests from a disturbance in the habitat was independent of predation during our study. However, Horkel et al. (1978) found that predators destroyed significantly more artificial nests when they were within 46 m of a disturbance in the habitat. Our study was not specifically designed to test the effects of proximity to disturbance of habitat directly and may have been statistically less sensitive.

Several measurements of vegetation structure (BHT, NOV, AHT, AWOV, and AWHT) were significantly increased in 1979 over those in 1978 and should have aided in concealment of nests. However, nest predation was 3 times greater in 1979 even through predator activity was similar between years. During 1979, when vegetation was tall and dense, there were no significant differences between measurements of vegetation structure at successful and unsuccessful nests. Vegetation structure above a critical minimum may have no influence on rates of nest predation. However, when vegetation was shorter and less dense, during 1978, there was a significant difference in the height and density (OV) of vegetation at successful and unsuccessful nests. Nests in taller and more dense vegetation had less predation. These data tend to support the hypothesis that below a critical minimum, height and density of the vegetation may be important factors to limit nest destruction by predators. Beyond this minimum, height and density of the vegetation may have no effect.

LITERATURE CITED

Baker, B. W. 1978. Ecological factors affecting wild turkey nest predation on south Texas rangelands. Proc. Southeastern Assoc. Fish and Wildl. Agencies 32:126-136.

Beasom, S. L. 1973. Ecological factors affecting wild turkey reproductive success in south Texas. Ph.D. Thesis. Texas A&M Univ., College Station. 215pp.

Cogar, V. C., J. D. Horkel, and N. J. Silvy. 1977. Vegetation type preference of Attwater's prairie chicken in coastal prairie. Proc. Southeastern Assoc. Fish and Wildl. Agencies 31:41-50.

Conover, W. J. 1971. Practical nonparametric statistics. John Wiley and Sons, Inc., N.Y. 462pp.

Gottfried, B. M., and C. F. Thompson. 1978. Experimental analysis of nest predation in an oil field. Auk 95:304-312.

Henry, V. G. 1969. Predation on dummy nests of ground-nesting birds in the southern Appalachians. J. Wildl. Manage. 33:169-172.

Horkel, J. D. 1979. Cover and space requirements of Attwater's prairie chicken (*Tympanuchus cupido attwateri*) in Refugio County, Texas. Ph.D. Thesis. Texas A&M Univ., College Station. 96pp.

——, R. S. Lutz, and N. J. Silvy. 1978. The influence of environmental parameters on nesting success of upland game birds. Proc. Southeastern Assoc. Fish and Wildl. Agencies 32:234-241.

Lutz, R. S. 1979. The response of Attwater's prairie chicken to petroleum development. M.S. Thesis, Texas A&M Univ., College Station. 82pp.

Ott, L. 1977. An introduction to statistical methods and data analysis. Duxbury Press, North Scituate, Mass. 730pp.

Robel, R. J., J. N. Briggs, A.D. Dayton, and L. C. Hulbert. 1970. Relationships between visual obstruction measurements and weight of grassland vegetation. J. Range Manage. 23:295-297.

CHANGES OCCURRING IN NEBRASKA'S PRAIRIE GROUSE RANGE

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Abstract: Prairie grouse within the Sandhills region of Nebraska include both greater prairie chickens (Tympanuchus cupido pinnatus) and sharp-tailed grouse (Pediocetes phasianellus jamesi). In 1965, 16 counties in the Sandhills had approximately 25,800 ha of irrigated cropland. By 1978, the total was about 214,100 ha. The bulk of the grassland conversion to irrigated cropland occurred in large blocks in eastern Sandhills. Ten lek survey routes selected for cover mapping averaged 89% native grassland in 1968 and 74% in 1978. The number of grounds per route has decreased, and the number of males per ground did not increase sufficiently to offset the general population decline.

The greater prairie chickens and sharp-tailed grouse in Nebraska occur primarily in the Sandhills, a 51,800 square kilometer area of stabilized sand dunes in the north-central portion of Nebraska. General topography ranges from flat, subirrigated meadows and rolling hills on the east to sharp, steep, ridges and long, narrow, dry valleys in the west. Dunes generally lay in a northwesterly - southeasterly direction. A few outlying populations of greater prairie chickens occur in the south-eastern and southwestern corners of the state.

The climate is mid-continent with wide temperature fluctuations seasonally and sometimes daily. The annual mean temperature is approximately 48 F with extremes from -40 F to 110 F. Average annual precipitation ranges from approximately 40.6 cm in the west to 61 cm in the east. About 80% of the precipitation occurs from April to September. The plant association is described as Sandhill Prairie (Kaul 1850) and is unique to Nebraska. In the Sandhill prairie, plants are generally more widely spaced than in other prairies. Principal grass components change from tall in the east to short in the west, and include prairie sandreed, (Calmovilfa longifolia) both big (Andropogon gerardii) and little bluestem,(A. scoparius) switchgrass, (Panicum virgatum) sand dropseed, (Sporobolus cryptandrus) sand lovegrass, (Eragrostis trichodes) gramma grasses, (Bouteloua spp.) and buffalo grass (Buchloe dactyloides). Interspersed among the grasses and on disturbed areas are a wide variety of forbs including lead plant, (Amorpha canescens) green sagewort, (Artemisia glauca) annual eriogonum, (Eriogonum annum) evening primrose, (Oenothera spp.) rose, (Rosa spp.) and soapweed, (Yucca spp.). Shrub species are limited and include American plum, (Prunus americana) western sandcherry, (Prunus besseyi) common chokecherry, (Prunus virginianus) and buckbrush (Symphoricarpus occidentalis).

Raising of beef cattle continues as the dominant industry in the Sandhills. Dryland farming was not successful in this area because of soil types and climate. Therefore, there is no other area of comparable size in the Great Plains that has changed so little since the cattlemen first came to the area approximately 100 years ago (Keech and Bentall 1971).

In 1960, at the 3rd Annual Prairie Chicken Conference, Marvin Schwilling, a grouse-research biologist for Nebraska, made the statement that "In Nebraska the present acreage of native grassland is in little danger of reduction by the plow, for most of the land is unsuited to tillage, proven during homestead days." Yet, 20 years later, drastic changes are occurring in the prairie grouse habitat in the Nebraska Sandhills.

The development of the center-pivot irrigation system in the early 60's, and the high quality acquifer underlying nearly all the Sandhills provided the essential ingredients for conversion of the grassland to irrigated corn field. Much of the grouse range, and especially the prairie chicken range along the eastern edge of the Sandhills, was subjected to plowing. Through the drilling of wells and installation of center-pivots, the "corn forest" has now become the dominant vegetational feature over some areas of the eastern Sandhills. A series of dry years coupled with spiraling corn prices and a deflated cattle market contributed heavily to the change from beef cattle ranching to "money crop" corn farming.

Center-pivot irrigation units installed as a supplement to a ranching operation can benefit wildlife. Waste grain for high quality winter food; or alfalfa as a year-around food for big game; and a place for young, upland birds to hunt insects and loaf are benefits. Late-season green leaves are heavily utilized by some upland game birds, especially prairie chickens.

In 1965, the 16 counties comprising the bulk of the Sandhills had a total of 25,800 irrigated hectares. By 1970, 76,300 ha were irrigated and by 1978 center-pivot conversions totalled 214,000 ha (Nebraska Agricultural Statistics). In the 9 counties that constitute the primary prairie chicken range, the irrigated acreages increased from 68,600 ha in 1970 to 181,700 ha in 1978 (+265%). Thus 85% of the hectares that were converted in the 16-county Sandhill area were concentrated in the 9-county prairie chicken range. While the 181, 00 ha constituted only 8.3% of the land area in the 9 counties, the majority of the irrigation was in large contiguous blocks in the best prairie chicken range. The percentage of irrigated land per county ranged from 14.4% in Holt County to 1.3% in McPherson County in 1978.

To document changes in land use, 10 lek survey routes in the northern part of the Sandhills were cover mapped in 1968, 1973, and 1978. Long term land use changes on 3 of the 10 routes were estimated for the period, 1954 through 1978, by comparing the cover mapping with land use data derived from 1954 ASCS aerial photographs.

Routes were traversed by automobile, and the cover type extending 0.8 km on both sides of the road was recorded at every 0.16 km or whenever a change occurred. If vision was obscured (such as irrigated corn 2 m tall), I assumed that the cover type visible extended the full 0.8 km.

Non-grassland habitat included building sites, center-pivot irrigation fields (excent those in alfalfa or set aside programs), summer fallow, and water areas (ponds,lakes,and rivers). The remainder was considered grassland habitat.

In 1968, the 10 lek survey routes averaged 11% non-grassland habitat with a range from 1% to 33%. By 1973, the average percentage non-grassland had risen to 18%, ranging from 1% to 48%. In 1978, the average was 26% non-grassland habitat and ranged from 2% to 66%.

Routes were grouped to represent eastern, central, and western portions of the survey area. Non-grassland habitat increased substantially during 1968-78 in all areas (204% east, 333% central, and 350% west). The percentages of the total area in non-grassland types also increased. The eastern segment shows 43% non-grassland habitat in 1978 compared to 21% in 1968. The central area increased to 20% non-grassland from 6% in 1968. The western area showed a large increase in hectares of non-grassland habitat, but only increased to 7% from 2% in 1968. The broken, rough topography of the western area didn't lend itself to extensive center-pivot development.

Data from spring lek counts on the 10 routes were compared to data obtained from cover mapping. Lek count data were grouped in 3-year intervals (1 year each side, plus year cover mapped) to avoid drastic 1-year changes in breeding population. The average numbers of leks per route declined from 8.9 in 1967-69, to 7.5 in 1972-74, to 7.0 in 1977-79. Males per lek steadily increased from 8.1 in 1967-69, to 8.5 in 1972-74, to 8.9 in 1977-79. During this same period the percentage of non-grassland habitat increased from 11% in 1968, to 18% in 1973, and to 26% in 1978.

Cover mapped routes then were grouped according to percentage of non-grassland habitat in 1978, as follows: 4 routes with >38%, 3 with 12-25%, and 3 with <12%. Data from leks for routes in each category were combined and evaluated for trends. Data for the group with >38% non-grassland showed a decline in leks per route for each 3-year period and an increase in males per leks for 2 of 3 periods. Data for the group with <12% non-grassland showed a decline in leks per route and an increase in males per lek for each 3-year period. Data for the 12-25% group were entirely different with leks per route declining only 1 period out of 3 and males per lek declining in each period. Data for this period were lacking for 1 or more routes in each of the 3-year intervals and may have influenced the trends.

Prairie chicken data showed a decline in leks per route for 7 of 9 years (1 year same) while the males per lek increased for 8 of 9 years.

Data on sharptails showed no trends under either method of comparison. This may be due to the greater number of prairie chicken leks (390 p.c. vs. 229 s.t.), or to the fact that most prairie chicken leks occurred on routes having a higher percentage of non-grassland habitat. The sharptail leks occur mostly on those routes showing the greatest amount of grassland and the least amount of change.

These data indicate that an increase in non-grassland habitat (especially cropland) occurred concurrently with a decline in numbers of leks used by prairie chickens. Leks of prairie chickens were often located on relatively flat meadows that are preferred sites for center-pivot irrigation development. The conversion from grassland to cropland destroys the suitability of the site for a lek. The loss of leks was only partially compensated by the increase in the average number of males per lek as the number of leks decreased.

The average leks per route for both species declined 21% from 1967-69 to 1972-79 while the males per ground increased 10%. The average of males per route (males per lek x leks per route) declined 14% during the same period. Thus, the increase in the average number of males per lek did not compensate for the number of leks lost.

The more limited scattering of center-pivot systems in the western segment of the range may have allowed an increase in numbers of prairie chickens and/or sharptails. The native vegetative composition of the area tends toward more mid-and short grasses than the central and eastern areas, which would favor sharptails more than prairie chickens. Continued evaluation is proposed to document species composition, populations, and land use changes.

LITERATURE CITED

Kaul, R. B. ca 1850. Vegetation map of Nebraska. 1p.

Keech, C. F., and R. Bentall 1971. Dunes of the plains. University of Nebraska Conservation and Survey Division. Resource Report 4. 18pp.

Nebraska Department of Agriculture. 1979. Nebraska agricultural statistics, annual report 1977, preliminary 1978. 180pp.

Schwilling, M. D. 1960. Effects of grazing on prairie chicken nesting. Third Annual National Prairie Chicken Conference, Stevens Point, Wisconsin. 9pp. Typescript.

LAND USE: A KEY TO GREATER PRAIRIE CHICKEN HABITAT IN MISSOURI[1]

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Abstract: A land-use study of agricultural crops was conducted in 2 townships and a 13-section area of central Missouri where census of cock prairie chickens on booming grounds had been completed. The population density differed among the study areas in relation to the amount of permanent grass present. One area of low prairie chicken density had 13.9% in grass, 1 of average density 45% in grass, and 1 of above average density 49.5% in grass. Compilation of cover would seem to be of value in relating population levels to types of habitat and for evaluating unoccuppied range where more sophisticated and refined methods of analyses are not feasible.

Greater prairie chickens were native to 59,570 km^2 of tall grass prairies of northern and western Missouri. The range of this bird diminished to 6,475 km^2 and the population to 14,000 birds by the early 1940's (Schwartz 1945, Fig. 1). Less than 2,331 km^2 populated with about 9,600 prairie chickens remained in 1979, principally in southwestern Missouri (Christisen 1979). The harvest season was closed in Missouri in 1907.

The importance of permanent grass to the survival of greater prairie chickens is documented for Missouri (Bennitt and Nagel 1937, Schwartz 1945, Arthaud 1968, Christisen 1969, Drobney 1973, Skinner 1974). However, the proportion and kinds of permanent grasses required by prairie chickens remain undefined.

Some researchers (Jones 1963, Drobney 1973) evaluated habitat components by the number of observations of prairie chickens in each cover type. Evans (1969) in Colorado identified each habitat component and estimated its relative importance on the basis of population levels. He hypothesized that a comparison of habitat factors in areas with high, low, and no prairie chicken populations would help to evaluate the importance of each factor.

[1]This study was financed in part by Federal Aid in Wildlife Restoration, Missouri Project W-13-R.

In this study, we selected areas with differing prairie chicken population densities, but only evaluated proportions of cover relative to numbers of prairie chickens. We assumed that more desirable habitats supported higher, and less desirable habitats lower, population densities of prairie chickens.

We are indebted to Alan Crossley for field surveys of Lick Creek and Mora, to Chester Vermaas for prairie chicken lek census of Green Ridge in 1965 and 1966, and to Susie Sapp for typing the manuscript. Also, we are grateful to T.S. Baskett for suggestions on the manuscript and to Steve Sheriff for statistical help.

STUDY AREAS AND METHODS

Data on land-use were compiled for 2 townships, Green Ridge (100.5 km^2) in Pettis County, west central Missouri, Lick Creek (93.2 km^2) in Audrain County, east central Missouri and the Mora Unit (Sections 1 through 13) in Benton County, west central Missouri (Fig. 1). Historically, all 3 areas probably had similar densities of prairie chickens.

Each study area was flat to slightly rolling. Lick Creek had 5% woodland, Green Ridge 3.4%, and Mora 2.2%; the former townships had about 2.5% in residential areas and Mora 1.7%. Lick Creek Township is a glaciated area with soil classified as Putnam-Mexico silt loams, derived from loess, dark gray, poorly drained, and of moderate fertility. Green Ridge Township and the Mora Unit are non-glaciated, classified as Oswego-Dennis silt loams derived from shales, dark brown to gray, deep, gently rolling, and fairly productive

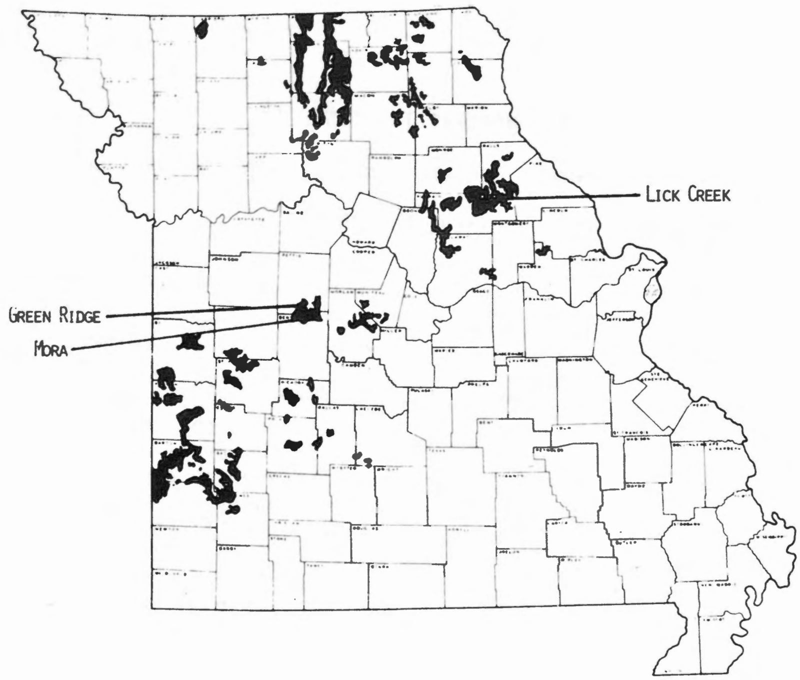

FIG. 1. THE GREATER PRAIRIE CHICKEN RANGE OF 1940 IN MISSOURI AND STUDY AREAS OF 1978 AND 1979.

