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RECENT POPULATION TRENDS AND HARVESTS OF NORTHERN BOBWHITE IN INDIANA

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INTRODUCTION

The northern bobwhite (*Colinus virginianus*) is a familiar and welcome bird to rural Indiana residents, which is highly valued for its hunting qualities. Bobwhite populations are closely associated with early successional and ecotonal habitats resulting from agricultural operations. The bobwhite is distributed throughout the eastern United States and reaches the northern limit of its range in the States just north of Indiana.

Recent population levels and population trends of bobwhite quail in Indiana are recorded in this paper based on objective population surveys and estimates of harvest during legal hunting seasons. Comparisons are made to past surveys and harvests. Additionally, weather variables that might explain these fluctuations are examined.

METHODS

Population trends were established using two distinct surveys. The first was a breeding population survey conducted since 1976 by personnel from the Indiana Department of Natural Resources (DNR) during late June. The second data set was the U.S. Fish and Wildlife Service Breeding Bird Survey (BBS) that provides breeding indices beginning in 1966.

DNR survey routes were originally established and stratified based on major soil associations (Reeves, 1953). One hundred roadside routes were established in 1947, and each consisted of 8 to 10 stops spaced at one-mile intervals. The number of calling male bobwhite was tallied at each stop during a three-minute period. DNR surveys were conducted from 1947 to 1958, after which they were apparently discontinued. In 1976, DNR quail surveys were reinstituted, and from 29 to 43 of the original routes were surveyed annually through 1987. In 1988, the number of routes was increased to 71 in order to map more accurately the distribution and relative abundance of bobwhite in Indiana. The same routes were used each year, although some routes were replaced as a result of road closures or problems with excessive traffic. Beginning in 1986, the number of stops was increased to 15 by adding stops to the ends of routes. Each route was surveyed once during 20-30 June, beginning at sunrise on mornings with good weather.

The BBS is a roadside survey designed to monitor the distribution and population trends of birds in North America (Robbins, *et al.*, 1986). Forty-two routes

