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FINE SCALE INFLUENCE OF WEATHER ON NORTHERN BOBWHITE ABUNDANCE, BREEDING SUCCESS, AND HARVEST IN SOUTH TEXAS

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ABSTRACT

Weather plays a substantial role in annual changes in populations of northern bobwhite (*Colinus virginianus*) within and among ecological regions. Few studies have tested this relationship within the confines of specific sites. We examined the fine scale influence of annual (12-month), seasonal (6-month), and monthly Modified Palmer Drought Severity Indices (PMDI) and raw precipitation on abundance, breeding success, and harvest of northern bobwhites on 2 sites in south Texas. We used 18 years (1984–01) of roadside census, juvenile : adult ratios, and harvest records from the Chaparral Wildlife Management Area (CWMA) in La Salle County and 15 years (1984–99) of juvenile : adult ratios and harvest records from a private property in Brooks County (BCP) to examine relationships and trends with weather variables. Bobwhite abundance was correlated ($r \geq 0.50$, $P \leq 0.035$) with 12- and 6-month sums of precipitation and PMDI. Breeding success was correlated ($r \geq 0.53$, $P \leq 0.023$) with 12-month precipitation for both sites and was correlated ($r = 0.53$, $P = 0.040$) with 6-month precipitation for BCP only. Harvest variables for CWMA were correlated ($r \geq 0.54$, $P \leq 0.022$) with 12- and 6-month PMDI, while BCP harvest/ha was correlated ($r = 0.54$, $P = 0.027$) with the 12-month precipitation sum. Monthly correlates with precipitation increased from spring to summer until July when they became negatively related to rainfall on both sites. Monthly PMDI correlates became increasingly important from spring through summer including July. Our findings account for at least part of the annual variation in northern bobwhite abundance in south Texas and provide information useful in understanding of the influence of weather at fine spatial scales.

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Key words: abundance, breeding success, *Colinus virginianus,* harvest, Modified Palmer Drought Severity Index, northern bobwhite, precipitation, south Texas, weather

INTRODUCTION

Climate and weather have a major effect on bird populations. Weather dictates the growth of plants and the foods they produce (Welty and Baptista 1988). The growth stage of shrubs and grasses and the amount of food available throughout any given year affects the population dynamics of ground nesting birds (McMillan 1964, Roseberry and Klimstra 1984:128, Giuliano et al. 1996). The relationship between weather variables and populations has been examined for many gallinaceous species (Peterson and Silvy 1994, Sheafer and Maleki 1996, Roberts and Porter 1998). Heffelfinger et al. (1999) found that reproductive failure was associated with low rainfall (0–6.3 cm) in October–March and high mean daily temperatures (32.2°–35.0° C) during the brooding season (Jun–Jul) for Gambel's quail (*Callipepla gambelii*). Conversely, ample seasonal rainfall and soil moisture have been positively correlated with the reproductive success of California quail (*C. californica*; McMillan 1964, Francis 1970, Botsford et al. 1988). Abundance, breeding success, and harvest have also been correlated with weather variables for northern bobwhite and scaled quail (*C. squamata*). These relationships are more apparent in semiarid environments than mesic clines (Cambell 1968, Rice et al. 1993, Bridges et al. 2001, Guthery et al. 2001).

Of the 6 ecological regions examined in Texas by Bridges et al. (2001), the strongest correlation ($r = 0.90$) between the Modified Palmer Drought Severity Index (PMDI) and bobwhite abundance was in the Rio Grande Plains, while raw precipitation for the same region was positively correlated but to a lesser degree ($r = 0.64$). The PMDI takes into consideration a suite of weather variables and was designed to better represent real-time conditions and transitional periods (Heddinghaus and Sabol 1991). For these reasons, Bridges et al. (2001) suggested that PMDI correlates may be more closely associated with changes in quail abundance than single weather variables at the landscape and ecological-region level. Few studies have tested these relationships within the confines of specific sites (Francis 1970). Furthermore, fine scale research may illuminate relationships, which are not apparent at larger scales, and may provide information helpful in understanding annual variation in bobwhite populations at the local level.

The objective of this study was to assess the relationship between weather and bobwhite populations at a fine spatial scale (i.e., ranch-level). Annual, seasonal, and monthly raw precipitation and PMDI values for 2 south Texas study sites were correlated with bobwhite abundance, breeding success, and harvest to test the following hypotheses: 1) annual PMDI from the nearest weather station is correlated more strongly with abundance, breeding success, and harvest than raw precipitation alone; 2) seasonal (Sep–Nov and Apr–Jun) PMDI from the nearest weather station is correlated more strongly with abundance, breeding success, and harvest than raw precipitation for the same time period; and 3) Monthly raw precipitation and PMDI values exhibit similar trends when correlated with abundance, breeding success, and harvest.