(Krusekopf 1962).

Data on land-use for townships were compiled in early to mid-summer by on-site inspection with the aid of aerial photos and farmer interviews. The Mora Unit was surveyed in early September. The kinds of cover (land-use) and acreages were recorded on aerial photo copies supplied by the Agricultural Stabilization and Conservation Service and taken in 1966, 1969, and 1970. Double-cropping, if present, was unidentifiable. Field sizes used were calculated by the ASCS or were estimated by use of an ASCS modified-grid system of measurement overlay of aerial photos. The land-use data, compiled on the Green Ridge Area in 1978, required about 4½ field days; the Lick Creek area required 6 days, and Mora, 2 days in 1979.

A census of birds on leks for each study area was conducted in March and April of 2 successive years, 1978 and 1979. The 1.6 km interval-grid pattern of county roads permitted coverage of each township and most of the Mora Unit. The number of males on each lek was tallied with the aid of binoculars in early morning, usually within an hour of sunrise. Lek surveys were conducted once each year except for Green Ridge where 13 were made in 1978 and 9 in 1979.

RESULTS

The lek census of the Lick Creek Township in 1978 averaged 0.6 cocks/1.6 km^2 (SD=2.0) and in 1979, 0.7 cocks (SD=1.8). A cursory survey of this area in 1977 showed 1.0 cocks/1.6 km^2.

The Green Ridge Township had 5.7 cocks/1.6 km^2 (SD=9.7) in 1978 and 7.8 cocks/1.6 km^2 (SD=11.4) in 1979. A similar but less exhaustive survey of this township in 1965 averaged 3.7 cocks/1.6 km^2 and 5.0 cocks in 1966.

No census data were available for the entire Mora sample but 22 km^2 had 12.7 cocks/1.6 km^2 (SD=15.5) in 1978 and 9.4 cocks (SD=12.6) in 1979. The density for 59.6 km^2 area including this sample was 6.8 cocks/1.6 km^2 in 1978 and 6.4 in 1979. We considered the Mora Unit as high, the Green Ridge average, and Lick Creek as low population densities.

Area cover differed between areas. Lick Creek, roughly 9,326 ha in size, had 77.8% in grain crops, 13.9% in grass, 0.7% in legumes and the balance non-cropland. Grassland and legumes were further identified as being 9.6% pasture and 3.8% hayland.

The 10,051-ha Green Ridge Area had 47.4% in grain crops, 45.0% in grass, 0.7% in legumes, and the remainder in non-cropland (woodland, residential, ponds, etc.). Of the grassland and legumes, 25.3% was used as pasture and 20.1% as hay. Both townships contained similar proportions of legumes.

The Mora Unit of 3,416 ha had 38.2% in grain crops, 49.5% in grass, 4.6% in legumes and the remainder non-cropland. This area had the highest proportions of grass and legumes and the lowest percentage of grain crops. Of the grassland and legumes, 28.7% was used as pasture and 26.0% as hay (Table 1).

Table 1. Percentage agricultural crops on study areas in Audrain, Pettis, and Benton counties Missouri in 1978[1] and 1979[2].

Kind	Lick Creek[2]	Green Ridge[1]	Mora[2]
Soybeans	48.3	33.1	17.2
Corn	12.3	4.6	7.3
Milo	4.9	8.8	7.7
Wheat	12.3	0.9	5.7
Other	trace	trace	trace
Grains[a]	77.8	47.4	38.2
Fescue	7.3	44.1	16.6
Mixed & other	1.9	0.9	5.7
Grass-legume mix	1.4		0.9
Unimproved	3.3	trace	18.1
Native prairie			8.2
Grasses[a]	13.9	45.0	49.5
Clovers	0.7	0.7	2.7
Alfalfa	trace		1.9
Mixed & other		trace	trace
Legumes[a]	0.7	0.7	4.6
Woodland	4.9	3.4	2.2
Residential	2.6	2.2	1.7
Miscellaneous	0.7		0.6
Non-cropland	8.2	5.6	4.5

[a]Exact amounts of trace elements are included in the totals.

DISCUSSION

Green Ridge, with 45% of the land in permanent grass, seems ideal for prairie chickens according to needs cited in the literature (Schwartz 1945, Baker 1953, Hamerstom et al. 1957). Many researchers accept 1/3 of an area in permanent grass as optimum. However, the permanent grass in Green Ridge is tall fescue, an introduced, cool-season grass. Drobney (1973) recorded only 2 instances of prairie chickens on fescue fields in 7,112 sightings. There were 94 ha of fescue, lightly-to-moderately grazed within his 1,512 ha study area where native prairie pasture comprised 46% of the land use. The fescue growth form of dense, heavy sod with sparse vegetative overstory appears unattractive to prairie chickens if other grasses are available. Therefore, in the absence of other grasses, prairie chickens appear limited to average densities (about 5 cocks/1.6 km^2) at Green Ridge with tall fescue as the primary grass cover. Fortunately, milo comprised 8.8% of the crops and possibly provided prairie chickens with both food and cover. The Green Ridge Township had a more attractive proportion of grass to other crops but the species of grass appeared less desirable to prairie chickens and the population remained below the expected carrying capacity.

The Lick Creek Township is a classic example of too little permanent grass of any kind relative to tilled land. Field observations indicated that habitat for prairie chickens becomes marginal at about the 25% level of permanent grass (Christisen 1970). Lick Creek Township has been sustaining a sparse population of prairie chickens with about 12% permanent grass for a decade or more. The acreage of grasses other than fescue amounted to only 5%, yet the greater variety of species may have benefited the birds. One other vegetation may have compensated for the lack of permanent grass cover; winter wheat comprised 12.3% of the cover in contrast to only 0.9% at Green Ridge. Wheat together with permanent grass represented about 25% of the cover at Lick Creek.

The Mora Unit was an area of 77.7 km^2 where landownerships were relatively stable and tracts of native prairie were common. The proportion of land in permanent grass was 49%, only 4% above Green Ridge, but about 32% of it comprised grasses besides tall fescue. About 18% was unimproved grassland and 8% native prairie. Also Mora had the most legumes (nearly 5%) and almost as much milo as Green Ridge. The higher proportion of permanent grass than either of the other study areas and greater diversity of grass species than Green Ridge supported a higher density of prairie chickens.

Schwartz (1945) found no relationship between the amount of permanent grass and the density of prairie chickens above the minimum of 39% grass. This study indicates diversity of grasses is another factor of population densities. Mora Unit probably represents optimum prairie chicken habitat for Missouri in amount and diversity of grasses.

Many factors determined the population levels of prairie chickens. The primary factor seemed to be the proportions and kinds of habitat components. When keyed to prairie chicken populations, cover composition seemed to offer a method for evaluating habitat for prairie chickens. Compilation of land-use data for relating population levels to habitat types, and for evaluating unoccuppied range, may be useful where more sophisticated methods of analyses are impractible.

LITERATURE CITED

Arthaud, F.L. 1970. Land use and prairie chicken populations in southwestern Missouri. Trans. Ks. Acad. Sci. 73:267-276.

Baker, M.F. 1953. Prairie chickens of Kansas. Univ. of Ks. St. Biol. Surv. Misc. Pub. 5. 68pp.

Bennitt, R., and W.O. Nagel. 1937. A survey of the resident game and furbearers of Missouri. Univ. of Missouri Studies 12(2). 215pp.

Christisen, D.M. 1969. National status and management of the greater prairie chicken. Trans. North Am. Wildl. and Nat. Resour. Conf. 34:207-216.

__________. 1970. Prairie chicken. Pages 79-83 in W.O. Nagel (Ed.), Conservation Contrasts. Mo. Dept. Conserv., Jefferson City.

__________. 1979. Annual prairie chicken inventory. Fed. Aid Proj. W-13-R Study 24(1), unpubl. 8pp.

Drobney, R.D. 1973. Habitat utilization by prairie chickens in relation to land-use practices in Benton County, Missouri. M.A. Thesis. Univ. of Mo., Columbia. 92pp.

__________, and R.D. Sparrow. Land use relationships and movements of greater prairie chickens in Missouri. Trans. Mo. Acad. Sci. 10 & 11:146-160.

Evans, K.E., and D.L. Gilbert. 1969. A method for evaluating greater prairie chicken habitat in Colorado. J. Wildl. Manage. 33:643-649.

Jones, R.E. 1963. Identification and analysis of lesser and greater prairie chicken habitat. J. Wildl. Manage. 27:757-778.

Hamerstrom, Jr., F.N., O.E. Mattson, and F. Hamerstrom. 1957. A guide to prairie chicken management. Wisconsin Conserv. Dept. Tech. Wildl. Bull. 15. 128pp.

Krusekopf, H.H. 1962. Major soil areas of Missouri. Univ. of Mo. Agr. Exper. Sta. Bull. 785. 19pp.

Schwartz, C.W. 1945. The ecology of the prairie chicken in Missouri. Univ. of Mo. Studies 20(1). 99pp.

Skinner, R.M. 1974. Grassland use patterns and prairie bird populations in Missouri. M.A. Thesis. Univ. of Mo., Columbia. 52pp.

EFFECTS OF SHINNERY OAK CONTROL ON LESSER PRAIRIE CHICKEN HABITAT[1]

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Abstract: This paper evaluates methods of shinnery oak (*Quercus havardii*) control relative to the habitat requirements of lesser prairie chickens (*Tympanuchus pallidicinctus*). Lesser prairie chickens require tall perennial grasses for nesting and loafing cover in winter, a diversity of forb species for foods, and brush for foods and loafing cover in summer. Application of herbicides may increase grass production and thereby improve nesting and winter cover. Picloram is recommended for shinnery oak control in lesser prairie chicken range because it has minor impact on forbs and sand sagebrush (*Artemesia filifolia*) after the 1st year following application. If perennial grasses are present in the understory, some shinnery oak is maintained for soil stability and alternate forage, and 150- to 300-ha blocks of rangeland are treated in rotation, then herbicidal control of shinnery oak could benefit both livestock and lesser prairie chickens.

INTRODUCTION

Shinnery oak and its hybrids occur in several million hectares of lesser prairie chicken habitat in western Oklahoma, eastern New Mexico, and northwestern Texas. The plant spreads by rhizomes and, in conjunction with heavy grazing, may form nearly pure stands. Shinnery oak may comprise 90% of annual vegetation production (Pettit 1977). Shinnery oak is poisonous to livestock, especially in spring when tannin levels are high in leaves (Sperry et al. 1964). Its presence lowers grass production and stocking capacity of rangelands. Improving range condition is difficult without controlling this shrub.

Reports on the effects of oak control on lesser prairie chicken populations vary. Jackson and DeArment (1963) believed aerial application of herbicides damaged the habitat of birds in Texas. Crawford (1974) observed increased bird numbers on areas treated once with 2,4,5-T but decreased numbers on areas treated twice, presumably due to a substantial decline in forb densities on the latter areas. Brush control may enhance nesting and wintering cover (Copelin 1963, Litton 1978) but may decrease winter food supplies (Copelin 1963). Lesser prairie chicken populations are negatively correlated with canopy coverage of shinnery oak (Cannon 1980), which suggests that its control could benefit the birds. Treated areas in both sand sagebrush and shinnery oak communities supported more lesser prairie chickens than untreated areas in Oklahoma (Donaldson 1969).

Wildlife managers must understand factors that affect lesser prairie chickens, because the occupied range of these birds has decreased over 90% since the 1800s (Taylor and Guthery 1980*b*). Purposes of this paper, therefore, are to define essential components of lesser prairie chicken habitat, evaluate existing literature on shinnery oak control relative to this definition, and develop guidelines for brush control that will benefit (or minimize harm to) lesser prairie chickens.

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ESSENTIAL COMPONENTS OF HABITAT

Tall Perennial Grasses

Although few studies have documented nesting habitat requirements of lesser prairie chickens, enough data are available to draw preliminary conclusions. In New Mexico, hens selected tallgrass communities as nesting cover in preference to forb or shrub communities (Davis et al. 1979).

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Important cover plants were sand bluestem (*Andropogon gerardii* var. *paucipilus*) and little bluestem (*Schizachyrium scoparium*). Nesting success was more than 3 times higher in areas with high percentages of tall perennial grasses than in areas with high percentages of forbs or shrubs. Sell (1979), working in west Texas, found that nesting hens selected the densest nesting cover available. Because tall perennial grasses were absent, sand sagebrush was the most important cover plant. Data from these studies suggest that tall, dense nesting cover, as provided by climax grasses, should be the goal of management for nesting habitat of lesser prairie chickens.

Residual stands of tall perennial grasses also provide cover for loafing in winter. Taylor and Guthery (1980*a*) found that lesser prairie chickens preferred shinnery oak-little bluestem communities over all other native types available during fall and winter in west Texas. Davis et al. (1979) also reported that sites dominated by grass were preferred cover for loafing during cool seasons. Tall grasses apparently provide better visual concealment and physical protection than does shinnery oak after leaf drop.

Forbs

Plant communities with high percentages of forbs are vital components of lesser prairie chicken habitat through direct and indirect provisions of foods. Published studies of food habits (Jones 1963, Crawford and Bolen 1976, Davis et al. 1979) reveal that the seeds, leaves, shoots, and flowers of forbs comprise 10-70% of the adult diet in a given season and area. Forb communities support higher populations of insects than other vegetational types (Jones 1963), and insects provide an additional major portion of the annual diet of adults. Broods are dependent on insects as the major source of food. No single forb species assumes a major role in providing food for lesser prairie chickens, so we believe that high diversity of forb species is reasonable as a goal in habitat management.

Shrubs

With the exception of sand sagebrush, shrubs rarely provide important nesting cover. Sand sagebrush may substitute for tall grasses when these plants are unavailable (Taylor and Guthery 1980*b*).

Tall shrubs or small trees provide habitat for loafing during the heat of summer (Copelin 1963). Copelin suggested shade was critical when temperatures reached or exceeded 23.5 C and soils were dry. He felt shade provided by shrubs and trees was most essential during drought.

The major contribution of shrubs, however, is the foods they supply (see Jones 1963, Crawford and Bolen 1976, Davis et al. 1979). Leaf galls, catkins, leaves, and acorns of shinnery oak may comprise as much as 70% of the seasonal diet. The leaf and flower buds of fragrant sumac (*Rhus aromatica*) and the leaves of sand sagebrush also may be important in the winter. Thus, key shrubs in lesser prairie chicken habitat management are shinnery oak, fragrant sumac, and sand sagebrush.

EFFECTS OF SHINNERY OAK CONTROL

Although lesser prairie chickens require additional components in their habitat, most notably lek sites, we believe that tall grasses, forbs and forb-dominated communities, and key shrubs are the essential considerations in shinnery oak control programs.

Biological Agents

McIlvain (1956) reported that goats have successfully controlled oaks in the Southwest when stocked at 7.5 animals/ha. However, overuse of grasses and forbs may occur at such heavy stocking rates, and this practice appears generally inimical to lesser prairie chicken habitat.

Fire

Fire only temporarily suppresses shinnery oak and may negatively affect lesser prairie chicken habitat management. Yields of grass the first 2 years after a burn may increase as much as 45 (McIlvain and Armstrong 1966) to 72% (Gould and Hebel 1970). However, Gould and Hebel found no increase in production after burns during years of low rainfall. Yields of little bluestem decreased after a burn regardless of precipitation. Lower little bluestem yields could reduce the quality of lesser prairie chicken nesting cover during the 1st post-burn spring. Concurrently, other grasses have not had enough time to regrow and provide alternative nesting cover. Reduced oak canopy removes brood cover and potentially could reduce chick survival. Years of low rainfall would magnify problems created by a lack of cover. If growing conditions are suitable, winter cover and 2nd year post-burn nesting cover should increase substantially. Forb production may increase after the burn because of increased soil nutrients and water availability, thereby potentially increasing lesser prairie chicken food supplies. However, shinnery oak acorn production fails in the 1st year post-burn.

After the 1st 2 post-burn years, yields of grasses and forbs decline to pre-treatment levels and shinnery oak density and canopy cover are higher than pre-treatment levels (Wiedeman and Penfound 1960). Thus, fire as a control for shinnery oak requires application every 3rd year (McIlvain and Armstrong 1966). The danger of wind erosion and the short-term effects make fire a tool of limited usefulness in management of shinnery oak communities.

Chemicals

Phenoxy herbicides.--Scifres (1972) found that 0.6 kg/ha of silvex boosted grass production on treated areas 350% over untreated areas the 1st year after application. Production the 2nd year was 427 kg/ha on treated areas compared to 191 kg/ha on untreated areas. Scifres also found that 2,4,5-T and 2,4-D did not increase grass yields the 1st year of application. Increases in yield of 110% for 2,4-D and 260% for 2,4,5-T were achieved the 2nd year. Similarly, Robison and Fisher (1968) found production increased 1,370 kg/ha the 1st year after 0.6 kg/ha of silvex was applied. However, grass production declined rapidly within 2 or 3 years after application as shinnery oak resprouted. These studies suggest that nesting and winter cover of lesser prairie chickens can be improved with phenoxy herbicides. Unfortunately, these chemicals generally reduce forb density. Also, McIlvain and Armstrong (1968) reported that 90% of existing sand sagebrush, and sand plum (*Prunus angustifolia*), and fragrant sumac were killed when 1.2 kg/ha of silvex was applied in consecutive years. Loss of forbs and key shrubs diminishes food supplies.