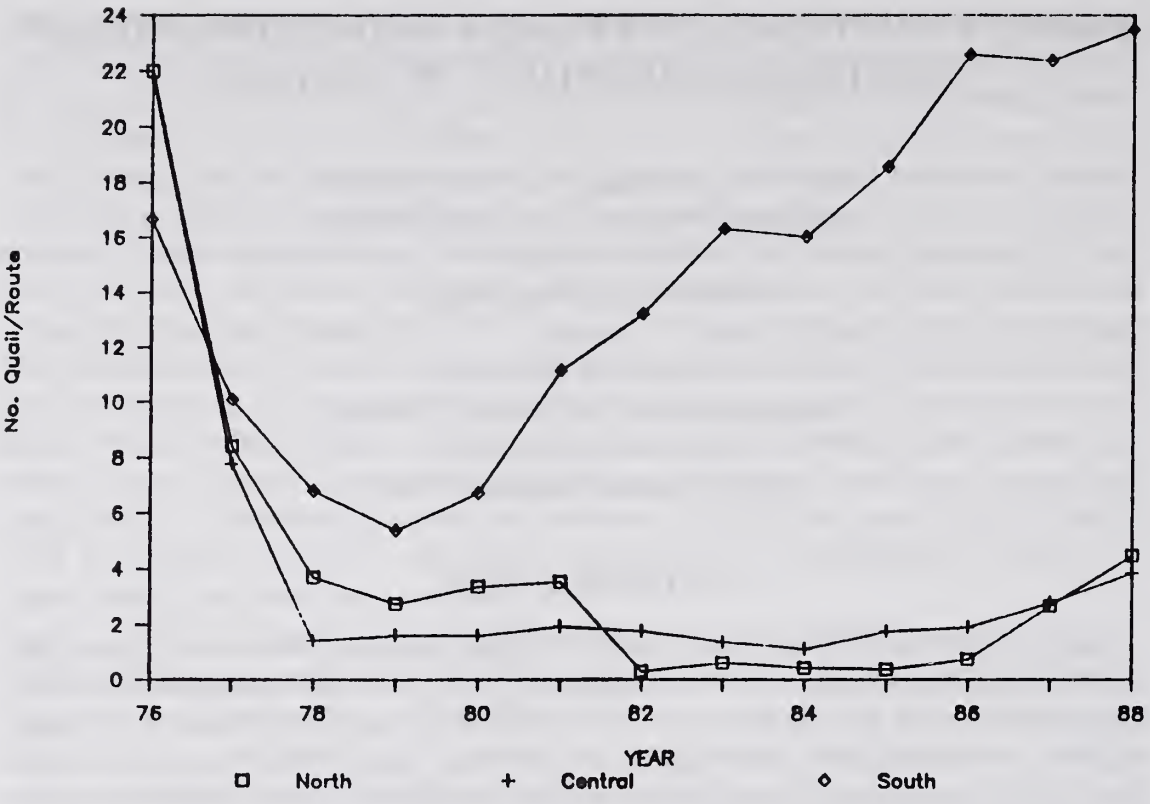


FIGURE 1. Regional population trends of bobwhite in Indiana based on DNR surveys from 1976 to 1988.

have been established in a stratified random manner in Indiana. Each route consists of 50 three-minute stops spaced at 0.5-mile intervals. Qualified volunteers survey each route once during June, beginning one hour before sunrise. All birds seen or heard within 0.25 miles of a stop are recorded. Each year from 1966 through 1987, 13 to 37 routes were surveyed. Only four of the 42 routes have not been surveyed at least once.

Results of the DNR and BBS surveys were handled in a similar manner. In the initial year of each survey, the number of quail detected was determined per stop for DNR surveys and per route for BBS. Subsequent annual population indices were calculated using changes in totals from comparable routes between each pair of successive years. Annual indices were calculated statewide and for northern, central, and southern regions of the State. Population surveys of northern bobwhite using counts of calling males is an accepted population monitoring technique but does not always accurately predict harvests (Rosene, 1957; Norton, *et al.*, 1961; Preno and Labisky, 1971; Ellis, *et al.*, 1972; Rosene and Rosene, 1972; Schwartz, 1974; Wells and Sexson, 1982).

Estimates of the number of quail hunters, harvest efforts, success rates, and total harvest were determined from post-season mail questionnaires. Questionnaires were sent to a random sample of hunters purchasing small game licenses each year since 1976 with the exception of 1982. From 1976 to 1987, usable questionnaires were received annually from an average of 5914 (range = 4742-8265) respondents, which represented 1.95% (range = 1.23-3.27%) of small game hunting license buyers. Harvest variables were adjusted for response and non-response biases, using correction factors developed for Indiana by Pfingsten (1980)