METHODS

Study Areas

Two areas were selected within the Rio Grande Plains ecological region of Texas (Gould 1975): the CWMA and the BCP. The CWMA encompasses 6,151 ha in Dimmit and La Salle Counties, Texas, approximately 32 km south-southwest of Cotulla, Texas. The Duval fine sandy loam and Dilley very fine sandy loam soils that predominate on the CWMA support very diverse plant communities. The major vegetative associations present are mesquite-granjeno (*Prosopis glandulosa-Celtis pallida*) parks and mesquite-blackbrush (*Acacia rigidula*) brush (McMahan et al. 1984). Introduced perennial grasses (Lehmann lovegrass [*Eragrostis lehmanniana*] and buffelgrass [*Cenchrus ciliaris*]) were seeded by previous owners or have invaded and presently constitute the majority of the herbaceous biomass found on the CWMA. Native grasses such as plains lovegrass (*Eragrostis intermedia*), plains bristlegrass (*Setaria macrostachya*), and tanglehead (*Heteropogon contortus*) have been reduced as a result of past overgrazing by livestock. The landscape is dominated by mesquite, various acacias (*Acacia* spp.), cacti (*Opuntia* spp.) and other chaparral species. Topography is gently rolling, with elevation ranging from 143 m to 187 m above sea level.

The BCP has ranged in size over the course of this study from 9,700 to 13,760 ha, but has remained at 13,760 ha since 1988. This site is predominately fine sandy soils and is entirely within the mesquite-granjeno parks vegetative association (McMahan et al. 1984). Common native grasses include brownseed paspalum (*Paspalum plicatulum*), Pan American balsamscale (*Elyonurus tripsacoides*), purple three-awn (*Aristida purpurea*), hooded windmillgrass (*Chloris cucullata*), and lovegrasses (*Eragrostis* spp.) Introduced grasses are present, but not dominant. Topography is flat with a 0 to 3% slope and elevations between 12 to 20 m above sea level.

Long hot summers and short mild winters characterize the climate for this region. In La Salle County, mean winter temperature is 12.7° C with a mean minimum of 6.7° C, and mean summer temperature is 29.4° C with a mean maximum of 36.1° C. The two areas typify the majority of South Texas with over 60% of both sites having been subjected historically to mechanical treatment to reduce brush. Woody vegetation dominates the landscape because of a variety of factors, but the primary causes are probably historic overgrazing by livestock and the suppression of natural fires. Coverage of woody plants varies from <30% canopy coverage, usually found on undisturbed sites, to >90% canopy coverage on drainages and areas that have been mechanically manipulated. Previous and present mineral exploration has resulted in several oil or natural gas well sites and numerous seismic and pipeline clearings. Water is well distributed on both areas and mean annual precipitation for CWMA and BCP is 55.4 and 65.4 cm, respectively.

Data Collection and Analysis

Rainfall data for CWMA are for the period January 1982–January 2001, whereas BCP data are for the period January 1984–December 1999. All raw precipitation data were collected from rain gauges located on site.

Annual and seasonal PMDI data used for CWMA are from NOAA station 4109, located west of Freer, Texas in northeast Webb County, approximately 72 km from the CWMA, and from NOAA station 4110 for BCP, located near San Manuel, Texas in northern Hildago County, approximately 64 km from BCP. Drought index data for both areas cover the period September 1982–January 2001.

Survey data were available only from CWMA and represent bobwhite observed/km along two 16.1 km survey routes on CWMA for the period 1983–2000. Counts were conducted 4–8 times per year, from mid-July through mid-October, and results were averaged.

We used harvest records to obtain juvenile:adult ratios as an index of breeding success and as an index of abundance expressed as the total bobwhite harvest for a given season. Additional harvest data collected from the BCP include the number of birds harvested divided by number of hectares hunted. Additional harvest parameters collected from the CWMA include the mean hunter bag for bobwhites across the whole season (total bobwhite harvest/number of hunters participating).