Picloram.--Scifres (1972) found that picloram applied at a rate of 0.6 kg/ha reduced shinnery oak densities 57% the 1st year of application. Grass production was not increased, however. Oak densities and grass production were similar between treated and untreated plots the 2nd year after application. Thus, lesser prairie chicken habitat was unaltered by picloram at this rate, except for a short-term loss of shinnery oak.

Pettit (1979) applied picloram at rates of 1, 3, 5, and 7 kg/ha. The chemical controlled 25% of the shinnery oak production and increased grass production about 260% at the 1 kg/ha rate. Forb production was unchanged at this rate the 2nd year after application. Thus, lesser prairie chicken nesting and winter cover was improved without eliminating shinnery oak and forbs. At rates higher than 1 kg/ha, picloram controlled 90% of the shinnery oak and grass yields increased from 150 kg/ha to 700 kg/ha. Forb production also increased 1 to 4 fold at the higher rates. Sand sagebrush resprouted and invaded open areas at all rates of picloram application, thereby maintaining frequencies equal to untreated areas. The major drawback of rates higher than 1.0 kg/ha was the loss of shinnery oak as a cover component and food source.

Tebuthiuron.--Pettit (1979) also studied the effects of a new urea compound (tebuthiuron) on shinnery oak communities. This chemical effectively root-killed 90% of the shinnery oak at rates of 1, 3, 5, and 7 kg/ha. Grass yields increased from 150 kg/ha on untreated plots to 800 to 1,000 kg/ha on treated plots the 1st year. Second year yields were 750 kg/ha on 1.0 kg/ha areas and 1,400 kg/ha for other treatment levels. However, rates higher than 1.0 kg/ha killed little bluestem and other important cover species for lesser prairie chickens and allowed annual grasses to increase. Yields of forbs and frequency of sand sagebrush were reduced after tebuthiuron applications at all rates tested. Complete loss of shinnery oak and partial loss of forbs and sand sagebrush limited both the diversity of lesser prairie chicken habitat and winter food supplies. However, all treatment rates would apparently improve nesting and winter cover.

Pettit and Jones (pers. comm.) found that 0.4 kg/ha of tebuthiuron apparently controls 90% of the shinnery oak and increases grass yields from 200 kg/ha in untreated areas to 1,200 kg/ha in treated areas without affecting forb densities.

RECOMMENDATIONS

Herbicides can substantially improve nesting and winter cover of lesser prairie chickens by increasing tall grass production. On areas managed solely for lesser prairie chickens, any of these chemicals could be applied, regardless of its impact on associated forbs and shrubs, when treated and untreated areas were interspersed. However, picloram appears to be the most desirable herbicide for use within lesser prairie chicken range because it has a minor or positive impact on forbs and sand sagebrush following the 1st year of application.

Because about 95% of currently occupied lesser prairie chicken range is on private land (Taylor and Guthery 1980*b*), recommendations for shinnery oak control must be compatible with ranch management objectives. Indeed, practices mutually benefitting ranch profits and lesser prairie chicken populations must be sought. We propose the following guidelines for shinnery oak managmeent on private land as best to reach the mutual goals of profits and prairie chickens:

1. Perennial grasses must be present in the understory before application of herbicides for shinnery oak control. If perennial grasses are not present in the understory, suppression of shinnery oak produces herbaceous communities dominated by false buffalograss (*Munroa squarrosa*), sand dropseed (*Sporobolus cryptandrus*), and three-awns (*Aristida* spp.)(Pettit pers. comm.). With the exception of sand dropseed, these species are of little value to either lesser prairie chickens or livestock. Moreover, the cost of applying herbicides necessitates a quick response by valuable forage grasses or the operation cannot be economically feasible.

2. Partial control of shinnery oak should be practiced. Eradication of shinnery oak may destabilize habitat. Droughts are not uncommon on the Southern Great Plains and, even under conscientious grazing management, severe depletion of vegetative cover could occur during a series of dry years. This would accentuate wind erosion problems on the sandy lands occupied by shinnery oak if the plant was extirpated. Moveover, foliage of shinnery oak supplements the diet of cattle and assumes greater importance in drier years. Maintenance of some oak is beneficial to stabilize forage production, control wind erosion, and improve lesser prairie chicken habitat.

The methods of control to maintain some oak and the optimum level of oak control to achieve are unclear. We suspect that elimination of

50-70% of the shinnery oak would be acceptable, but the literature gives no indication of how to achieve the desired level of control. However, picloram applied in the spring at rates of 1 and 2 kg/ha controlled 25 and 90%, respectively, of the shinnery oak (Pettit 1979). Perhaps an intermediate rate of application would result in intermediate control of the oak.

3. Shinnery oak control treatments should occur as rotations on large blocks (150 to 300 ha) of land. We realize that this guideline is contrary to the standard recommendations of strip patterns or small treatments. We make the recommendation because it is a reasonable compromise between the habitat requirements of lesser prairie chickens and the realities of private land management. Lesser prairie chickens are relatively mobile (Sell 1979, Taylor and Guthery 1980*a*) and thus are better able to adjust their range than many gallinaceous birds. Moreover, control of large blocks of land is more economical to accomplish. Treatment of different blocks in different years could easily be incorporated into ranch management plans and it would leave new treatments, old treatments and, during early years, some untreated habitat available to lesser prairie chickens.

CONCLUSION

Much of the information in this paper is speculative. However, it represents our best efforts based upon existing knowledge. We believe application of these recommendations will improve lesser prairie chicken habitat and that increased population density will be the ultimate product.

LITERATURE CITED

Cannon, R. W. 1980. Current status and approaches to monitoring populations and habitat of lesser prairie chickens in Oklahoma. M.S. Thesis. Oklahoma State Univ., Stillwater. 62pp.

Copelin, F. F. 1963. The lesser prairie chicken in Oklahoma. Okla. Wildl. Conserv. Dept. Tech. Bull. 6. 58pp.

Crawford, J. A. 1974. The effects of land use on lesser prairie chicken populations in West Texas. Ph.D. Thesis. Texas Tech Univ., Lubbock. 69pp.

________, and E. G. Bolen. 1976. Fall diet of lesser prairie chickens in West Texas. Condor 78:142-144.

Davis, C. A., T. Z. Riley, R. A. Smith, H. R. Suminski, and M. D. Wisdom. 1979. Habitat evaluation of lesser prairie chickens in eastern Chaves County, New Mexico. Dept. Fish and Wildl. Sci., N. Mex. Agric. Exp. Sta., Las Cruces. 141pp.

Donaldson, D. D. 1969. Effect on lesser prairie chickens of brush control in western Oklahoma. Ph.D. Thesis. Oklahoma State Univ., Stillwater. 80pp.

Gould, W. L., and C. H. Hebel. 1970. Control of shinnery oak, mesquite, and creosotebush in New Mexico. USDA N. Mex. Inter-agency Range Comm. Rep. 4. 33pp.

Jackson, A. S., and R. DeArment. 1963. The lesser prairie chicken in the Texas Panhandle. J. Wildl. Manage. 27:733-737.

Jones, R. E. 1963. Identification and analysis of lesser prairie chicken habitat. J. Wildl. Manage. 27:757-778.

Litton, G. W. 1978. The lesser prairie chicken and its management in Texas. Texas Parks and Wildl. Dept. Booklet 7000-25. 22pp.

McIlvain, E. H. 1956. Shinnery oak can be controlled. Prog. Rep. 5502. Souther Great Plains Field Sta., Woodward, Okla. 4pp.

________, and C. G. Armstrong. 1958. Shinnery oak control by aerial spraying in the Southern Great Plains. Southern Great Plains Field Sta., Woodward, Okla. 5pp.

________. 1966. A summary of fire and forage research on shinnery oak rangelands. Tall Timbers Fire Ecol. Conf. 5:127-129.

Pettit, R. D. 1977. Sand shinnery oak. Noxious Brush and Weed Control Research Highlights, Texas Tech Univ. 8:8-9.

________. 1979. Effects of picloram and tebuthiuron pellets on sand shinnery oak communities. J. Range Manage. 32:196-200.

Robison, E. D., and C. E. Fisher. 1968. Chemical control of sand shinnery oak and related forage production. Pages 5-8 in Brush Research in Texas: 1968. Texas Agric. Exp. Sta. Consolidated Prog. Rep. 2583-2609.

Scifres, C. J. 1972. Herbicide interactions in control of sand shinnery oak. J. Range Manage. 25:386-389.

Sell, D. L. 1979. Spring and summer movements and habitat use by lesser prairie chicken females in Yoakum County, Texas. M.S. Thesis. Texas Tech Univ., Lubbock. 41pp.

Sperry, O. E., J. W. Dollahite, G. O. Hoffman, and B. J. Camp. 1964. Texas plants poisonous to livestock. Texas Agric. Exp. Sta. Bull. 1028. 59pp.

Taylor, M. A., and F. S. Guthery. 1980*a*. Fall-winter movements, ranges, and habitat use of lesser prairie chickens. J. Wildl. Manage. 44:521-524.

________. 1980b. Status, ecology, and management of the lesser prairie chicken. USDA For. Serv. Gen. Tech. Rep. RN-77. 15pp.

Wiedeman, V. E., and W. T. Penfound. 1960. A preliminary study of the shinnery oak in Oklahoma. Southwestern Nat. 5:117-122.

LIVETRAPPING FEMALE PRAIRIE CHICKENS ON SPRING LEKS[1]

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Abstract: Four capture techniques were tested on female lesser prairie chickens (*Tympanuchus pallidicinctus*) on spring leks in eastern New Mexico, 1976-78. Cannon nets were most efficient (2.6 man-days/female captured) and easiest to use; best results occurred when nets were placed in the center of a lek with cannons mounted at a low (20°) vertical angle. Cannon netting on a lek was suspended after 2-3 firings to avoid undue interference with copulation. Vertical mist nets were inefficient (16.8 man-days/female captured); inclined mist nets and baited drop nets were unsuccessful.

In a 3-year study of lesser prairie chickens (*Tympanuchus pallidicinctus*) in eastern New Mexico, it was necessary to capture large numbers of prenesting females on spring leks. Because females visit spring leks predictably for only a short period (Jones 1964, Campbell 1972, Crawford and Bolen 1975) and in small numbers (Copelin 1963, Campbell 1972), we needed to use efficient techniques to capture wary females without affecting survival or the subsequent probability of copulation.

None of the techniques described in the literature seemed optimum. Use of cannon nets (Dill and Thornsberry 1950, Dill 1969) was considered an efficient means of capturing grouse on leks (Peterle 1956, Dalke et al. 1963, Viers 1967, Watt 1969, Wallestad, 1975, R.K. Anderson, personal communication), but disrupted display and copulatory activities when used excessively (Dalke et al. 1963, Viers 1967, Silvy and Robel 1968, F.N. Hamerstrom, Jr., personal communication). Inclined mist nets (Silvy and Robel 1968), vertical mist nets (Campbell 1972), and bownets and noose carpets (Anderson and Hamerstrom 1967) did not alter prairie chicken behavior on leks, but efficiency of capture was questionable. Drop nets over grain bait (Jacobs 1958) were successful on prairie chicken leks in Wisconsin (J. Toepfer, personal communication), but our birds apparently had no previous experience feeding on concentrated or artificial (agricultural grain) food sources. Finally, the use of a helicopter-mounted net (W.C. Brownlee, personal communication) seemed promising, but the technique was abandoned after several dangerous spin-outs (body revolving with blades) with a Bell G3B1.

Because of our experiences and vague literature, we tested 4 capture techniques to identify the most efficient. Generally, each technique was used during mid-March through late April to encompass seasonal peaks in female visits to leks (Copelin 1963, Jones 1964, Crawford and Bolen 1975) and during the 1st 3 hours of daylight, when daily activities at leks peaked.

RESULTS AND DISCUSSION

Cannon nets captured the largest number of females, and were the most efficient, requiring only 2.6 man-days[6] per female captured (Table 1).

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[6]A man-day is the trapping effort of 1 person on 1 day. This includes the set-up, take-down, and maintenance of nets, as well as the use of the net on a lek, and travel to and from the trap site.

Table 1. Relative efficiency and percentage mortality of each technique used to livetrap female lesser prairie chickens on spring leks, 1976-78.

Technique	Number of man-days	Number of females captured	Trapping efficiency: No. man-days/female captured	%Trapping mortality
Cannon net	101	39	2.6	3%
Vertical mist net	151	9	16.8	0%
Inclined mist net	5	0	-	-
Baited drop net	23	0	-	-

These nets were easiest to prepare, to maintain, and to operate and required only 1 worker per net. The nets could be left in place indefinitely until fired or until a change in trapping location was desired. Best results were obtained on lek territories occupied by the central, dominant males (Robel 1966:329, Hamerstrom and Hamerstrom 1973: 17-19). Relatively large numbers of females visited the central territories and often congregated at specific locations ("hen spots"). Hen spots were usually in scattered, low cover if present.

The folded net lay flat and both sexes tended to ignore it. One group of 4 females established a temporary hen spot on the net. Placement of the net in or beside the territories of the dominant males, with no apparent negative response from either males or females, enabled multiple captures of up to 5 females.

Before firing the net, the observer had to decide whether the hen was within the area that would be covered by the falling net. The outer perimeter of net extension was marked with stones and/or twigs, and the blind was placed at the edge of the lek in direct view of the markers. Only 7 of 46 hens escaped intended capture. Most of the 7 were missed early in the study; alteration of the vertical angle for mounting the cannons increased efficiency of capture. Best results were obtained when the cannons were pointed at about waist height of a worker 5 steps away. Aiming the cannons higher allowed some birds to fly from under the net before it settled to the ground. Lowering the cannons reduced the tendency to jerk the back edge of the net off the ground (this allowed 1 hen to escape) and to rebound onto the net. Pieces of inner tube on the anchor lines aided in alleviating both of these problems. After all adjustments were made, only birds standing near the net's projected boundaries and facing away from the cannons had an opportunity to escape the net by flying. Lowering the angle of the cannons as prescribed did not result in injury to the birds.

Because long-term trapping with cannon nets on a lek can alter bird behavior (Dalke et al. 1963, Viers 1967, Silvy and Robel 1968, F. N. Hamerstrom, personal communication) and thus interfere with copulation, we temporarily discontinued cannon-netting on each lek after 2 or 3 firings.

Used in the above manner, cannon nets apparently interfered little with lekking behavior. During the peak period of female visitation (1st 2 weeks of Apr), males typically returned to the lek within ½-hour after the net was fired, and displayed in the usual manner (Scott 1950, Copelin 1963, Jones 1964, Sharpe 1968). When the net was fired 2 or more hours after sunrise or when it was fired early or late in the breeding season (before or after the peak period of female visitation), males sometimes did not return to the lek until the next morning, but suffered no apparent disruption in social dominance or breeding. The dominant, interior males, which perform most of the successful copulations (Robel 1970), apparently retained their dominance and were observed to copulate successfully after cannons had been fired on the lek.

Only 2 of 25 nests of females trapped with cannon nets and subsequently radio-marked produced an entire clutch of infertile eggs; this partially supports the belief that cannon-netting did not disrupt fertilization.

Nine females were captured in vertical mist nets (Campbell 1972), but the technique was inefficient (Table 1). Two or 3 workers were needed to erect and dismantle the nets daily to avoid problems caused by livestock, wind, and non-target species. Erecting the nets had to be accomplished in early morning darkness; the nets and poles were bulky and awkward to handle, particularly under the windy conditions that often occurred later in the morning when nets were being dismantled.

Vertical mist nets usually were placed near the center of the lek. Attempts to flush females into the nets were made from blinds (1 to 4 blinds per net) placed approximately 10 m opposite the nets. Females usually flew around or over the nets. Occasionally, females flew into the nets but did not become entangled. Because each female was flushed independently (only one was in best position for capture at a given moment), multiple captures were precluded.

The low success in capture was primarily a function of hen wariness; females recognized and avoided the vertical nets as they flushed. Males commonly entangled themselves in the nets, even when no attempts were made to flush the birds. The ensuing disturbance required to free males usually ended trapping for the morning. When disturbed (flushed) by the sight of workers, females seldom returned to the lek the same morning except occasionally during the period of peak female visitation.

Four females were captured in vertical mist nets at livestock watering tubs adjacent to leks following morning display periods during the dry spring of 1976. At each tub, a mist net was erected in a V-shape partly enclosing the tub and the birds were flushed from the rim of the tub into the net.

Problems of assembly and disassembly of inclined mist nets (Silvy and Robel 1968) were similar to problems encountered with vertical mist nets. The inclined mist nets reduced the potential trapping area by ½ because females could only be flushed into the net from 1 side (they could be flushed into vertical mist nets from either side). Although inclined mist nets were not tested as thoroughly as the other nets, limited use during the 1st spring (1976) was discouraging. Females were reluctant to walk under or near the nets, and none came sufficiently close to the nets for us to attempt to capture them (Table 1). Watt (1969) also found inclined mist nets inefficient for use in capturing female greater prairie chickens on spring leks.

Drop nets baited with corn and milo (Jacobs 1958) on spring leks (Copelin 1963, J. Toepfer, personal communication) were used in 1976 without success (Table 1). Both sexes were wary of the nets, and no birds fed on the grain. The birds may have been unfamiliar with grain as a food source.