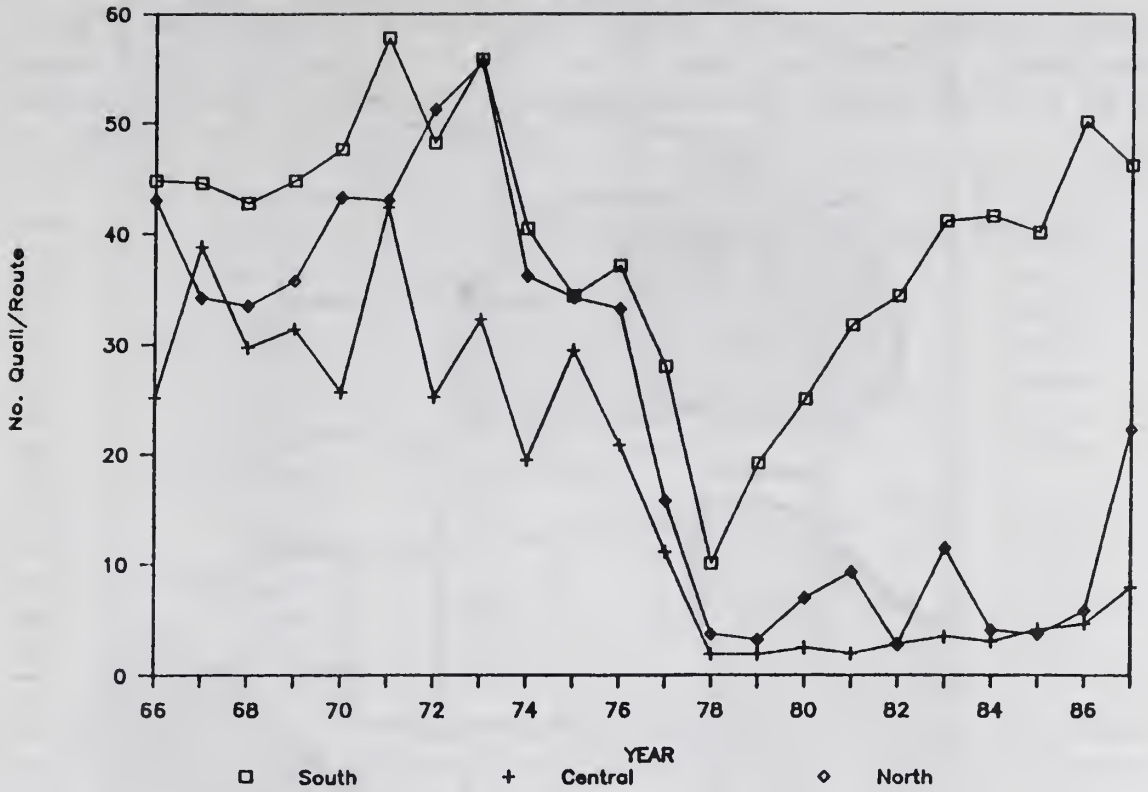


FIGURE 2. Regional population trends of bobwhite in Indiana based on BBS from 1966 to 1987.

and Rolley (1987). Therefore, our estimates of harvest and hunter numbers for these years differ from those previously published (Machan, 1986: p. 109).

Weather variables for the period December through March of the years 1965 to 1987 were compiled from annual reports of climatological data (National Oceanic and Atmospheric Administration, 1965-1987). For each winter (December-March), total snowfall and average temperature were extracted for three regions of Indiana (north, central, and south). Annual BBS indices of bobwhite populations for these regions were recalculated and examined statistically using these two weather variables. Simple correlations and multiple regressions were performed. Because annual indices are not independent events, the previous year's index was also used in the multiple regression models.

RESULTS

Population trends. Bobwhite populations as determined from DNR surveys were relatively high throughout Indiana in 1976 (Figure 1). A series of successive, harsh winters reduced populations by 84% by 1979 from 1976 levels. Recovery of bobwhite populations in southern Indiana was steady and attained levels comparable to pre-1977 levels by 1980. Populations in northern and central Indiana have not rebounded but are showing gradual increases.

BBS surveys showed similar population trends for the same period as the DNR surveys (Figure 2), but populations prior to 1976 were even higher. Bobwhite populations in southern Indiana had recovered to 1976 levels by 1982 or 1983. Regression analyses showed agreement between BBS and DNR surveys during