We assumed that harvest indices are related directly to bobwhite abundance; however, the relationship is not necessarily proportional. The CWMA is part of a public hunting system where hunting pressure is largely unregulated, whereas BCP is a commercial hunting camp and adjusts annual harvest to reach a target spring breeding density of 60% of the estimated fall bobwhite population. For the period 1983 through 2000 mean annual bobwhite harvests for CWMA and

Table 1. Correlations between annual (Sep–Aug) sums of raw precipitation (Precip) and the Modified Palmer Drought Severity Index (PMDI) and northern bobwhite abundance (Bobwhite/km), breeding success (Juv:adult), annual total harvest (Harvest), mean harvest per hunter (Bag), and harvest per hectare (Harvest/ha) for the Chaparral Wildlife Management Area (CWMA), La Salle county, Texas, 1982–01 and a private ranch (BCP), Brooks county, Texas, 1984–99.

	Raw precip				PMDI			
	CWMA		BCP		CWMA		BCP	
Variable	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*
Juv:adult	0.53	0.023	0.72	0.003	0.15	0.566	0.25	0.313
Harvest	0.44	0.066	0.48	0.058	0.54	0.022	0.30	0.220
Bag	0.42	0.083			0.58	0.011		
Bobwhite/km	0.50	0.035			0.51	0.031		
Harvest/ha			0.54	0.027			0.42	0.086

BCP were 1,839 (min = 30, max = 11,219) and 3,356 (min = 471, max = 7,712) respectively, and mean annual hunter days for the same time period were 1,396 (min = 212, max = 3,796) and 448 (min = 152, max = 680), respectively.

We plotted abundance and harvest variables against raw precipitation data and PMDI data. We then visually inspected plots for non-linearities, in particular, anything that would suggest a threshold effect. All variables were tested for normality using the Lilliefors test (Wilkinson 1990). Because most variables were significantly non-normal, we used Spearman Rank Correlations to examine the relationship between abundance, breeding success, and harvest with raw precipitation and PMDI. We calculated relationships for the sum of the 12-month period (Sep–Aug) preceding each hunting season, the fall (Sep–Nov) and breeding season (Apr–Jun) time periods (6-month sum) and single month values. Tests were considered significant at the $P < 0.05$ level.

RESULTS

Abundance

Correlations with CWMA census were essentially the same for raw precipitation ($r = 0.50$ [$P = 0.035$]) and PMDI ($r = 0.51$, $P = 0.031$) for the 12-month sum (Table 1). Bobwhite abundance was also correlated with 6-month precipitation ($r = 0.58$, $P = 0.013$), and 6-month PMDI ($r = 0.58$, $P = 0.012$, Table 2). Monthly raw precipitation values were correlated with bobwhite abundance for May ($r = 0.55$, $P = 0.018$) and June ($r = 0.63$, $P = 0.005$, Fig. 1). Monthly PMDI values were correlated ($r \geq 0.49$) during 3 months (May–Jul) with the strongest correlation coming in July ($r = 0.56$, $P = 0.017$, Fig. 2).

Breeding Success

Age ratio was correlated ($r \geq 0.53$) with 12-month and 6-month raw precipitation for BCP and was correlated ($r = 0.53$) only with 12-month precipitation for CWMA (Tables 1–2). February was the only monthly raw precipitation value correlated ($r = 0.53$, $P = 0.025$) with age ratio, and August was the only monthly PMDI value correlated ($r = 0.49$, $P = 0.040$) for CWMA (Figs. 1 and 2). There were no monthly precipitation values correlated with BCP age ratio, but August and June BCP PMDI values were correlated ($r = 0.54$, $P = 0.021$; and $r = 0.46$, $P = 0.050$, respectively) with age ratio (Fig. 2).

Harvest

Annual harvest and bag were correlated ($r \geq 0.54$) with 12- and 6-month PMDI for CWMA (Tables 1–2). Bobwhite harvest/ha was correlated ($r = 0.54$, $P = 0.027$) with 12-month raw precipitation for BCP (Table 1).

June was the only monthly raw precipitation value correlated ($r = 0.47$, $P = 0.047$) with annual harvest for CWMA and May was the only precipitation value correlated ($r = 0.51$, $P = 0.042$) for BCP (Fig. 1). The only monthly PMDI value correlated ($r = 0.52$, $P = 0.027$) with annual harvest was August for BCP (Fig. 2).

May was the only monthly raw precipitation value

Table 2. Correlations between seasonal (Sep–Nov and Apr–Jun) sums of raw precipitation (Precip) and the Modified Palmer Drought Severity Index (PMDI) and northern bobwhite abundance (Bobwhite/km), breeding success (Juv:adult), annual total harvest (Harvest), mean harvest per hunter (Bag), and harvest per hectare (Harvest/ha) for the Chaparral Wildlife Management Area (CWMA), La Salle county, Texas, 1982–01 and a private ranch (BCP), Brooks county, Texas, 1984–99.