Eighty-five percent of the females were captured during the 1st 2 weeks of April, although we manned nets on leks from mid-March to late April. This agrees closely with results in western Texas (Crawford and Bolen 1975), that showed 82% of all visits to spring leks by female lesser prairie chickens occurred during the 1st 2 weeks of April. Female visits to spring leks by other lekking grouse occur during similar short periods (Scott 1942, Klett 1957, Lumsden 1965 and 1968, Robel 1970, Pepper 1972, Hamerstrom and Hamerstrom 1973, Jenni and Hartzler 1978, Wiley 1978), although dates vary with locality. Efficient capture of large numbers of females visiting leks can be accomplished using cannon nets as described in this paper with minimal effect on behavior and copulation at the leks.

LITERATURE CITED

Anderson, R. K., and F. Hamerstrom. 1967. Hen decoys aid in trapping cock prairie chickens with bownets and noose carpets. J. Wildl. Manage. 31:829-832.

Campbell, H. 1972. A population study of lesser prairie chickens in New Mexico. J. Wildl. Manage. 36:689-699.

Copelin, F.F. 1963. The lesser prairie chicken in Oklahoma. Okla. Dept. Wildl. Conserv. Tech. Bull. 6. 58pp.

Crawford, J.A., and E. G. Bolen. 1975. Spring lek activity of the lesser prairie chicken in west Texas. Auk 92:808-810.

Dalke, P.D., D.B. Pyrah, D.C. Stanton, J.E. Crawford, and E. F. Schlatterer. 1963. Ecology, productivity, and management of sage grouse in Idaho. J. Wildl. Manage. 27:811-841.

Dill, H.H. 1969. A field guide to cannon net trapping. U.S. Fish and Wildl. Serv. 18pp.

_________, and W.H. Thornsberry. 1950. A cannon-projected net trap for capturing waterfowl. J. Wildl. Manage. 14:132-137.

Hamerstrom, F.N., Jr., and F. Hamerstrom. 1973. The prairie chicken in Wisconsin. Wis. Dept. Nat. Res. Tech. Bull. 64. 52 pp.

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

Jenni, D.A., and J.E. Hartzler. 1978. Attendance at a sage grouse lek: implications for spring censuses. J. Wildl. Manage. 42:46-52.

Jones, R.E. 1964. The specific distinctness of the greater and lesser prairie chickens. Auk 81:65-73.

Klett, A.T. 1957. Banding and marking methods in studying seasonal movements of the sharp-tailed grouse in Morton County, North Dakota. M.S. Thesis, Utah St. Univ., Logan. 53 pp.

Lumsden, H.G. 1965. Displays of the sharp-tailed grouse. Ont. Dept. Lands and Forests, Res. Rep. (Wildl.). 68 pp.

_________. 1968. The displays of sage grouse. Ont. Dept. Lands and For. Res. Rep. (Wildl.) 83. 94pp.

Pepper, G.W. 1972. The ecology of the sharp-tailed grouse during spring and summer in the aspen parklands of Saskatchewan. Sask. Dept. Nat. Res. Wildl. Rep. 1. 56pp.

Peterle, T.J. 1956. Trapping techniques and banding returns for Michigan sharp-tailed grouse. J. Wildl. Manage. 20:50-55.

Robel, R.J. 1964. Quantitative indices to activity and territoriality of booming Tympanuchus cupido pinnatus. Trans. Kans. Acad. Sci. 64: 702-712.

_________. 1966. Booming territory size and mating success of the greater prairie chicken (Tympanuchus cupido pinnatus). An. Behav. 14: 328-331.

_________. 1970. Possible role of behavior in regulating greater prairie chicken populations. J. Wildl. Manage. 34:306-312.

Scott, J.W. 1942. Mating behavior of the sage grouse. Auk 59:472-498.

_________. 1950. A study of the phylogenetic or comparative behavior of three species of grouse. Annals, N.Y. Acad. Sci. 51:1062-1073.

Sharpe, R.S. 1968. The evolutionary relationships and comparative behavior of prairie chickens. Ph.D. Thesis, Univ. Nebraska, Lincoln. 230pp.

Silvy, N.J., and R.J. Robel. 1968. Mist nets and cannon nets compared for capturing prairie chickens on booming grounds. J. Wildl. Manage. 32:175-178.

Viers, C.E. 1967. Home range and movements of the greater prairie chicken (Tympanuchus cupido pinnatus) with notes on activities. M.S. Thesis, Kansas St. Univ., Manhattan. 70pp.

Wallestad, R. 1975. Life history and habitat requirements of sage grouse in central Montana. Mont. Dept. Fish and Game. 65pp.

Watt, P.G. 1969. Mobility patterns, habitat relationships and reproductive success of greater prairie chickens (Tympanuchus cupido pinnatus) in northeastern Kansas. M.S. Thesis, Kansas St. Univ., Manhattan. 118pp.

Wiley, R.H. 1978. The lek mating system of the sage grouse. Sci. Amer. 213:114-125.

DISTRIBUTION AND NUMBERS OF GREATER PRAIRIE CHICKENS IN OKLAHOMA

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Abstract: Distribution and numbers of greater prairie chickens (Tympanuchus cupido pinnatus) in Oklahoma were estimated during a 2-year study (1977-79). An estimated 8,415 birds occupied 6,100 km^2 in 13 northeastern counties. Although status varied in counties occupied by prairie chickens, the general trend indicated a 42% decrease in occupied range and 34% decrease in numbers since 1943. The population can be divided into a relatively stable western component and a rapidly declining eastern component. Declines in the eastern component appear related to more intensive agricultural development in those counties.

The geographic range of the greater prairie chicken (Tympanuchus cupido pinnatus) historically included portions of Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Missouri, Nebraska, Ohio, Oklahoma, and Texas (Baker 1953, Johnsgard 1975) and may have extended eastward into extreme western Pennsylvania (Schwartz 1945). In the early 1900's, greater prairie chickens increased in response to the abundant winter foods provided by the agricultural practices of settlers. However, as native tall grass prairie disappeared with tillage, numbers of prairie chickens decreased (Duck and Fletcher 1944, Mohler 1952, Hamerstrom and Hamerstrom 1961, Aldrich 1963, Evans and Gilbert 1969).

In Oklahoma, the greater prairie chicken coexisted with lesser prairie chickens (T. pallidicinctus), sharp-tailed grouse (Pediocetes phasianellus), and sage grouse (Centrocercus urophasianus) in the early 1900's (Nice 1931). Greater prairie chickens were abundant throughout the eastern two-thirds of the state and reached peak numbers around the early 1900's (Duck and Fletcher 1944). By 1925, habitat destruction resulting in loss of rangeland had severely reduced the population in many counties. Prairie chicken populations continued to decline in distribution and population levels through 1958 (Jacobs 1959). This paper describes the current distribution and population numbers of greater prairie chickens in Oklahoma based upon information collected from October 1977 to June 1979.

[1]Oklahoma Department of Wildlife Conservation, Oklahoma State University, U. S. Fish and Wildlife Service, and Wildlife Management Institute, cooperating.

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METHODS

Questionnaires were mailed during fall, 1977 to Game Rangers, Area Managers, and Biologists of the Oklahoma Department of Wildlife Conservation. Background requests included geographical area of responsibility and length of time having worked in the area. Biological considerations included the location of flocks and the approximate number of birds in each, stability of the population, and designation of areas thought to possess increasing or decreasing populations. We asked individuals to comment about factors believed to be limiting populations of prairie chickens in the area.

Recipients of questionnaires were asked to identify landowners who might be approached concerning additional information about flocks. Farmers and ranchers were contacted initially during winter 1977, while others were contacted during spring, 1978 and 1979. Information collected from these individuals included locations of flocks and population estimates. We collected supplemental information with field visits during both springs.

Cumulative population data were plotted on detailed county road maps. Information was compiled to provide a distribution and nonstatistical estimate of numbers for each county. Areas providing "potential" habitats were excluded.

Field investigations using ground counts and aerial surveys were conducted on 7 selected study areas during the spring 1978 and 1979 to determine lek densities (Martin and Knopf, ms). These observations were used for comparison with estimated population numbers of prairie chickens on each study area. Population estimates from data generated by interviews were available for 3 study areas exclusively. Estimates of population numbers on the remaining 4 study areas were calculated from estimates on areas larger than each specific study area.

RESULTS

A spring population of 8,415 greater prairie chickens currently inhabits 6,100 km^2 in Oklahoma. The largest continuous distribution is in eastern Kay and northwestern Osage counties (Fig. 1). Kay County supports 500 birds on 730 km^2 and Osage County maintains 3,000 birds on 1,690 km^2.

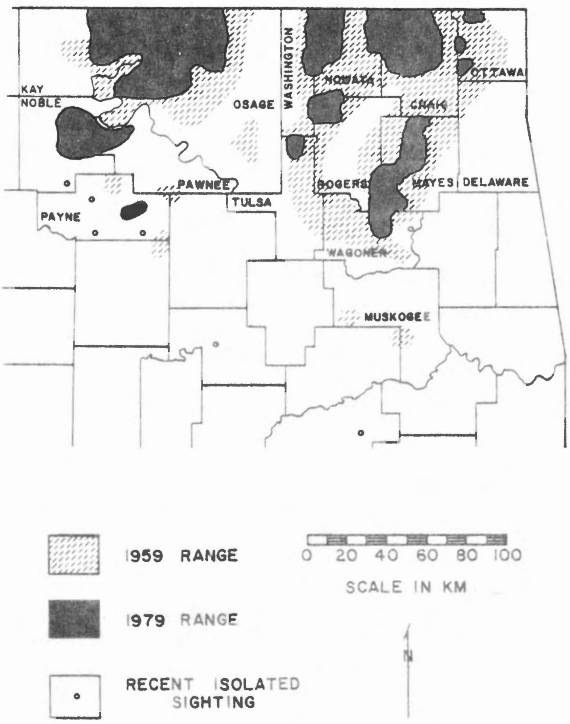

Fig. 1. Distribution of the greater prairie chicken in northeastern Oklahoma.

Several scattered "populations" occur elsewhere in the state. The population in Noble and Pawnee counties includes 1,150 birds that range over 665 km^2. The larger populations occurring predominantly in Craig, Mayes, Rogers, and Nowata counties include 3,100 birds collectively over a 2,745 km^2 range. An additional 615 birds occur on 270 km^2 in isolated populations in Payne, Tulsa, and Ottawa counties.

Comparisons of these data with intensive field investigations indicated study areas 1,5, and 8 were reported to possess 200, 50, and 100 birds, respectively. Field investigations revealed 163, 64, and 120 birds for these areas, respectively. Areas 2 and 3 were estimated at possessing 74 birds each from average estimates for Osage County. Field investigations reported 75 and 38 birds, respectively. Areas 4 and 7 were estimated to contain 64 and 47 birds, respectively, however, intensive surveys indicated 8 and 127 birds, respectively.

DISCUSSION

Geographic Range

The range of the greater prairie chicken in Oklahoma has declined to a portion of that described in 1943 (Table 1) by Duck and Fletcher (1944) and in 1958 (Fig. 1) by Jacobs (1959). The estimate of occupied range in the state was reduced 42% from 10,530 km^2 in 1943 to 6,100 km^2 in 1979.

Table 1. Comparison of the historical and contemporary (1979) estimates for range and population numbers of the greater prairie chicken in Oklahoma.

County	Historical summary (1944)		Current status (1979)		Percentage change	
	Population	Range (km^2)	Population	Range (km^2)	Population	Range
Craig	3,348	440	1,000	875	-70	+99
Kay	--	--	500	730	+	+
Mayes	1,346	870	450	585	-66	-33
Muskogee	70	1,077	--	--	-100	-100
Noble	--	--	750	480	+	+
Nowata	1,689	1,295	800	605	-53	-53
Osage	2,958	2,590	3,000	1,690	+1	-35
Ottawa	821	492	550	115	-33	-77
Pawnee	176	780	400	185	+127	-76
Payne	165	922	15	80	-91	-91
Rogers	1,206	96	350	340	-71	+254
Tulsa	70	388	100	75	+43	-81
Wagoner	566	700	200	130	-65	-81
Washington	240	880	300	210	+25	-76
Total	12,655	10,530	8,415	6,100	-34	-42

In the western portion of the range, greater prairie chicken populations appear stable. The Osage County range of 1,690 km^2 corresponds to that of 1958, whereas it represents a 35% decrease from 1943. The birds in Noble County were not reported in either of the earlier studies, and residents feel that chickens 1st appeared during the last 10-15 years. Pawnee and Payne counties demonstrated decreases in range of 76% and 91%, respectively. Greater prairie chickens were not reported in Kay County in 1943, although Jacobs illustrated a 1958 distribution there larger than the current range.

For the eastern part of the state, greater prairie chickens occupy only scattered remnants of the range reported by Jacobs (1959). Increases of 99% in Craig County and 254% in Rogers County since 1943 were noted. However, these increases were exceptions. Thirty-three to 81% reductions in range were seen in Mayes, Nowata, Ottawa, Tulsa, Wagoner, and Washington counties since 1943. The decline in these 6 counties totals over

2,900 km^2. Few prairie chickens were located in Muskogee County despite a 1,077 km^2 range in 1943.

Population Levels

Populations of greater prairie chickens decreased from estimates made in 1943 (Table 1) by Duck and Fletcher (1944). A statewide population of 12,655 birds in 1943 decreased 34% to a minimum of 8,415 birds in 1979. For the western portion of the range numbers of birds remained relatively stable in Osage County, while population gains in Kay, Noble, and Pawnee counties more than offset losses in Payne County.

Fewer prairie chickens currently inhabit the eastern counties. Most counties showed major declines in prairie chicken numbers. The slight increases in population numbers reported for Tulsa and Washington counties were insufficient to compensate these major losses.

Factors Influencing Populations Since 1943

Estimates of prairie chicken densities in the literature vary from 1.9 birds/km^2 for greater prairie chickens in Missouri (Schwartz 1945) to 3.9 birds/km^2 for Attwater's prairie chickens in southern Texas (Lehmann 1941). Current densities of greater prairie chickens in Oklahoma average 1.4 birds/km^2, ranging from 0.2 birds/km^2 in Payne County to 4.8 birds/km^2 in Ottawa County.

Declining populations of greater prairie chickens are often attributed to changes in land-use practices. Rangelands are critical to the birds, and population densities appear to fluctuate with variations in the quantity and/or quality of rangelands (Schwartz 1945, Hamerstrom et al. 1957, Christisen 1969, Arthaud 1971). The current status of the bird in Oklahoma well illustrates its sensitivity to rangeland condition.

Osage County remains the stronghold for greater prairie chickens in Oklahoma due to the predominance of native rangeland. Private landholdings are large and often held as trusts. These ranches appear to be grazed under proper range management practices. The range expansion of prairie chickens into Noble County supports this belief. Prairie chickens appear to have colonized Noble County from Osage County, and their distribution in Noble County is also centered upon the locations of a few major landholdings managed predominantly as grazing operations.

The eastern component of the greater prairie chicken range in Oklahoma appears to be a deteriorating habitat. Private landholdings are small relative to the western component. Grazing operations are still common in the north, but native grasses are occasionally replaced by tame grasses. In the southern counties row cropping predominates, possibly favored also by greater topsoil depth. These practices result in a decline of habitat due to imbalances in the rangeland/agriculture ratio for greater prairie chickens.

LITERATURE CITED

Aldrich, J. W. 1963. Geographic orientation of American Tetraonidae. J. Wildl. Manage. 27:529-545.

Arthaud, F. L. 1971. Land-use and prairie chicken populations in southwestern Missouri. Trans. Kansas Acad. Sci. 73:267-276.

Baker, M. F. 1953. Prairie chickens of Kansas. Univ. Kansas Mus. Nat. Hist. State Biol. Surv. Misc. Publ. 5. 66pp.

Christisen, D. M. 1969. National status and management of the greater prairie chicken. Trans. N. Am. Wildl. Nat. Resour. Conf. 34:207-217.

Duck, L. G., and J. B. Fletcher. 1944. A survey of the game and furbearing animals of Oklahoma. Okla. Game and Fish Dept. State Bull. 3. 144pp.

Evans, K. E., and D. L. Gilbert. 1969. A method for evaluating greater prairie chicken habitat in Colorado. J. Wildl. Manage. 33:643-649.

Hamerstrom, F. N., O. E. Mattson, and F. Hamerstrom. 1957. A guide to prairie chicken management. Wisconsin Conserv. Dept. Tech. Bull. 15. 128pp.

______________, and F. Hamerstrom. 1961. Status and problems of North American grouse. Wilson Bull. 73:284-294.

Jacobs, K. F. 1959. Restoration of the greater prairie chicken. Okla. Dept. Wildl. Conserv. Div. Fed. Aid in Wildl. Restor., Proj. No. W-65. 42pp.

Johnsgard, P. A. 1975. North American game birds of upland and shoreline. Univ. Nebr. Press, Lincoln. 183pp.

Lehmann, V. W. 1941. Attwater's prairie chicken. Its life history and management. N. Am. Fauna 57. U. S. Gov. Print. Off., Washington. v + 65pp.

Mohler, L. L. 1952. Fall and winter habits of prairie chickens in southwest Nebraska. J. Wildl. Manage. 16:9-23.