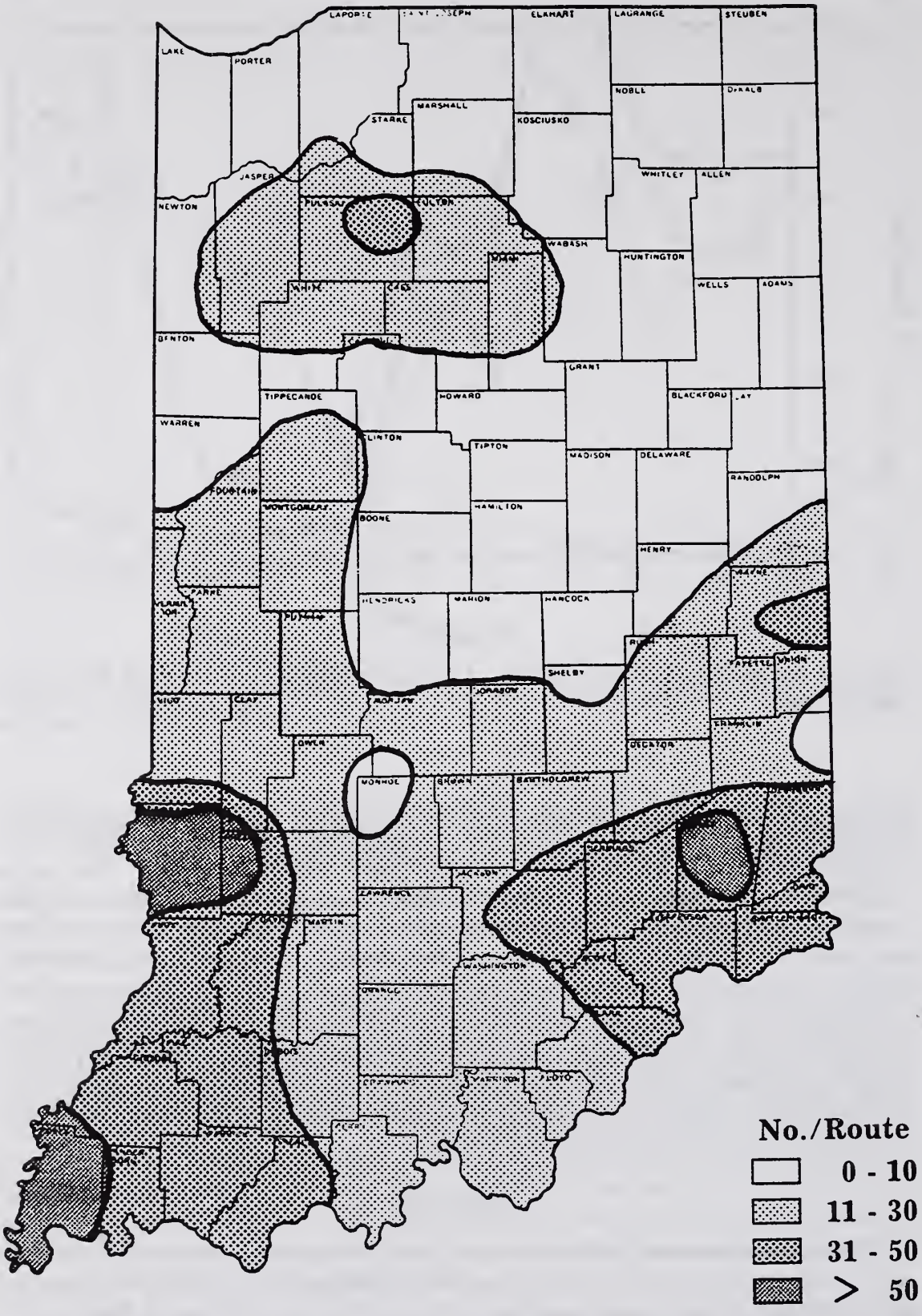


FIGURE 3. The relative distribtution of bobwhite in Indiana based on DNR surveys in 1988.

TABLE 1. Bobwhite harvest statistics for Indiana, 1976-1987. Excluded is information from landowners that legally hunt on their own property without purchasing a small game license. These landowners would add approximately 7% to the numbers harvested below (Castrale, *et al.*, 1985).