	Raw precip				PMDI			
	CWMA		BCP		CWMA		BCP	
Variable	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*
Juv:adult	0.30	0.230	0.53	0.040	0.07	0.795	0.14	0.569
Harvest	0.46	0.057	0.44	0.095	0.57	0.013	0.20	0.433
Bag	0.40	0.105			0.61	0.007		
Bobwhite/km	0.58	0.013			0.58	0.012		
Harvest/ha			0.50	0.057			0.27	0.288

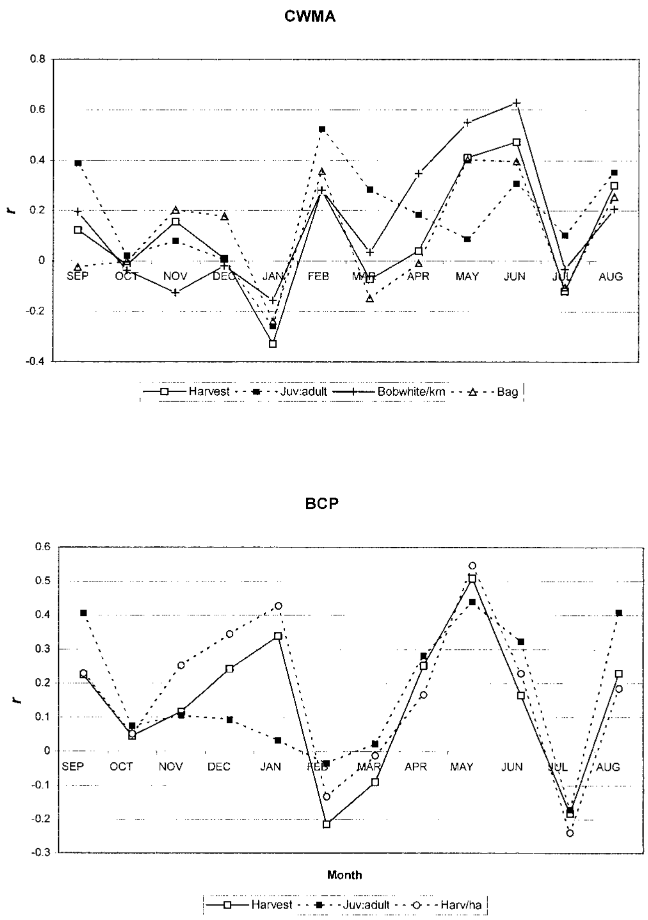

Fig. 1. Correlations between monthly raw precipitation for 12 months preceding hunting seasons (Sep–Aug) and northern bobwhite annual total harvest (harvest), breeding success (Juv: adult), abundance (Bobwhite/km) and mean harvest per hunter (bag) for the Chaparral Wildlife Management Area (CWMA), La Salle county, Texas, 1982–01 and for a private ranch (BCP) in Brooks county, Texas 1984–99. Note: birds harvested/ha were only estimated on the BCP and abundance was estimated only on the CWMA.