Nice, M. M. 1931. The Birds of Oklahoma. Revised Edition. Okla. Biol. Surv. 3 (No. 1). 224pp.

Schwartz, C. W. 1945. The ecology of the prairie chicken in Missouri. The Univ. of Missouri Studies. 20:1-99.

DISTRIBUTION AND STATUS OF THE LESSER PRAIRIE CHICKEN IN OKLAHOMA[1]

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Abstract: The range, population size, and status of the lesser prairie chicken (Tympanuchus pallidicinctus) in western Oklahoma were determined during a 2 1/2 year study initiated in July 1977. The contemporary range includes several spatially isolated segments totaling 2,791 km^2; a decline of 55% in 20 years. Sand sagebrush (Artemisia filifolia) rangeland comprises 68% of the range and occurs primarily along the North Canadian (Beaver) River in Texas, Beaver, Harper, and Woodward counties. Shinnery oak (Quercus havardii) rangeland comprises most of the remaining range and occurs in Woodward, Ellis, Roger Mills, and Beckham counties. The spring population was estimated at 7,500 birds in 1979; 58% inhabited rangelands of sand sagebrush and 40% shinnery oak.

Historically, the lesser prairie chicken (Tympanuchus pallidicinctus) ranged over much of central and western Oklahoma (Copelin 1958, Sutton 1967). Population levels began declining in the early 1900's and have fluctuated dramatically (Davison 1935, 1940; Duck and Fletcher 1944; Copelin 1963). The last extensive survey that reported the population size and distribution of lesser prairie chickens in Oklahoma was conducted by Copelin (1958, 1963). The purpose of this study was to determine the contemporary range, population size, and status of the species in Oklahoma. We thank P. A. Vohs and J. A. Bissonette for advice on the study design and comments on the manuscript.

STUDY AREA

Lesser prairie chickens were reported (Copelin 1958, 1963) to inhabit parts of Beaver, Beckham, Blaine, Cimarron, Dewey, Ellis, Greer, Harper, Roger Mills, Texas, Woods, and Woodward counties. These counties occur primarily in the Grama-Buffalograss section of the Great Plains Shortgrass Prairie Province with some extensions eastward into the Bluestem-Grama Prairie section of the Tall-Grass Prairie Province (Bailey 1976). This study was confined to these counties because interviews with State Game Rangers and biologists indicated a considerable decrease in occupied range had occurred since Copelin's (1963) survey.

Within the study area, lesser prairie chicken habitats have traditionally included the Sand Sage Grassland and Shinnery Oak Grassland game types (Duck and Fletcher 1943). The Sand Sage Grassland game type occurs along the North Canadian (Beaver) River through the length of the Panhandle (Cimarron, Texas, and Beaver counties) and extending into Harper and Woodward counties. The Shinnery Oak Grassland game type is prominent in parts of Woodward, Ellis, Roger Mills, and Beckham counties. A few flocks extended into the Shortgrass Highplains and Mixed Grass Eroded Plains game types (Duck and Fletcher 1943) according to Copelin's (1963) survey. Detailed descriptions of the vegetative and life-form composition of lesser prairie chicken habitats in Oklahoma can be found in Copelin (1963), Jones (1963), and Donaldson (1969).

METHODS

A questionnaire was mailed to State Game Rangers and biologists located within the study area. Subsequent interviews with landowners combined with field verification of reported sightings provided the basis for determining current range and distribution of remaining populations. Population locations were plotted on county highway maps (8mm = 1 km) and area of occupied range was quantified with a Numonics model 1224 electronic digitizer.

Six 16-section (4,144 ha) study areas, 3 in Sand Sage Grassland and 3 in Shinnery Oak Grassland were established to determine density of

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displaying males within the larger remaining segments of the range of the species. During the springs of 1978 and 1979, each study area was searched for active leks along east-west transects approximately 0.8 km apart between daylight and approximately 2 hours after sunrise. The calls made by displaying males on leks were triangulated and plotted on topographic maps (Hamerstrom and Hamerstrom 1973) to aid in the location of active leks. Each lek was censused at least 3 times during April and the 1st week in May.

The density of displaying males on each study area was used to estimate the population size in adjacent, continuous rangeland. An adult sex ratio of 1:0.78, which is an average ratio from several lesser prairie chicken studies (Taylor and Guthery 1979), was used to estimate total population numbers. While no statistical estimate of population size can be obtained in this manner, the method has been used previously to evaluate prairie chicken population trends (Duck and Fletcher 1944; DeArment, personal communication). Because intensive study areas were located within good habitats rather than marginal sites, our estimates of population size may be biased upward.

RESULTS

The contemporary range of the lesser prairie chicken in western Oklahoma (Fig. 1) is comprised of several spatially isolated segments totaling 2,791 km^2 (Table 1). The predominant vegetative associations are Sand Sage Grasslands (68%) and Shinnery Oak Grasslands (32%). Occupied Sand Sage Grassland range occurs primarily along the North Canadian River in eastern Texas, Beaver, Harper, and northern Woodward counties. Occupied Shinnery Oak Grassland range occurs in scattered tracts across southern Woodward, Ellis, and Roger Mills counties. Approximately 5% of the range estimate for Sand Sage Grassland includes Shortgrass High Plains infested by sand sagebrush.

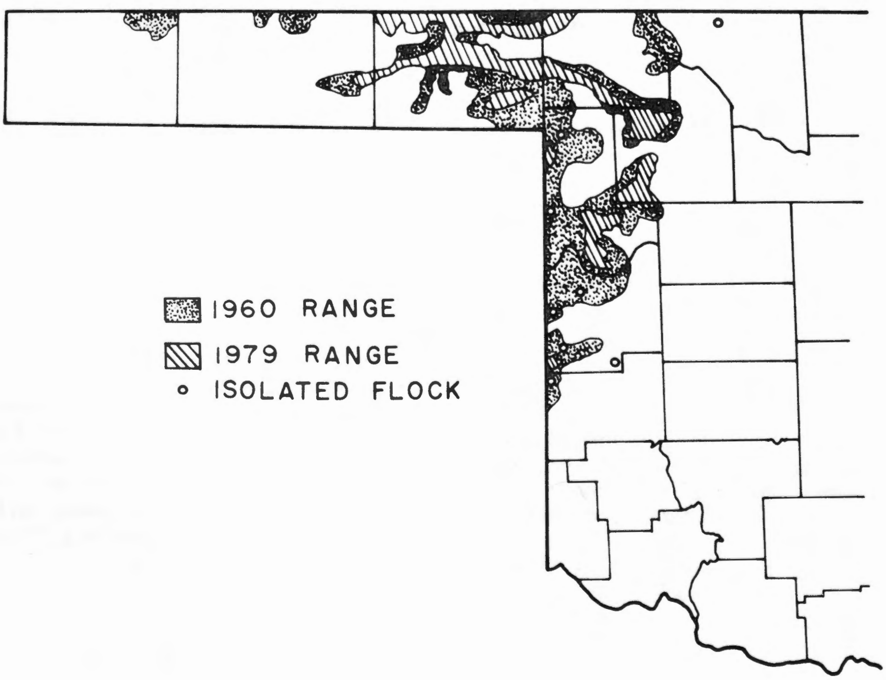

Fig. 1. Distribution of the lesser prairie chicken in western Oklahoma.

Table 1. Comparison of the historical (Duck and Fletcher 1944, Copelin 1963) and contemporary (1979) range (km^2) of the lesser prairie chicken in Oklahoma.

County	1944	1960	1979	Percentage reduction (1960 to 1979)
Beaver	1,803	1,515	1,182	21
Beckham	720	41	3	93
Blaine	0	10	0	100
Cimarron	998	86	0	100
Dewey	303	10	0	100
Ellis	1,736	2,169	461	79
Greer	207	10	0	100
Harper	715	368	350	5
Roger Mills	1,373	956	106	89
Texas	332	78	59	24
Woods	461	249	5	98
Woodward	1,495	733	625	15
Total	10,143	6,225	2,791	55

Our estimates of the number of lesser prairie chickens in Oklahoma in 1979 was approximately 7,500 birds, up 3% from the 1978 estimate (Table 2). Sand Sage Grassland supported 58% of the population, and Shinnery Oak Grassland supported 40%. Remnant flocks inhabiting relic tracts of the Mixed Grass Eroded Plains and Shortgrass High Plains comprised about 2% of the population.

DISCUSSION

The range of the lesser prairie chicken in Oklahoma has decreased approximately 55% since the study of Copelin (1963), and nearly 72% since the mid-1940's (Duck and Fletcher 1944). The majority of the remaining range lies within Roger Mills, Ellis, Woodward, Harper, and Beaver counties (Fig. 1). Prairie chicken range within the Shinnery Oak Grasslands of Ellis and Roger Mills counties has declined to a small fraction of historical levels. Occupied range in Sand Sage Grasslands in Woodward, Harper, and Beaver counties has also decreased, but only slightly in comparison. Small populations have disappeared in Blaine, Cimarron, Dewey, and Greer counties since Copelin's (1963) survey, while isolated populations persist in eastern Texas, northern Woods, and northwestern Beckham counties.

The current population estimate of 7,500 birds represents a decline of 50% from Copelin's (1963) spring 1960 estimate of 15,000 birds. Most of the present population inhabits parts of Beaver, Harper, Woodward, and Ellis counties (Table 2). Population size relative to Copelin's (1963) survey has declined in Ellis and Roger Mills counties, closely paralleling the loss in occupied range. Historical population estimates (Duck and Fletcher 1944) for the counties listed by Copelin (1963) also reflect this decline, with the exception of Beaver County. Duck and Fletcher's (1944) population estimate for Beaver County (Table 2) appears unrealistic when historical range estimates (Table 1) and flock locations (Copelin 1958, 1963) are considered.

Copelin (1963) expected that increases in rangeland acreage following his studies would have a favorable effect on lesser prairie chicken population levels in the 5 counties where the birds were most abundant. Since his survey, rangeland acreage in Beaver, Harper, Ellis, Woodward, and Roger Mills counties increased an average of 12% (USDA, SCS 1962, 1976). The actual change in rangeland acreage ranged from a decrease of 4% in Roger Mills County to an increase of 40% in Ellis County. The decreases in population numbers and distribution, especially in Ellis County, suggest that overgrazing or other land-use practices have adversely affected remaining flocks and compensated the "favorable" gains in rangeland acreage.

Within the current range, Shinnery Oak Grasslands support higher prairie chicken densities than Sand Sage Grasslands. These results support Copelin's (1963) earlier observations. However, Sand Sage Grassland appears to be a more stable habitat in Oklahoma since it is unsuited for row crop farming (Allgood et al. 1962) and proper stocking rates of cattle are necessarily low to support successful grazing operations (E.C. Snook, State Range Conservationist).

Although shinnery oak rangeland soils are subject to wind erosion, row cropping is possible in certain areas if minimum tillage techniques are employed (Cole et al. 1966). Shinnery Oak Grassland supporting prairie chickens occurs on large ranches where conversion to row cropping is

Table 2. Comparison of historical (Duck and Fletcher 1944) and contemporary estimated numbers of lesser prairie chickens in Oklahoma.

County	1944 survey	1978 Game Ranger and biologist survey	1978 estimate	1979 estimate	Percentage change 1944-1979
Beaver	445	2,000	3,408	3,492	+685
Beckham	228	20	25	20	- 91
Cimarron	50	0	0	0	-100
Dewey	268	0	0	0	-100
Ellis	7,500	3,000	1,046	1,681	- 78
Harper	855	500	735	542	- 37
Roger Mills	2,560	300	200	210	- 92
Texas		800	89	132	
Woods	50	20	20	40	- 20
Woodward	2,950	2,500	1,752	1,410	- 52
Total	14,906	9,140	7,275	7,527	

absent or minimal, and cattle grazing intensities are moderate by choice. Even though Shinnery Oak Grasslands can withstand row cropping and overgrazing somewhat better than soils in Sand Sage Grasslands (Allgood et al. 1962; Cole et al. 1966; Snook, personal communication), the former may be lost in the future if grazing intensity increases.

Most remaining populations of lesser prairie chickens occur on large blocks of privately owned, native rangeland. The complete absence of stable breeding populations on adjacent, smaller landholdings suggests that associated land-use practices are incompatible with the habitat requirements of the species. The future status of lesser prairie chickens in Oklahoma will reflect the practices of individual landowners, since few scattered populations remain on public lands. Current populations, although widely scattered and isolated, should remain stable provided that the large ranches: (1) remain intact, (2) support grazing operations primarily, and (3) are managed within proper grazing guidelines.

LITERATURE CITED

Allgood, F.P., J.L. Bohl, and M.O. Mitchell. 1962. Soil survey of Beaver County Oklahoma. Series 1959, No. 11. USDA, SCS, Oklahoma Agric. Experiment Sta. 80pp.

Bailey, R.G. 1976. Ecoregions of the United States. USDA U.S. Forest Service. Ogden, Utah. 75pp.

Cole, E.L., A.J. Conrad, and C.E. Rhoads. 1966. Soil Survey of Ellis County Oklahoma. Series 1961, No. 38. USDA, SCS, Oklahoma Agric. Experiment Sta. 81pp.

Copelin, F.F. 1958. Welfare status of the lesser prairie chicken in Oklahoma. M.S. Thesis. Oklahoma State University, Stillwater. 45pp.

__________. 1963. The lesser prairie chicken in Oklahoma. Okla. Wildl. Conserv. Dept. Tech. Bull. 6. 58pp.

Davison, V.E. 1935. Game Bird Project. Unpubl. Ms. Okla. Game and Fish Dept., Okla. City. 105pp.

__________. 1940. An 8-year census of lesser prairie chickens. J. Wildl. Manage. 4:55-62.

Donaldson, D.D. 1969. The effect on lesser prairie chickens of brush control in western Oklahoma. Ph.D.Thesis. Oklahoma State University, Stillwater. 80pp.

Duck, L.G., and J.B. Fletcher. 1943. A game type map of Oklahoma. Div. of Wildl. Restoration. Okla. State Game and Fish Dept., Okla. City. 1p.

__________. 1944. A survey of the game and furbearing animals of Oklahoma. Okla. Game and Fish Dept. State Bull. 3. 144pp.

Hamerstrom, F.N. and F. Hamerstrom. 1973. The prairie chicken in Wisconsin: Highlights of a 22-year study of counts, behavior, movements, turnovers, and habitats. Wisconsisn Dept. of Nat. Resour. Tech. Bull. 64. 52pp.

Jones, R.E. 1963. Identification and analysis of lesser prairie chicken habitat. J. Wildl. Manage. 27:757-778.

Sutton, G.M. 1967. Oklahoma birds. Univ. of Okla. Press. Norman. 674pp.

Taylor, M.A., and F.S. Guthery. 1979. Status, ecology, and management of the lesser prairie chicken. Texas Tech. Univ. College of Agric. Sci. Publ. T-9-000. 60pp.

USDA, SCS. 1962. Oklahoma conservation needs inventory. Stillwater.

USDA, SCS. 1976. Report on the Arkansas River basin in Oklahoma. M.A.I.D.S. data for Oklahoma.

SPRING-SUMMER FOODS OF LESSER PRAIRIE CHICKENS IN NEW MEXICO[1]

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Abstract: Spring and summer foods of lesser prairie chickens (*Tympanuchus pallidicinctus*) in eastern New Mexico were studied in 1976-78. Spring foods were mainly green vegetation (79% volume), especially shinnery oak catkins (32%). Shinnery oak acorns were also important (15% volume). Summer foods of adult-size birds were mostly insects (55%), especially grasshoppers (Acrididae and Tettigoniidae, 39%) and treehoppers (Membracidae, 10%). Use of green vegetation was down to 23%, but use of acorns rose to 21% in summer. Foods of chicks and young juveniles were 99 to 100% insects, especially grasshoppers (chicks 62%, young juveniles 88%). The shinnery oak-grassland community is important in providing prairie chicken foods. Large-scale eradication of this community should be avoided, but control of shinnery is needed in some areas to provide tallgrass cover for nesting and other uses.

Lesser prairie chickens (*Tympanuchus pallidicinctus*) occupy semi-arid grasslands that typically include a large component of shrubs, either shinnery oak (*Quercus havardii*) or sand sagebrush (*Artemisia filifolia*). A number of studies of habitat-use have been conducted in these communities, but few studies have included food habits. Jones (1963a, 1963b, 1964) studied food habits in each month in the sand sagebrush-grasslands of the Oklahoma panhandle. More cursory studies were conducted in shinnery oak-grassland by Davison (1935) and Martin et al. (1951) in western Oklahoma, by Frary (1957) in eastern New Mexico, and by Crawford (1974) and Crawford and Bolen (1976a, 1976b) in northwestern Texas.

We present results from a 3-year study (1976-78) of spring and summer food habits in shinnery oak-tallgrass in eastern New Mexico.

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STUDY AREA AND METHODS

The study area (15,500 ha) is in the Mescalero Sands, immediately west of the Caprock (western edge of the Llano Estacado), north of U.S. Highway 380 and south of U.S. 70. Located 65 km east of Roswell, the area is relatively isolated from cultivation.