Year	No. hunters	Efforts/ hunter	Harvest/ hunter	Harvest/ effort	Bobwhite harvested
1976	100,679	6.03	3.51	0.58	353,826
1977	75,241	5.50	2.25	0.41	169,107
1978	60,667	4.94	1.18	0.24	71,315
1979	43,673	4.78	1.28	0.27	56,050
1980	33,002	4.87	1.43	0.29	47,079
1981	33,799	4.52	1.66	0.37	56,186
1982	—	—	—	—	—
1983	34,231	4.90	2.44	0.50	83,667
1984	27,966	6.13	2.15	0.35	60,197
1985	22,811	6.41	3.33	0.52	75,968
1986	21,880	6.94	3.73	0.54	81,672
1987	25,072	6.38	4.61	0.72	115,567

the period 1976-1987. The coefficient of determination (r^2) for statewide indices was 0.78 ($P < 0.01$) and was highest for central ($r^2 = 0.82, P < 0.001$) and southern ($r^2 = 0.87, P < 0.001$) regions. Northern routes had an r^2 of 0.68 ($P < 0.01$).

Approximately 50% fewer bobwhite are tallied per stop on BBS routes as on DNR routes. Bobwhite may be overlooked on BBS routes, because attention is also focused on other birds. Additionally, BBS include time periods (prior to sunrise and late morning), when bobwhite are less likely to call.

Population distribution. The current relative abundance of bobwhites in Indiana based on DNR surveys in 1988 showed highest numbers in southwestern and southeastern Indiana (Figure 3). Bobwhite were present on most routes except for some in northeastern Indiana. Southcentral, portions of central, and northwestern Indiana had intermediate levels.

DNR survey data for the same routes during the years 1952-1958 and 1987-1988 were mapped to compare the distribution and relative abundance of bobwhite (Figure 4). Differences in the statewide decline in numbers from the earlier period are apparent. The mean number of bobwhite/stop declined from 2.24 to 1.03. Sixty-one of 71 routes had fewer bobwhite during 1988. The proportion of the State that averaged < 1.0 bobwhite/stop increased from < 20% to almost 50%. Areas with > 3.0 bobwhite/stop declined from approximately 50% to < 5% of the State.

Harvest by sportsmen. From 1976-1987, the number of bobwhite harvested by licensed hunters ranged from over 350,000 in 1976 to less than 25,000 (Table 1). The number harvested was most highly correlated with spring indices ($r^2 = 0.94$, df = 9, $P < 0.001$) and the number of hunters afield ($r^2 = 0.69$, df = 9, $P < 0.01$). Other harvest statistics (efforts/hunter, harvest/hunter, and harvest/effort) were not significantly correlated with the number harvested. A regression model incorporating all harvest variables explained 96% of the variation in bobwhite harvested. Although statewide populations have rebounded to 44% of 1976 levels, harvests and hunter numbers are 33% and 25% of 1976 levels.