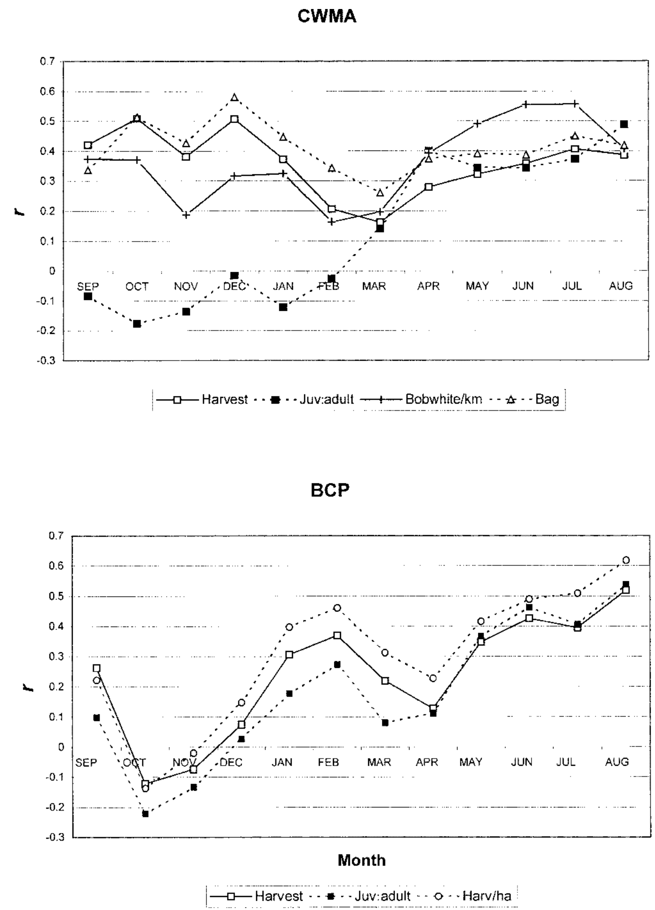

Fig. 2. Correlations between monthly Modified Palmer Drought Indices (PMDI) for 12 months preceding hunting seasons (Sep-Aug) and northern bobwhite annual total harvest (harvest), breeding success (Juv:adult), abundance (Bobwhite/km) and mean harvest per hunter (bag) for the Chaparral Wildlife Management Area (CWMA), La Salle county Texas, 1982–01 and for a private ranch (BCP) in Brooks county, Texas 1984–99. Note: birds harvested/ha were only estimated on the BCP and abundance was estimated only on the CWMA.

correlated ($r = 0.56$, $P = 0.026$) with bobwhite harvest/ha for BCP. However, monthly PMDI values were correlated ($r \geq 0.49$) during 3 months (Jun–Aug) with the strongest correlation coming in August ($r = 0.62$, $P = 0.006$, Fig. 2).

DISCUSSION

Drought index data used for the purpose of this study were taken from the nearest NOAA weather station. Data collected at these stations certainly differs to some degree from weather conditions on site. If the weather stations were actually located on the study sites the PMDI may have accounted for more variability. We did not test variables against a regional PMDI index because the purpose of this study was to examine fine scale trends and relationships.

Annual roadside counts were only conducted at the CWMA. This index of abundance was correlated with the 12- and 6-month sums of raw precipitation and PMDI; however, there was little difference between PMDI and precipitation for both time periods. These findings do not support the hypothesis that PMDI accounts for more variability in abundance than raw precipitation alone at finer scales and contrasts the findings of Bridges et al. (2001) at coarser scales.

The 12- and 6-month sums of raw precipitation were more strongly correlated with breeding success than PMDI sums for both study sites. This does not support the hypothesis that the PMDI accounts for more variation in age ratios than raw precipitation alone. The complexity of factors influencing this index leads us to believe that bobwhite reproductive efforts are influenced by weather differently from indices of abundance. Precipitation can only partially account for the variation in the breeding success of bobwhites. Other factors such as high summer temperatures could directly and negatively affect re-nesting attempts, reproductive condition, juvenile survival, and available thermal space (Guthery et al. 2001, Heffelfinger et al. 1999, Forrester et al. 1998). Although PMDI incorporates several weather variables including temperature, our results did not show a significant correlation with age ratio. At fine scales, other factors including degree of grazing pressure, amount of ground disturbance, and habitat management practices may also influence breeding success.

The CWMA harvest variables were correlated more strongly with annual and seasonal sums of PMDI than with raw precipitation sums. These findings are consistent with our hypothesis that PMDI accounts for more variation in harvest as an index of abundance than precipitation alone at fine scales. However, BCP harvest variables were conversely related and were inconsistent with the same hypothesis, but that may be the product of uneven hunter effort. Harvest at the CWMA was through a public hunting system and was regulated only by the number of days the area was open to quail hunters (mean annual hunter days = 1,396). Conversely, harvest at the BCP was regulated to reach a target spring bobwhite breeding density. The number of outings per season varied greatly from year to year and did not necessarily reflect the availability of birds (mean annual hunter days = 448). In other words, hunter effort was notably different between sites. For this reason we expected differences in correlations with weather variables between sites. We have more confidence in the CWMA harvest variables because consistent annual hunter effort may be related more closely to abundance.

Trends in monthly precipitation correlates were similar for both sites. With the exception of CWMA age ratio, rainfall became increasingly important from spring through summer until July where correlations became negative (Fig. 1). Precipitation has been shown to have direct and detrimental effects on young birds (Welty and Baptista 1988, Healy and Nenno 1985). Furthermore, Rosene (1969:145) suspected that heavy rainfall during the nesting and brooding season could greatly reduce bobwhite recruitment. Although our results do not provide definitive evidence that large amounts of July rainfall negatively influence bobwhite production, we feel that July precipitation and bobwhite production warrants further investigation.