About 90% of the study area is occupied by sandy, often duny soil that supports a shinnery oak-tallgrass community. Principal vegetation of this community includes shinnery oak, sand bluestem (*Andropogon hallii*), little bluestem (*Schizochyrium scoparium*), three-awn (*Aristida* spp.), dropseed (*Sporobolus* spp.), hairy grama (*Bouteloua hirsuta*), and a variety of forbs. Various degrees of degradation resulting from grazing by livestock occur in this community. Some locations, especially far from water, support heavy stands of climax species (sand bluestem and little bluestem) interspersed with shinnery oak while other areas have heavy stands of shinnery with sparse, heavily grazed bluestem cover.

The remaining 10% of the study area consists of flat expanses of clay soil supporting a shortgrass community occurring as scattered parcels within the expansive shinnery oak-tallgrass community. Principal species are blue grama (Bouteloua gracilis), buffalograss (Buchloe dactyloides), three-awn, broom snakeweed (Xanthlocephalum sarothrae), and forbs, especially croton (Croton spp.). In some areas, mesquite (Prosopis glandulosa) is a conspicuous invader.

Climate (Maker et al. 1971) is semi-arid and continental, with distinct seasons, wide daily and annual ranges in temperature, and plentiful sunshine. Nearly 3/4 of the annual precipitation ($\bar{X}$= 35.5 cm/yr) falls during May-October, mostly from brief but often intense thundershowers.

Prairie chickens were collected randomly from the shinnery oak-tallgrass community. Age of each bird collected was determined by techniques of Copelin (1963) and Campbell (1972). Age groups used to segregate birds for food habits were chicks (approx. 1-4 weeks), young juveniles (approx. 5-10 weeks), and adult-size (approx. 11 weeks and older). Birds were placed in groups by comparing weight and plumage with birds in radio-marked broods of known-age. Composition of the diet for each season and/or age group was determined by the aggregate percent method (Martin et al. 1946).

In all 3 years, the March-April diet was mostly green vegetation and the June-August diet mostly insects. Hence, these 2 periods were readily labelled spring and summer, respectively, in terms of prairie chicken diet. However, the May diet was springlike in 1976, but was summerlike in 1977 (no crops collected May 1978). The extensive use of insects (summerlike) in May 1977 apparently was due to high rainfall in March-April (2.39 cm, compared with 0.89 in 1976 and 0.78 for 30-year mean), resulting in earlier availability of insects. As a result of the annual variation in May foods, we recognize a typical spring diet occurring in March-April each year, plus May in years typical of spring food availability. The summer diet occurs in June-August of each year, plus May in years of early insect availability. Our designation of spring and summer periods in relation to lesser prairie chicken diet essentially parallels that of Davison (1935:87), who identified spring as "...the gobbling season from late February until the crop of insects are again available."

SPRING FOODS

The spring diet (Table 1) was mostly (78.7%) green vegetation, including shinnery oak catkins (31.8%) and wild buckwheat (Eriogonum annuum) leaves (20.1%). Shinnery acorns (15.5%) were important minor foods. Shinnery oak was the species used most in spring; its catkins, acorns, and leaves collectively composed 49.1% of the diet.

Availability of food sources played a large part in determining the spring diet. Shinnery oak was the most abundant plant present, composing 29.1 to 48.8% of the vegetation (Davis et al. 1979), and its catkins were readily available in spring. Insects were relatively scarce.

Table 1. Percentage composition of the spring diet (Mar-Apr 1976-78, plus May 1976) of lesser prairie chickens in eastern New Mexico, 1976-78, N=21.

Food item	Mean	Standard error
Mast and Seeds		
Shinnery oak (Quercus havardii) acorns	15.2	5.7
Unidentified seeds	0.3	
Total mast and seeds	15.5	5.8
Vegetative Material		
Shinnery oak (Quercus havardii) catkins	31.8	9.7
Wild buckwheat (Eriogonum annuum) leaves	20.1	6.6
Broom snakeweed (Xanthocephalum sarothrae) leaves	6.4	4.6
Composite (Compositae) flowers	2.9	
Bitterweed (Hymenoxys spp.) leaves	2.7	
Downy phlox (Phlox sp.) leaves	2.7	
Shinnery oak (Quercus havardii) leaves	2.1	
Buckley penstemon (Penstemon buckleyi) leaves	2.0	
Spurge (Euphorbia spp.) leaves	1.9	
Broom groundsel (Senecio spartoides) leaves	1.5	
Unidentified leaves	0.9	
Ratany (Krameria spp.) leaves	0.8	
Unidentified sprouts	0.7	
Unidentified flowers	0.7	
Vervain (Verbena spp.)	0.7	
Rubber rabbitbrush (Chrysothamnus nauseosus) leaves	0.4	
Evening primrose (Oenothera serrulata) leaves	0.3	
Narrowleaf gromwell (Lithospermum incisum) leaves	0.1	
Total vegetative material	78.7	7.6
Animals		
Treehoppers (Membracidae)	3.7	
Scarab beetles (Scarabaeidae)	1.3	
Leaf beetles (Chrysomelidae)	0.3	
Snout beetles (Curculionidae)	0.3	
Unidentified beetles	0.3	
Ants (Formicidae)	T[a]	
Total animals	5.9	3.8

[a]Trace (less than 0.1%)

Our spring data are in general agreement with the few and limited previous studies of spring food habits in shinnery oak-grassland. Martin et al. (1951) noted that 81% of the contents of the crops of 7 birds collected in spring (Apr-May), in western Oklahoma was plant material while 19% was animal; we found 94.2% plant and 5.8% animal. Martin et al. (1951) also noted high use of oak (52%) from fall through spring; we found 49.1% in spring. Davison (1935:87) reported that in western Oklahoma (sample size not specified):

> "Spring usually finds plenty of acorns and greens for the birds...In the spring of 1935, an acorn was a rarity and the stomachs examined contained no food except green leaves and the blossoms of the oak. Many birds were observed as they fed on these oak flowers, showing it to be their chief food."

The only previous study from shinnery oak-grassland in New Mexico (Frary 1957) provided no comparative spring data.

Our findings for spring were parallel to those of Jones (1963a, 1963b, 1964) despite his working in a different habitat (sand sagebrush-grassland), where oak was scarce or absent, and reporting data from droppings instead of crop contents. Jones (1963a:49) identified March-May as spring months, and the 291 droppings he analyzed for those months showed (Jones 1964:113) that green vegetation (although different species from our area) was the principal food in March and April. Less green material was eaten in May, when the diet became more summerlike by the inclusion of more insects and seeds.

SUMMER FOODS (ADULT-SIZE BIRDS)

A change in the diet of adult-size birds occurred between spring (Table 1) and summer (Table 2). Insects, especially grasshoppers (Acrididae and Tettigoniidae) and treehoppers (Membracidae) made up most (55.3%) of the summer diet, in contrast with low use in spring. Use of green vegetation (23.3%) was less than 1/3 its spring value, and represented largely different species, especially erect dayflower (*Commelina erecta*), fame flower (*Talinum parviflorum*), and broom snakeweed. Use of acorns (21.2%) was approximately 1/3 greater than in spring. Total use of shinnery was down nearly 1/2 (to 22.5%) in summer, reflecting the large drop in use of catkins. The main spring-to-summer changes in diet were related clearly to large changes in food availability. Shinnery oak catkins virtually disappeared by late spring, and the new crop of acorns began to mature in summer. Great increases in abundance of insects and various forbs, including erect dayflower and fame flower, were observed in the field. Increases in insects in summer were noted by Davison (1935) and were documented by Jones (1963a:51-52) for western Oklahoma.

Our summer findings may not be directly comparable to those of other workers because of probable differences in handling of data from juvenile birds. We grouped data (Table 2) specifically from birds we considered to be adult size (at least 11 weeks of age). Neither Davison (1935) nor Martin et al. (1951) commented on ages of birds collected in summer, but they likely pooled data from all birds collected because sample sizes were small. Frary (1957) was unable to collect birds during May-August, and Jones (1963:772) included data from birds over 1 month of age with those of older birds.

Table 2. Percentage composition of the summer (Jun-Aug 1976-78, plus May 1977) diet of adult-size lesser prairie chickens in eastern New Mexico, 1976-78. *N*=18.

Food item	Mean	Standard error
Mast and Seeds		
Shinnery oak (*Quercus havardii*) acorns	21.2	8.1
Unidentified seeds	0.2	
Total mast and seeds	21.4	8.2
Vegetative Material		
Erect dayflower (*Commelina erecta*) leaves, flowers	7.6	5.2
Fame flower (*Talinum parviflorum*) leaves, flowers	5.2	5.2
Broom snakeweed (*Xanthocephalum sarothrae*) leaves	4.4	
Buckley penstemon (*Penstemon buckleyi*) leaves	2.8	
Insect galls from shinnery oak (*Quercus havardii*)	1.1	
Broom groundsel (*Senecio spartoides*) leaves	0.8	
Unidentified flowers	0.6	
Shinnery oak (*Quercus havardii*) leaves	0.2	
Spurge (*Euphorbia* spp.) leaves	0.2	
Daisy fleabane (*Erigeron* sp.) leaves	0.2	
Composite (Compositae) buds	0.2	
Total vegetative material	23.3	7.2
Animals		
Short-horned grasshoppers (Acrididae)	25.4	8.6
Long-horned grasshoppers (Tettigoniidae)	13.7	6.8
Treehoppers (Membracidae)	10.2	4.9
Ants (Formicidae)	3.1	
Mantids (Mantidae)	0.8	
Shield-backed bugs (Scutelleridae)	0.5	
Darkling beetles (Tenebrionidae	0.4	
Spiders (Araneida)	0.4	
Snout beetles (Curculionidae)	0.2	
Caterpillars (Lepidoptera)	0.2	
Silken fungus beetles (Crytophagidae)	0.2	
Moths (Lepidoptera)	0.1	
Robber flies (Asilidae)	0.1	
Total animals	55.3	9.3

Despite possible differences, our summer findings were similar to those of other studies in shinnery oak-grassland. Davison (1935:86) reported the summer (Jun-Aug) diet in western Oklahoma (sample size not given) to be "mostly insects", especially grasshoppers. Martin et al. (1951:97) reported that foods of 6 birds collected in western Oklahoma were

67% animal material (we found 55.3%) and that grasshoppers were the principal item in the animal diet.

Jones (1963a, 1963b, 1964) found that in 246 droppings collected during summer (Jun-Aug per Jones 1963a:64) in the sand sagebrush grasslands of northwestern Oklahoma, animal material (insects) was the main food in June (51.3%) and August (69.3%). Insects ranked second in July at 41.1%. The mean of these values, 53.9%, was practically the same as our 55.3%. Grasshoppers provided most of the animal portion of the diet.

Other studies have documented dietary changes from predominantly plant materials and few if any insects in spring to a much larger proportion of insects in summer in the greater prairie chicken (Tympanuchus cupido) (Judd 1905, Lehmann 1941, Schwartz 1945, Grange 1948, Jones 1963b) and the sharptail grouse (Pedioecetes phasianellus) (Grange 1948, Renhowe 1968, Sisson 1976). However, insects formed only small proportions of the summer diet of adult sharptails in Nebraska (Kobriger 1975) and greater prairie chickens in Kansas (Baker 1953), Illinois (Yeatter 1943), and Missouri (Korschgen 1962), and no studies of either species have revealed as high a proportion of insects in the summer diet as found for lesser prairie chickens in our study and in those by Davison (1935), Martin et al. (1951), and Jones (1963a, 1963b, 1964). Thus, the lesser prairie chicken is the only prairie grouse that eats more insects than plant material in summer.

Table 3. Percentage composition of the diet of lesser prairie chickens approximately 1-4 weeks of age (chicks) in eastern New Mexico during June-July, 1976-78. N=10.

Food item	Mean	Standard error
Mast and Seeds		
None		
Vegetative Material		
None		
Animals		
Short-horned grasshoppers (Acrididae)	49.5	10.2
Treehoppers (Membracidae)	26.1	12.0
Long-horned grasshoppers (Tettigoniidae)	12.1	5.4
Ants (Formicidae)	4.5	3.0
Mantids (Mantidae)	2.8	
Snout beetles (Curculionidae)	2.0	
Robber flies (Asilidae)	2.0	
Darkling beetles (Tenebrionidae)	1.0	
Cockroaches (Blattidae)	T[a]	
Total animals	100.0	

[a]Trace (less than 0.1%)

Table 4. Percentage composition of the diet of lesser prairie chickens approximately 5-10 weeks of age (juveniles) in eastern New Mexico during July-August, 1976-78. N=17.

Food item	Mean	Standard error
Mast and Seeds		
Shinnery oak (Quercus havardii)	0.5	0.6
Narrowleaf gromwell (Lithospermum incisum) seeds	0.1	
Total mast and seeds	0.6	0.6
Vegetative Material		
Erect dayflower (Commelina erecta) leaves, flowers	0.1	
Total vegetative material	0.1	
Animals		
Short-horned grasshoppers (Acrididae)	80.4	5.0
Long-horned grasshoppers (Tettigoniidae)	7.7	3.1
Mantids (Mantidae)	4.4	1.7
Snout beetles (Curculionidae)	3.1	
Crickets (Gryllidae)	1.8	
Treehoppers (Membracidae)	0.6	
Robber flies (Asilidae)	0.4	
Click beetles (Elateridae)	0.3	
Unidentified insects	0.3	
Leaf beetles (Chrysomelidae)	0.1	
Silken fungus beetles (Crytophagidae)	0.1	
Flies (Diptera)	0.1	
Total animals	99.3	0.6

SUMMER FOODS (BIRDS OF THE YEAR)

The crop contents of chicks (birds less than 5 weeks of age) were 100% insects, with the 2 families of grasshoppers composing 61.6% and treehoppers 12.1% (Table 3). However, the 2 youngest birds collected (under 2 weeks of age) contained 80% treehoppers. Juveniles approximately 5-10 weeks of age ate almost entirely grasshoppers (Table 4), and use of treehoppers was much less than for chicks (Table 3).

The high use of treehoppers by chicks, especially the smallest ones, may have resulted from selection of small prey and/or being incapable of feeding on many of the larger grasshoppers. Selection of larger prey by larger birds would explain the shift from treehoppers to greater quantities of grasshoppers by juveniles as the young birds increased in size.

Treehoppers, nearly absent from the diet of juveniles, reappeared in larger amounts in adult-size birds. This is inconsistent with the simple idea that larger birds eat larger insects.

However, data from individual crops show that adult-size birds ate treehoppers almost exclusively in May, when they ate no grasshoppers. Apparently, adults ate appreciable quantities of treehoppers in May because grasshoppers were not readily available, and chicks ate treehoppers (in Jun-Jul, when grasshoppers were abundant) because of their small size.

A small sample of 1 crop and gizzard and 7 droppings analyzed by Jones (1963a:77) showed that insects also were the principal food of lesser prairie chicken broods in northwestern Oklahoma, although he found more use of plant material (14.8%) than we did. The differential use of insects by chicks and juveniles versus adult birds was also documented for greater prairie chickens (Lehmann 1941; Yeatter 1943; Schwartz 1945; Baker 1953; Jones 1963a, 1963b; Renhowe 1968), sharp-tailed grouse (Judd 1905, Hart 1950, Kobriger 1965, Renhowe 1968, Pepper 1972, Sisson 1976), and for several other species of grouse (Johnsgard 1973).

MANAGEMENT CONSIDERATIONS

Lesser prairie chickens are closely associated with the shinnery oak-grassland community in much of their occupied range. In this community, at least in New Mexico, they derive most of their diet from a rather small number of plants (and associated insects) that are common in the less grassy areas. Shinnery oak provides preferred concealment for foraging birds of all age classes in summer (Davis et al. 1979), and is the most heavily utilized food of prairie chickens on a yearlong basis; its acorns, catkins, leaves, and galls in various combinations provide adult-size birds with approximately 50% of their diet in spring (Table 1), 25% in summer (Table 2), and from 50 to 70% in fall and winter (Davis et al. 1979). Several other important food plants (Tables 1, 2; Davis et al. 1979) also occur in association with shinnery oak; insects (especially grasshoppers and treehoppers) associated with the above plants are the main summer foods of all age classes (Tables 2, 3, 4).

Because of the importance of shinnery oak-grassland to prairie chickens for both food and cover, further large-scale eradication of this community should be avoided. Even the addition of grain fields to enhance fall and winter food sources, suggested by the work of Crawford (1974) and Crawford and Bolen (1976b), should be minimal. Grain fields may improve fall and winter food sources, but they displace natural vegetation that supplies not only fall-winter food but also spring and summer food as well as cover.

Where shinnery oak and other non-grassy species dominate the community, and bluestem grasses (especially sand bluestem) are scarce, it is probable that food is abundant and suitable cover for nesting and other uses is limiting (Davis et al. 1979). In such areas, a partial reduction in shinnery oak would be desirable. The findings of Davis et al. (1979) provided insight concerning desirable combinations of shinnery and other plants. They found the greatest abundance of lesser prairie chickens where basal composition of vegetation was approximately 58% grasses (with 27% sand bluestem and 5% little bluestem), 31% shrubs (29% shinnery), and 11% forbs. These plants were well scattered in the area, so that both food and cover were available nearly everywhere. Similar composition and interspersion can be achieved in shinnery-dominated areas by partial reduction of shinnery or possibly by applying herbicides in blocks (Doerr and Guthery 1980) or in swaths, leaving some untreated areas. In either case, control of grazing would be required to allow recovery and spread of bluestem grasses.

LITERATURE CITED

Baker, M. F. 1953. Prairie chickens of Kansas. Univ. Kans., Mus. Nat. Hist. and Biol. Surv. Kans., Misc. Publ. 5. 68pp.