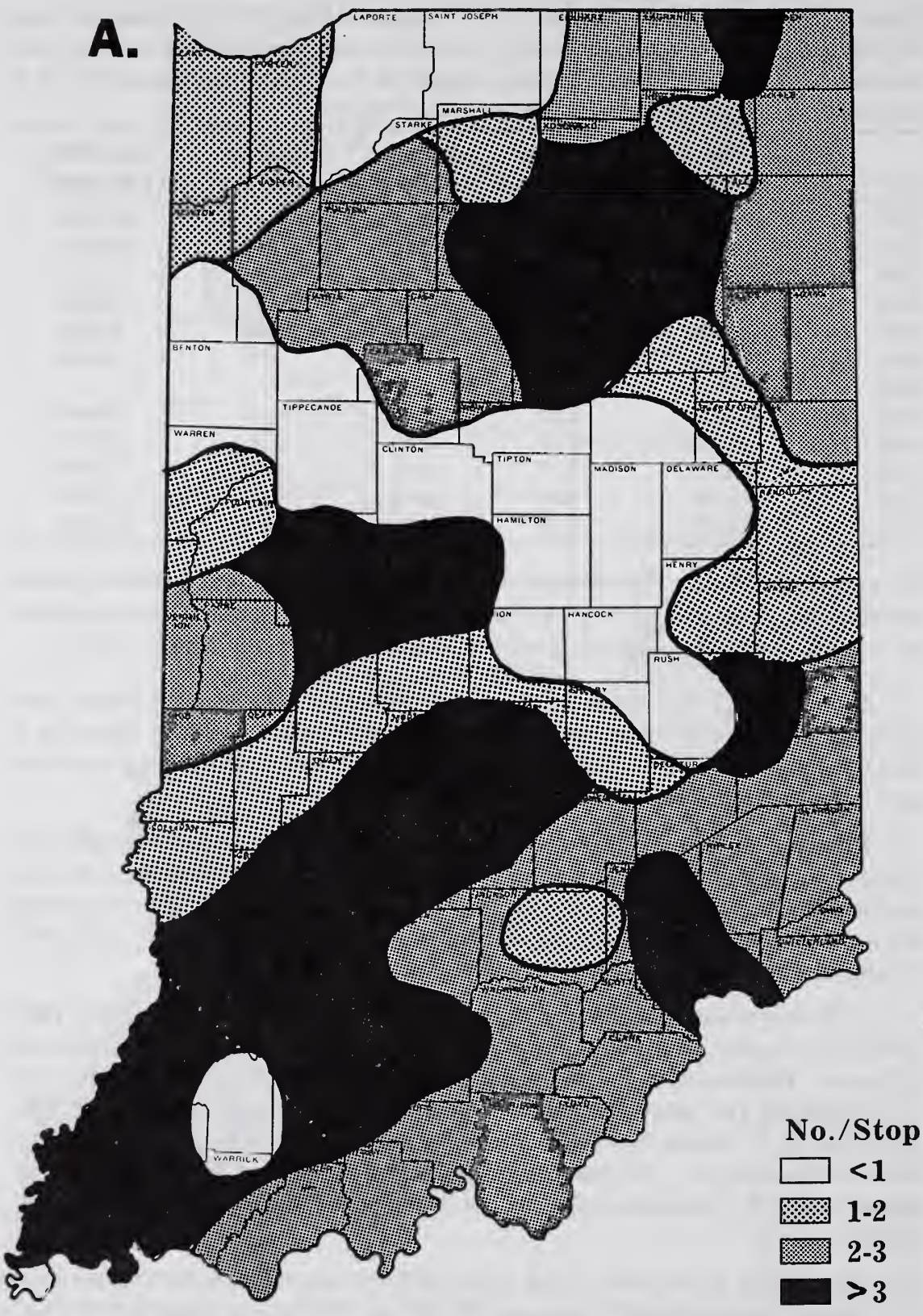
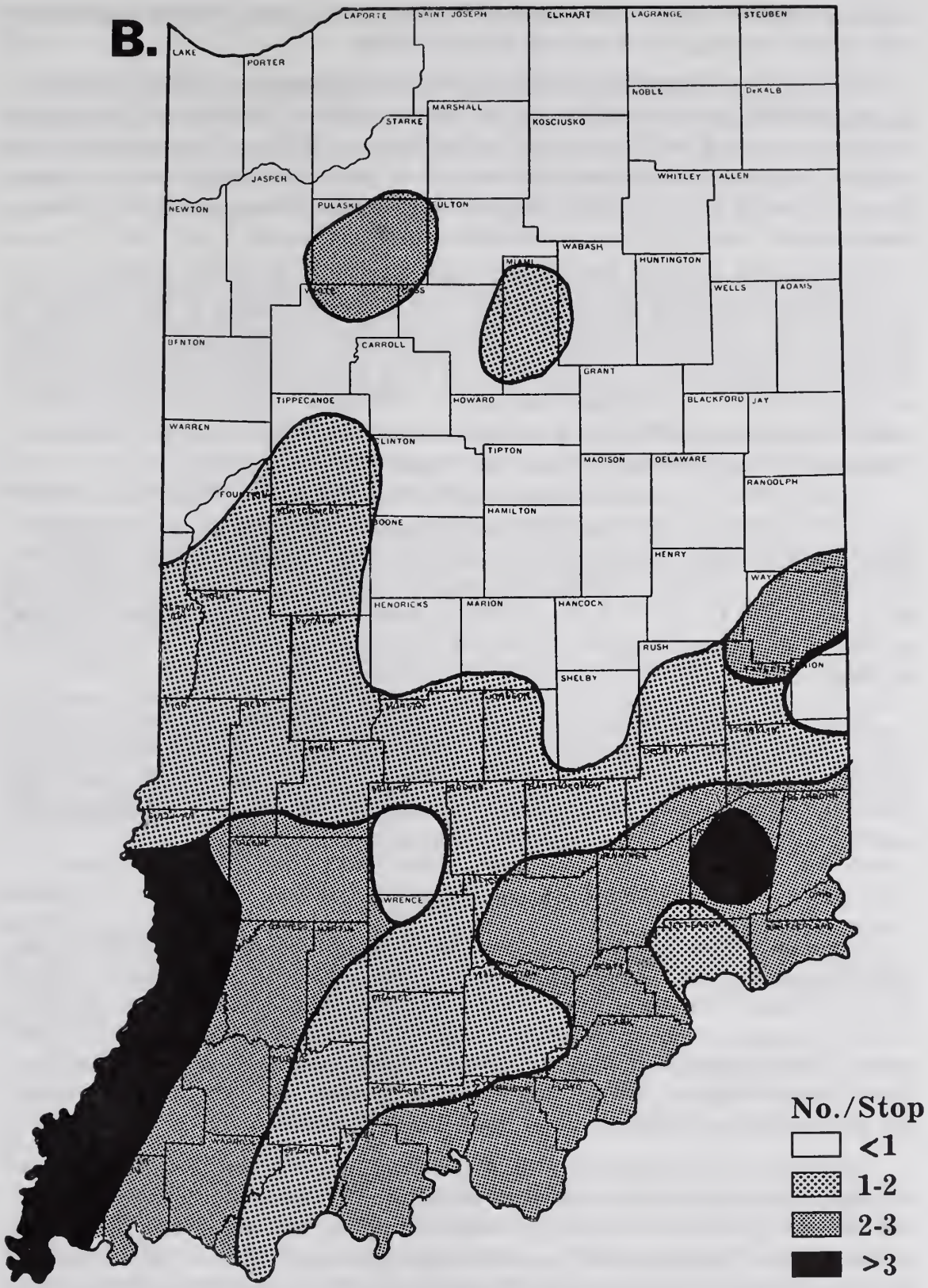