Monthly PMDI values did not demonstrate this relationship with July (Fig. 2). Instead, PMDI became increasingly important from spring through summer including July. This does not support our hypothesis that monthly raw precipitation and PMDI values are correlated similarly with abundance, breeding success, and harvest.

In conclusion, at fine scales raw precipitation accounted for more variation in bobwhite census, and age ratio than PMDI, whereas PMDI accounted for more variation in harvest variables only at the public hunting area, CWMA. Our findings provide information useful in understanding of the influence of weather on annual variation of bobwhite populations in South Texas.

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LITERATURE CITED

Botsford, L. W., T. C. Wainwright, J. T. Smith, S. Mastrup, and D. F. Lott. 1988. Population dynamics of California quail related to meteorological conditions. Journal of Wildlife Management 52:469–477.

Bridges, A. S., M. J. Peterson, N. J. Silvy, F. E. Smeins, and X. Ben Wu. 2001. Differential influence of weather on regional quail abundance in Texas. Journal of Wildlife Management 65:10–18.

Campbell, H. 1968. Seasonal precipitaion and scaled quail in eastern New Mexico. Journal of Wildlife Management 32: 641–644.

Forrester, N. D., F. S. Guthery, S.D. Kopp, and W. E. Cohen. 1998. Operative temperature reduces habitat space for northern bobwhites. Journal of Wildlife Management 62: 1506–1511

Francis, W. J. 1970. Influence of weather on population fluctuations in California quail. Journal of Wildlife Management 34:249–266.

Giuliano, W. M., R. S. Lutz, and R. Patino. 1996. Reproductive responses of adult female northern bobwhite and scaled quail to nutritional stress. Journal of Wildlife Management 60:302–309.

Gould, F. W. 1975. Texas plants—a checklist and ecological summary. Texas A&M University, Texas Agricultural Experimental Station, College Station.

Guthery, F. S., C. L. Land, and B.W. Hall. 2001. Heat loads on reproducing bobwhites in the semiarid subtropics. Journal of Wildlife Management 65:111–117.

Healy, W. M., and E. S. Nenno. 1985. Effect of weather on wild turkey poults survival. Proceedings of the National Wild Turkey Symposium 5:91–101.

Heddinghaus, T. R., and P. Sabol. 1991. A review of the Palmer Drought Severity Index and where do we go from here? Seventh Conference on Applied Climatology. American Meteorological Society, Boston, Massachusetts.

Heffelfinger, J. R., F. S. Guthery, R. J. Olding, C. L. Cochran, Jr., and C. M. McMullen. 1999. Influence of precipitation timing and summer temperatures on reproduction of Gambel's quail. Journal of Wildlife Management 63:154–161.

McMahan, C. A., R. G. Frye, and K. L. Brown. 1984. The vegetative types of Texas including cropland. P-R Project W-107-R, Texas Parks and Wildlife Department, Austin.

McMillan, I. I. 1964. Annual population changes in California quail. Journal of Wildlife Management 28:702–711.

Peterson, M. J., and N. J. Silvy. 1994. Spring precipitation and fluctuations in attwater's prairie chicken numbers: hypothesis revisited. Journal of Wildlife Management 58:222–229.

Rice, S. M., F. S. Guthery, G. S. Spears, S. J. DeMaso, and B. H. Koerth. 1993. A precipitation based model for northern bobwhites on semiarid rangeland. Journal of Wildlife Management 57:92–102.

Roberts, S. D., and W. F. Porter. 1998. Influence of temperature and precipitation on survival of wild turkey poults. Journal of Wildlife Management 62:1499–1505.

Roseberry, J. L., and W.D. Klimstra. 1984. Population ecology of the bobwhite. Southern Illinois University Press, Carbondale, Illinois.

Rosene, W. 1969. The bobwhite quail: its life and mangement. Rutgers University Press, New Brunswick, New Jersey.

Sheaffer, S. E., and R. A. Malecki. 1996. Predicting breeding success of Atlantic coast population Canada geese from meteorological variables. Journal of Wildlife Management 60: 882–890.

Welty J. C., and L. Baptista. 1988. The life of birds. Saunders College Publishing, San Francisco, California.

Wilkinson, L. 1990. SYSTAT: The system for statistics. SYSTAT, Inc. Evanston, Illinois.