Campbell, H. 1972. A population study of lesser prairie chickens in New Mexico. J. Wildl. Manage. 36:689-699.

Copelin, F. F. 1963. The lesser prairie chicken in Oklahoma. Okla. Cons. Dept. Tech. Bull. 6. 58pp.

Crawford, J. A. 1974. The effects of land use on lesser prairie chicken populations in west Texas. Ph.D. Thesis. Texas Tech Univ. 69pp.

Crawford, J. A., and E. G. Bolen. 1976a. Fall diet of the lesser prairie chicken in west Texas. Condor 78:142-144.

______________. 1976b. Effects of land use on lesser prairie chicken populations in west Texas. J. Wildl. Manage. 40:96-104.

Davis, C. A., T. Z. Riley, R. A. Smith, H. R. Suminski, and M. J. Wisdom. 1979. Final Rep.: Habitat evaluation of lesser prairie chickens in eastern Chaves County, New Mexico. N.M. State Univ. Agric. Exp. Stn., Las Cruces. 141pp.

Davison, V. E. 1935. The Davison Ranch, Ellis County, Oklahoma game bird project. Unpubl. Rep., Okla. Game Fish Dept., 105pp.

Doerr, T. B., and F. S. Guthery. 1980. Effects of shinnery oak control on lesser prairie chicken habitat. Proc., Prairie Grouse Symp.

Frary, L. G. 1957. Evaluation of prairie chicken ranges. P-R Compl. Rep., Proj. W-77-R-3, N.M. Dept. Game Fish, Santa Fe. 81pp.

Grange, W. B. 1948. Wisconsin grouse problems. Wis. Cons. Dept., Madison. 318pp.

Hart, C. M., O. S. Lee, and J. B. Low. 1950. The sharp-tailed grouse in Utah. Utah Dept. Fish Game Publ. 3. 79pp.

Johnsgard, P. A. 1973. Grouse and quails of North America. Univ. Nebr. Press, Lincoln. 553pp.

Jones, R. E. 1963a. A comparative study of the habitats of the lesser and greater prairie chickens in Oklahoma. Ph.D. Thesis. Okla. St. Univ., Stillwater. 160pp.

______________. 1963b. Identification and analysis of lesser and greater prairie chicken habitat. J. Wildl. Manage. 27:757-778.

______________. 1964. Habitat used by lesser prairie chickens for feeding related to seasonal behavior of plants in Beaver County, Oklahoma. Southwest Nat. 9:111-117.

Judd, S. D. 1905. The grouse and wild turkeys of the United States and their economic value. U.S. Dept. Agr. Biol. Surv. Bull. 24. 55pp.

Kobriger, G. D. 1965. Status, movements, habitats and foods of prairie grouse on a sandhills refuge. J. Wildl. Manage. 29:788-800.
Korschgen, L. J. 1962. Food habits of greater prairie chickens in Missouri. Am. Midl. Nat. 68:307-318.
Lehmann, V. W. 1941. Attwater's prairie chicken - its life history and management. U.S. Dept. Int., N. Amer. Fauna 57. 65pp.
Maker, H.J., V. G. Link, J. U. Anderson, and M.V. Hodson. 1971. Soil associations and land classification for irrigation:Chaves County. N.M. St. Univ. Agric. Exp. Sta. Res. Rep. 192. 48pp.
Martin, A. C., R. H. Gensch, and C. P. Brown. 1946. Alternate methods in upland game bird food analysis. J. Wildl. Mange. 10:8-12.
Martin, A. C., H. S. Zim and A. L. Nelson. 1951. American wildlife and plants, a guide to wildlife food habits. McGraw-Hill, New York. 500pp.
Pepper, G. W. 1972. The ecology of sharp-tailed grouse during spring and summer in the aspen parklands of Saskatchewan. Sask. Dept. Nat. Res. Wildl. Rep. 1. 55pp.
Renhowe, B. A. 1968. Food habits of the sharp-tailed grouse (Pedioecetes phasianellus jamesii) and the greater prairie chicken (Tympanuchus cupido pinatus) in western South Dakota. M. S. Thesis. South Dak. St. Univ., Brookings. 55pp.
Schwartz, C. W. 1945. The ecology of the prairie chicken in Missouri. Univ. Mo. Stud. 20:1-99.
Sisson, L. 1976. The sharp-tailed grouse in Nebraska. Nebr. Game and Parks Comm., Lincoln. 88pp.
Yeatter, R. E. 1943. The prairie chicken in Illinois. Ill. Nat. Hist. Surv. Bull. 22:377-416.

FOODS OF PRAIRIE CHICKEN ON MANAGED NATIVE PRAIRIE

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Abstract: The objective of this study was to quantify principal foods used by the greater prairie chicken (*Tympanuchus cupido pinnatus*) on a managed native prairie in Missouri from December 1978 through November 1979. Analysis of 1,181 samples show the principal seasonal and year-round foods. Wild plants comprised 69.5% by volume of the year-round diet with vegetative leaf material and wild rose being the principal foods. An earlier Missouri study found cultivated grains comprise 63% of the total foods, 33.8% greater than found in this study. Management of public prairie should be carried out with a combination of burning at 3-4 year intervals in conjunction with rest-rotation haying or grazing to maintain seed production of the native plants.

Habitat for the greater prairie chicken in Missouri has increased in recent years due to public purchase of several native prairies. Since 1959, 22 prairies totaling 2,535 ha have been preserved in western Missouri. Sixteen of the 22 prairies have resident flocks of greater prairie chickens. The objective of this study was to describe the principal foods used by the prairie chicken on a managed native prairie.

I wish to acknowledge the help of Leroy J. Korschgen for verification of identified foods and for review of this report.

STUDY AREA

This study was carried out on Taberville Prairie in west central Missouri and owned by the Missouri Department of Conservation. Taberville is a native tall grass prairie with 550 ha of virgin prairie and 130 ha of mixed grassland and cropland.

The native, warm season grasses comprised 70 to 90% of the plant composition by weight. The 4 most important plant families were grasses (Gramineae), composites (Compositae), legumes (Leguminosae), and sedges(Cyperaceae). These 4 families made up 50% of the plant composition by number of species (Toney, unpublished). The diversity of soils, varied from rocky sandstone outcrops to deep loams, and added to the richness of the vegetative composition and structure.

The climate typifies warm continental type with frequent and often extreme changes in temperature, humidity, and winds. The growing season approximates 195 days. The average rainfall is 101.25 cm per year. Precipitation is evenly distributed by season: spring, 30%; summer, 33%; fall, 25%; and winter, 12%. Snowfall averages 32.5 cm per year (Preston 1977).

Hay harvest by units on a rest-rotation system has been the primary management practice. Approximately 1/3 of the area is hayed and controlled burning is practiced on 1/3 of the area each year.

METHODS

Prairie chicken droppings were collected monthly from December 1978 through November 1979. Collection sites included booming grounds, undisturbed prairie, edges of crop fields, and hayed units. Fall, winter, and months of April, May, and September samples were collected from undisturbed prairie and booming grounds. Samples for June, July, and August were obtained from edges of crop fields and hayed units.

One hundred samples, each comprised of 3 individual droppings, were analyzed each month from January through November 1979. Eighty-one samples were analyzed for December 1978, the 1st month of the study.

Preparation for analysis consisted of briefly soaking the sample in water, placing it in a 16-mesh-per-cm sieve, and separating the particles by gently working the material while washing under a tap. The washed sample was placed on blotter paper and dried in an oven.

A binocular dissecting microscope was used to identify the food residues. Each identified item was assigned, by ocular estimate, a percentage of the total bulk. Appraisals of foods were made by percentage occurrence and volume for month, season, and year. Items that comprised 1.0% of more, by volume, were considered to be principal foods. Plant classification used in this study followed that of Steyermark (1963).

RESULTS

Data from analysis of 1,181 samples constitute the basis for this report. Green grass (unidentified grass & sedge leaves) and green leaf (unidentified native broadleaf plants) materials were grouped as food categories; all other items were identified and listed under species or generic headings. No differentiation was made of the insect taxa.

Winter: Prairie chickens utilized 40 plant foods during winter (Dec-Feb) and 18 were classified as principal foods (Table 1). Cultivated grains were used most heavily during February when snows covered much of the native vegetation. Native plants were utilized all months, with greatest usage in December and January.

Wild rose (Rosa carolina), abundant on the prairie, ranked 1st both by occurrence and volume. Rose was important all months, and was the only item that maintained high usage throughout the period. Corn ranked 2nd with greatest use in February. Although corn was readily available to the birds, it was not heavily used in December and January. Wheat ranked 3rd in volume and was used by 38% of the birds. Wheat was not used in February during snow periods. Sorghum was used by 20.6% of the birds and ranked 4th with its greatest use in January. Sorghum was little used in February during the severe part of the winter. Green grass ranked 6th in importance, a part of which probably was winter wheat. Three other items had volumes over 1.0% and a frequency of use over 15%: Ladies'-tobacco (Antennaria neglecta), smooth sumac (Rhus glabra), and twigs

Table 1: Occurrence/volume percentages of the principal foods of prairie chickens in Taberville Prairie, by season and year, 1978-79.

Food	Spring 300[a]	Summer 300[a]	Fall 300[a]	Winter 281[a]	Year 1,181[a]
Green leaf	46.0/16.7	68.7/43.2	33.0/24.8		37.5/21.5
Green grass	95.0/35.5	17.0/5.4	30.0/9.4	20.9/3.8	41.1/13.7
Wild rose	19.0/2.5	3.7/0.2	20.3/9.0	74.0/29.4	28.5/10.0
Wheat	23.7/8.9	0.3/0.3	18.7/9.9	38.0/19.7	19.9/9.5
Corn	16.7/9.0		8.7/5.3	43.4/22.6	16.8/9.0
Sorghum	15.3/7.3		29.7/14.5	20.6/9.6	16.3/7.8
Korean lespedeza	25.0/7.9	17.7/10.2	9.0/3.6	7.8/0.1	15.0/5.5
Soybeans	5.3/3.1	0.7/tr	4.0/3.8	6.0/4.7	4.0/2.9
Ladies'-tobacco	15.7/3.0		5.3/1.6	15.6/3.6	9.1/2.0
Dwarf sumac		1.0/0.7	19.0/7.0	0.3/tr	5.0/2.0
Dewberry		17.0/7.0			4.3/1.8
Phlox		11.3/6.6			2.9/1.7
Buttonweed		10.7/5.0	7.7/0.6	0.3/tr	4.7/1.4
Red mulberry		13.7/5.6			3.5/1.4
Black cherry		9.3/4.4			2.4/1.1
Lanceleaf ragweed	2.0/tr	1.7/0.4	22.0/3.3	15.3/0.6	10.2/1.1
Early buttercup	14.0/3.1				3.6/0.8
Wild strawberry		10.7/2.8			2.7/0.7
Smooth sumac				15.3/2.2	3.6/0.5
Twigs & buds	9.3/0.4	1.7/0.1	1.7/0.1	15.3/1.3	6.9/0.4
Prairie dropseed			4.3/1.6		1.1/0.4
Gray dogwood		1.7/0.7	1.0/0.8		0.7/0.4
Swamp dogwood		1.3/0.6	1.3/0.8		0.7/0.4
Common ragweed			6.7/1.2	11.0/0.1	4.5/0.3
Mead's sedge	9.3/1.1				2.4/0.3
False dandelion		2.3/1.0			0.6/0.3
Spring beauty	23.0/0.8				5.8/0.2
Pencil flower		3.0/0.7			0.8/0.2
Slender lespedeza	0.3/tr		13.0/0.4	28.4/0.3	10.2/0.2
Sleepy catchfly	0.3/tr	18.7/0.6			4.8/0.2
Coralberry	0.3/tr		1.7/0.2	11.0/0.4	3.1/0.1
Horse nettle			3.7/0.5	1.0/tr	1.2/0.1
Tick-trefoils				4.6/0.5	1.1/0.1
Many-flowered rose	0.6/tr			1.0/0.4	0.4/0.1
Common lespedeza	3.0/tr		4.0/0.3	2.1/tr	2.3/0.1
Meadow fescue		0.7/tr		1.4/0.3	0.5/0.1
Sedge	4.3/0.3				1.1/0.1
Possum haw				1.7/0.2	0.3/0.1
Goat's rue		1.0/0.2			0.3/0.1
Crab-grass	2.0/tr	0.3/0.2	1.0/tr	0.3/tr	0.9/0.1
Insects	65.3/0.3	76.7/3.7	25.7/1.1	1.4/tr	43.4/1.3
Total	99.9	99.6	99.8	99.8	100.0

[a]Number of samples.

and buds. Ten items each had a volume of over 0.1%, but less than 1.0%. One of these, slender lespedeza (Lespedeza virginica), exceeded 28% by occurrence and may warrant future management consideration. Four of the 10 items were important foods for a given month: Tick-trefoils (Desmodium sp.) and meadow fescue (Festuca pratensis) in December, many-flowered rose (Rosa multiflora) in February, and possum haw (Ilex decidua) in January. Insects were not heavily used during this period.

Spring: Prairie chickens utilized 51 plant foods during spring (Mar-May) and 14 of these accounted for 99.6% of all foods (Table 1). Insects were consumed by 65.3% of the birds and accounted for 0.3% of the volume.

Green grass and green leaf material accounted for 52.2% of all foods used. Green grass ranked 1st all months. Green leaf material was not used in March, but was important in April and May. Corn, wheat, and sorghum were principal foods during 1 or more of the months. Corn was most used in March and May, wheat in March and April, and sorghum in March, with little used in April and May. Korean lespedeza (L. stipulacea), mainly leaves, was the 2nd most important food in May, but it was little utilized in March or April. Five other foods with volumes of 1.0% or more, but less than 4.0%, were soybeans, early buttercup (Ranunculus fascicularis), ladies'-tobacco, wild rose, and Mead's sedge (Carex Meadii). Soybeans, similar to usage of wheat grain, were utilized by only a few birds. Early buttercup was used most in May, ladies'-tobacco all months, wild rose in March and May, and Mead's sedge in April. Three items had volumes over 0.1% but less than 1.0%; spring beauty (Claytonia virginica) and sedge (Carex sp.) were principal foods in May.

Summer: Prairie chickens utilized 50 plant foods during the warmer months of summer (Jun-Aug) when 21 of these accounted for 95.5% of the food volume (Table 1). Insects continued to show an increase in usage (76.7%) and accounted for 3.7% of the volume. Grasshopper was the most common insect, with the greatest use in August.

Green leaf material was the most important food category and accounted for 43.2% of the volume. Korean lespedeza ranked 2nd for the season, with highest use in July and August. Dewberry (Rubus flagellaris) fruits, were selected frequently and were principal foods all months. Phlox (Phlox pilosa) ranked 2nd in June, but was not used the other months. Trees and shrubs contributed principal foods during this period. Red mulberry (Morus rubra) fruits ranked 5th, with primary use in June and July; black cherry (Prunus serotina) fruits became acceptable foods in August as did gray dogwood (Cornus racemosa), swamp dogwood (Cornus obliqua), and dwarf sumac (Rhus copallina). Green grass usage continued into the summer but decreased each month. Buttonweed (Diodia teres), a low growing plant on poor sites, was selected often in August and was the 2nd most frequently consumed food for that month. Wild strawberry (Fragaria virginiana) was heavily used in June, but ranked 9th for the season. False dandelion (Pyrrhopappus carolinianus), a weedy species adjacent to the prairie, was a principal food in July. Ten items ranked between 0.1% and 1.0%, by volume, for the season. Five of the 10 were important for a given month: Sleepy catchfly (Silene antirrhina) in June, pencil flower (Stylosanthes biflora), lanceleaf ragweed (Ambrosia bidentata), goat's rue (Tephrosia virginiana), and crab grass (Digitaria sanguinalis) in August. Cultivated grains were not important during the summer months.

Fall: Prairie chickens utilized 46 plant foods during fall (Sep-Nov); 21 of these accounted for 98.7% of the food volume (Table 1). Insect usage dropped to 25.7% by occurrence and 1.1% by volume.

Green leaf materials led the list for the period, but usage decreased by October. Farm crops returned to the diet, with sorghum being eaten in 2nd largest amount. Wheat, corn and soybeans followed sorghum in volume used. Wild rose also gained in importance and was heavily used in October and November. Woody plants again provided much food, with dwarf sumac leading the list for November. Highest use of swamp and gray dogwood occurred during this period. Green grass also regained importance in October and partially replaced the summer and early-fall reliance upon green leaf materials. Other foods of importance were ladies' tobacco, lanceleaf ragweed, and buttonweed in September; common ragweed (A. artemisiifolia), and horse nettle (Solanum carolinense) in October; prairie dropseed (Sporobolus heterolepis), coralberry (Symphoricarpo orbiculatus), slender lespedeza and common lespedez (L. striata) in November.

Year: Year-round, a total of 115 plant foods was utilized; 16 plant items each accounted for 1.0% of the total volume (Table 1). Insects were used throughout the year, but accounted for only 1.3% of the volume.

Wild foods accounted for 70.6% of the total volume. Vegetative leaf material composed of green leaf and green grass accounted for 35.2% of average diets. Wild rose, a common native, was a principal winter food that ranked 1st for that season and 3rd for the year. Korean lespedeza, an introduced plant in fields and along roadways, was readily consumed and made up 5.5% of the volume. A number of native plants were principal foods during a given month but not used in other months. Woody species with persistent fruits were important over several months in contrast to the lesser use of herbaceous species that lacked persistent fruits.

The grains of wheat, corn, and sorghum were used in about the same proportion and ranked 4th, 5th, and 6th respectively for the year. Wheat and corn were of greatest importance during the winter. Sorghum was most used during fall. Corn and sorghum were not used during summer months. Soybeans, a common crop, was used by a small percentage (4.0%) of the birds. These 4 crop species accounted for 29.2% of the volume.

Seeds of herbaceous and woody plants accounted for 57.6% by volume of all foods consumed. Green leafy plant parts (including Korean lespedeza, green leaf, and green grass) comprised 40.7% of the volume. Twigs & buds contributed only 0.4% of the volume.

Annuals (38.2%) and herbaceous perennials (42.4%) were consumed in nearly equal amounts. Annual cultivated crops comprised 29.2% and wild annual plants 9.0% of the volume. Of the 12 important woody species (18.3% by volume), 9 were shrubs and 3 were trees. The shrubs, in small clumps, were found scattered over the area while trees were primarily edge species. Fruits of shrubs were used throughout the year, while fruits of trees most commonly were seasonal.

Insects occurred in 43.4% of the samples, but comprised only a small percentage (1.3%) by volume. Grasshoppers (Acrididae) and beetles (Coleoptera) were the 2 more common insects used. Gravel occurred in 14.3% of the samples, but seldom in greater than trace amounts.

DISCUSSION

The foods of prairie chickens in Missouri were documented by Korschgen (1961) 2 decades ago. Prior to 1961, few prairie plant species remained as food sources for wildlife because of annual haying or heavy grazing on most private lands. Korschgen's study showed cultivated grains (63% volume) to be the most important foods utilized. Cultivated grains in the present study accounted for only 29.2% of the total volume. Prairie chickens in Taberville Prairie showed a 33.3% higher usage of wild foods than Korschgen reported in 1961. The increased population, as shown by spring census data (Toney, unpublished), indicated that the birds were well sustained on the foods selected.

Native plant usage as found in this study was generally comparable to that reported by Judd (1905), Gross (1930), and Yeatter (1943), but more similar to those findings of Horak (1971) in Kansas where birds on "good" range utilized less cultivated grains than birds on "poor" range (Davis 1976). Cultivated crops will continue to be of greater importance than native plants on areas lacking managed native prairies.

Management of native or naturalized foods is important to prairie chickens in Missouri where intensive farming by double cropping and fall plowing is practiced. Areas with large acreage of improved fescue pasture also will require management of food sources if prairie chicken populations are to be maintained or increased.

The Missouri Department of Conservation now provides assistance in planting and management of native warm season grasses on private lands. This practice should help provide cover needs for prairie chickens. Inclusion of selected native broadleaf plants with the warm season grasses will help provide quality foods.

On native prairies, hay harvest or grazing on a rest-rotation system will encourage greater plant diversity (Toney, unpublished). Periodic controlled burns every 3 to 4 years to remove excess plant litter and to stimulate seed production is recommended.

LITERATURE CITED

Davis, R. M. 1976. National Range Handbook. U.S Dept. Agr. SCS. 72pp.

Gross, A. O. 1930. Wisconsin prairie chicken investigations progress report. Wis. Cons. Comm., Madison. 19pp.

Horak, G. J. 1971. Population dynamics of prairie chickens in grassland and cropland areas. P-R Final Rep., Prog. W-23-R, Ks. Forestry, Fish and Game Comm. 98pp.

Judd, S. D. 1905. The grouse and wild turkeys of the U.S. and their economic value. U.S. Dept. Agr. Biol. Surv. Bull. 24. 55pp.

Korschgen, L. J. 1961. Food habits of greater prairie chickens in Missouri. Am. Midl. Nat. 68:307-318.

Preston, G. D. 1977. Soil survey of Vernon County, Missouri. U.S. Dept. Agr. SCS 63pp.

Steyermark, J. A. 1963. Flora of Missouri. The Iowa State Univ. Press. 1725pp.

Yeatter, R. E. 1943. The prairie chicken in Illinois. Ill. Nat. Hist. Surv. Bull. 22:375-416.

THE STATUS AND MANAGMENT OF GREATER PRAIRIE CHICKENS IN MINNESOTA[1]

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Abstract: The Greater Prairie Chicken probably did not occur in presettlement Minnesota except in the extreme southern part of the state. The greater prairie chicken moved northward with agriculture at a rate of about 16 km/year. The range expanded northeasterly with logging and associated fires. Peak numbers occurred in the state in the late 1800's and later declined due to intensification of land use in the prairie portion of the state, plus forest succession in cleared areas. The last hunting season was in 1942 when 58,300 birds were bagged. By 1970, the population was restricted to grassland habitat of 8 northwestern and 2 northcentral counties; some grasslands are secured as wildlife management areas by the Minnesota Department of Natural Resources and as Waterfowl Production Areas by the U.S. Fish and Wildlife Service. In 1973, the Minnesota Prairie Chicken Society was established to promote education, management and research activities and to coordinate an annual booming ground survey by volunteers and agency personnel. In 1974, the Nature Conservancy initiated the "Minnesota Prairie Chicken Preserve System." By 1980, some 20,640 ha had been acquired within the population range by the State Department of Natural Resources, U.S. Fish and Wildlife Service, or the Nature Conservancy. The average tract size approximates 134 ha. A restoration effort, using pen-reared birds, was initiated in 1977 in an area having some 809.4 ha of acquired grassland but located out of the primary range. Some success has been noted. Throughout the range, males were censused from 1974-1980 with densities averaging 1 male/section in occupied habitat. Research studies suggest that the existing nesting habitat should support more birds. Brood habitat and predation may be limiting. Intensive land use on private lands adjacent to acquired grasslands has created "habitat islands" and necessitates that management provide most of the life cycle needs on sanctuaries. Burning on a 4-year rotation, haying of legume fields, food plots, and limited grazing are used to provide the mosiac of necessary habitat conditions on sanctuaries.

[1]Abstract only available for the proceedings.

DISTRIBUTION OF PRAIRIE CHICKEN HARVEST AND HUNTERS IN OKLAHOMA[1]

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Abstract: A hunter questionnaire designed to assess the amount of prairie chicken (*Tympanuchus* spp.) harvest, hunting pressure, and hunters in Oklahoma was distributed and evaluated. The 4-day (2-weekend) November season allowed a take of 2 birds per day, 4 in possession. 1,202 usable responses representing 28% of the total hunter pool were obtained.

Expansion of the data indicated that 4,346 prairie chicken permit holders expended an estimated 8,043 hunter-days harvesting an estimated 5,105 prairie chickens. Three areas (of 41), all near the border of Oklahoma with Kansas, supported 63% of the estimated hunter activity and 70% of the total estimated harvest. These areas were within the continuous range of greater prairie chickens (*T. cupido*) in Oklahoma as identified by Martin and Knopf (1980). Another region (encompassing 3 areas), identified as continuous range of greater prairie chickens, had only 5% of the estimated hunter activity, and 2% of the estimated harvest. Lesser prairie chickens (*T. pallidicinctus*) received little hunting pressure, 211 estimated hunter-days and an estimated harvest of 134 birds.

Hunter success for greater prairie chickens approximated 0.50 birds per hunter-day in the areas bordering Kansas, and declined southward. Hunter success declined with the advance of the 4-day season. Hunter success was higher on public than private lands the 1st day of the season, but was reversed during subsequent days. Over 21% of the harvest occurred on public lands, which constituted less than 2% of the total huntable range.

Hunter interest was primarily local; 79% of all prairie chicken hunters lived in the 15 (of 77) counties containing huntable prairie chicken range. Urban hunters made up 40% of the hunter pool; 43% of these lived in Tulsa, the largest metropolitan area in huntable prairie chicken range. Of rural hunters, 41% hunted in their county of residence. Of urban hunter-days, 40% were spent in Osage County, mostly in 1 area that contained the Oklahoma Department of Wildlife Conservation's prairie chicken management units.

Urban hunters killed fewer birds ($\bar{X}$ = 1.25 birds/hunter) than local ($\bar{X}$ = 1.55 birds) and non-local ($\bar{X}$ = 1.46 birds/hunter) rural hunters. Urban hunters spent more time hunting per day ($\bar{X}$ = 4.07 hours) than local hunters ($\bar{X}$ = 3.43), but hunted fewer days ($\bar{X}$ = 2.80 days), and harvested the most birds per hunter ($\bar{X}$ = 1.55 birds). Non-local, rural hunters were similar to urban hunters except that their kill per day ($\bar{X}$ = 0.69 birds) was higher than that of urban hunters ($\bar{X}$ = 0.63 birds).

[1]A contribution from Federal Aid to Wildlife Restoration, Oklahoma Pittman-Robertson Project W-82-R. Presented in abstract form only.

CONCLUDING COMMENTS - Fritz L. Knopf

Prairie grouse biologists have always been a cohesive group. Few other wildlife species or groups of species arouse sufficient interest to precipitate periodic meetings of both research and management personnel to exchange ideas, experiences, and companionships. Since its inception in 1957, the Prairie Grouse Technical Council has met biannually in 1 of the central states. I'm confident that the 14th meeting in Nebraska during 1981 will be as well attended and received as the 12th was at Pierre, South Dakota, and the 13th at Wisconsin Rapids, Wisconsin that I attended. Certainly it was the support of prairie grouse biologists for those technical meetings that precipitated the initial plans for this symposium in Stillwater, Oklahoma.

This symposium is especially the product of 1 individual's forethought, planning, perseverance, and professionalism. In 1977, Paul Vohs proposed the symposium at the Technical Council Meetings in South Dakota, and received the full backing of that group. He labored endlessly in the coordination, administration, and editorial monotony of making this happen.

In 1978, Dr. Vohs asked Mark Byard and myself to sit on the steering committee for the symposium. The objectives of the meeting were narrowed, and we generated a list of selected topics that we thought merited review. With the assistance of some of you, we identified potential authors and solicited manuscripts. Those manuscripts included syntheses of the status of each species that you heard yesterday, plus the excellent presentation on research needs by Bob Robel. Speaking on behalf of the steering committee, we thank each of those authors for their time, energies, and involvement. The program benefited greatly from the exhaustive effort that went into updates and evaluations. In addition, we requested manuscripts on habitat management practices, natural areas and preserves, reintroductions and transplantings, and a bibliography on prairie grouse. We regret that those manuscripts could not be available today. Hopefully, the topics will be addressed soon in the professional literature.

We wish to thank also the authors of volunteered papers--those individuals who are currently active in research and management efforts. It is their ideas, shared, that provide insights into new questions, approaches, and testable hypotheses (i.e., possible answers) that advance prairie grouse management. Hopefully, the experimental design of Lutz and Silvy will inspire a multitude of creative, new approaches in the near future.

Besides the authors, others deserve thanks for their support and participation in this program.

1. We are indebted to Dr. George Hulsey for his enlightening and entertaining address at last night's banquet.

2. Our chairpersons, Frank Schitoskey, Byron Moser, and Ron Klataske deserve special thanks for overseeing sessions of the program.

3. We are grateful to the Oklahoma Department of Wildlife Conservation for its constructive inputs and enthusiastic support, and for the printing of flyers and programs.

4. The Oklahoma State University community has been generous to share its facilities and services. We thank the Arts and Sciences Extension Office and the Student Union. Howard Jarrell and the College of Arts and Sciences Research office provided every assistance. The Oklahoma Cooperative Wildlife Research Unit served as the host at this meeting, and we especially thank Judy Gray and Sue Davis for their cheery attendance to correspondence and to final preparation of the proceedings.

5. Finally, for financial and logistical support, we thank our sponsors:

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   The National Audubon Society.

The content of many of the papers we have heard has not been surprising. The status reports indicated that each species is undergoing continuous declines in population with time. Current threats vary with location, but generally include agricultural pressures. The imminent threat appears to be in the development of center-pivot irrigation systems--in Nebraska as Ken Robertson points out, and also in Kansas, Colorado, Oklahoma, and parts of Texas. Fortunately, water resources people are forecasting doom for the Ogallala aquifer from which much of the water originates, and the future existence of these mechanical "blackbird roosts" appears restricted to sites with developed surface water. Hopefully, economic costs of the water will force agriculture to return to dry-land practices and, especially, grassland management.

As long as we have grasslands supporting prairie grouse, we will have economic pressures to put cattle on those lands. The "empty niche" misnomer of the bison certainly provides those interests with an ecological rationale which is difficult to argue. Grazing management practices will continue to be the primary habitat concern for prairie grouse in the next decade. Comparative evaluations of grazing systems and their favorable or unfavorable influences upon prairie grouse are needed now.

Bob Robel provided us with an eloquent overview of research priorities relative to information needs about the biology of prairie grouse. Why do these gregarious relatives of barnyard fowl occur in such low densities? What ultimate and proximate factors regulate their densities and how are they operative? What are the roles of nutrition, disease, parasitism, predation, and intraspecific competition in determining population levels? Surely, prairie grouse management would be more effective if we had the kinds of basic information that is available for the bobwhite, mallard, and white-tailed deer.

The 2nd series of research needs (which Bob alluded to briefly) may be viewed as equally critical to improving management efforts. Besides the biological understanding of prairie grouse, we must refine our methodological approaches to population and habitat inventories. Each author reporting on the status of these species yesterday realized the problems in estimating numbers of birds. In Oklahoma, for example, population estimates of greater prairie chickens provided to Ron Westemeier ranged from a minimum of 8,415 to 80,000 birds. Perhaps here is the opportunity and incentive to proceed with advancement in survey methodologies. With the knowledge of contemporary range of the species now available, the O.D.W.C. can now meet the important assumption that survey methods are being applied to known range. Are any other states generating statistically valid population estimates? Is it not coincidental that the latest Wildlife Monograph (No. 72) by Ken Burnham, Dave Anderson, and Jeff Laake has a frontispiece illustrating a line-transect procedure adapted for prairie chickens?

The range of these species of prairie grouse is becoming fragmented in many areas, especially for the lesser prairie chickens as John Crawford pointed out. How are we going to re-establish birds in some of the lost habitats when those habitats are recovered? The U.S. Fish and Wildlife Service is currently sponsoring transplants of Columbian sharptails to the National Bison Range in Montana, and the Colorado Division of Wildlife is interested in expanding its greater prairie chicken range. What methods are most suitable for these transplants? Wildlife biologists know that to establish a new breeding population of wood ducks, for example, requires only that they capture and relocate the hen with brood shortly after hatching of the clutch, prior to any habitat imprinting by ducklings. Why haven't such techniques been adapted and tried on prairie grouse? How are we going to re-establish population? These questions appear critical to management efforts to save Attwater's prairie chickens. Hopefully, research will commence soon (probably on 1 of the more common species) to generate an effective technique while we still have a gene pool of Attwater's to work with.

Relative to research, I have another observation. We have countless studies of prairie grouse habitats: sometimes exhaustive, thorough and intensive descriptions of seasonal habitats. For example, we all are convinced that well-developed residual (usually grassland) cover is essential, even critical, for successful prairie grouse nesting. Yet, I am aware of no studies that have compared "nonhabitat grasslands" to verify this relationship. We can't refer to any habitat component as "essential" or "critical" unless we prove it is unavailable in areas without grouse (all other factors being equal). Lutz and Silvy reported that residual cover was important only to a critical minimum, after which some other factor may exert a greater influence. Studies of prairie grouse habitats need to incorporate some of the more refined and thorough statistical approaches currently appearing in the avian literature. We must apply the powers of multivariate, discriminant function, and principal component analyses to our "beautifully simplistic" grassland habitat types.

Finally, whereas opportunities for future research are overwhelmingly diverse, the task facing management appears sometimes overwhelming. Multiple-use management isn't a planning approach when applied to prairie grouse habitats; but rather, a pre-established reality. Economic pressures range from grazing and grain production, through petroleum mining and drilling, to motocross rallys.

Underlying these user demands is the basic observation that most birds occur on private landholdings. Lawrence and Silvy emphasized the need to work with private landowners, and the point applies equally well to Oklahoma's prairie chickens. Landowners hold the key to prairie grouse management, and management agencies must work cooperatively and effectively with these individuals. The task is not a small one.

In conclusion, most of us are professional wildlife biologists with research or management responsibilities related to the conservation of these "chickens of the grass." From a professional view, the prairie grouse represent one of the most challenging of all groups. The greater, lesser, and Attwater's prairie chickens plus sharp-tailed grouse have similar habitat requirements and can be treated collectively in a symposium such as this one. However, although our research efforts are narrowly focused on basically grassland habitats, those of us who are responsible for management programs are less fortunate. Managers must interpret the knowledge gained from research:

(1) Relative to game-species management in the central plains states

(2) Relative to threatened-species management in states on the edges of the bird's respective ranges, or

(3) Relative to endangered-species management where small isolated populations have either been cut off from the main body of the geographic range, or represent all that remains of that range historically.

Each management effort, in turn, is initiated within the ominous shadow of extinction as seen in many states for especially the greater prairie chicken, but more dramaticallly in the 5th species included in this group, the heath hen. In retrospect, one has to wonder why this symposium was so long in coming. I only hope that a sequel symposium reporting dramatic advances is forthcoming. On behalf of the steering committee, thank you for your attendance and participation.