FIGURE 4. Relative distributions of bobwhite in Indiana for 1952-1958 (A) and 1987-1988 (B), using data from identical DNR survey routes.



Bobwhite hunting is better now than in 1976, if judged by the number harvested per hunting trip and the number harvested during the season by each hunter. The number of bobwhite harvested per hunter and per hunting effort fell sharply from 1976 levels to lows in 1978. These variables gradually increased thereafter, although increases have been more pronounced in the last several years. The number of efforts per hunter followed a similar trend, although differences were less pronounced. Thus, from 1976-1987, it appears that the more

casual bobwhite hunters discontinued hunting during years when populations were lowest, leaving the more avid hunters afield.

For the period 1940-1954, 800,000 bobwhite were harvested annually by hunters, with as many as 1.5 million in 1940 (Reeves, 1955). Harvests again exceeded 1 million in the late 1950's (Machan, 1986). These estimates are certainly inflated relative to modern figures, because they fail to take into account various survey biases. However, it is likely that harvests were several times greater than during recent years.

Impacts of weather. Winter snowfall and mean daily temperature were significantly correlated with each other and with BBS indices in each region of the State. The inverse correlation between snowfall and BBS index was highest in southern Indiana ($r = -0.61$, $df = 19$, $P = 0.003$) and lower in northern ($r = 0.47$, $df = 19$, $P = 0.028$) and central ($r = -0.43$, $df = 19$, $P = 0.045$) Indiana. Annual winter snowfall for this period averaged 102 cm, 64 cm, and 42 cm for northern, central, and southern Indiana, respectively.

From 1966-1987, daily average temperatures during the winter were $-1.94°$ C, $-1.00°$ C, and $1.67°$ C for northern, central, and southern regions, respectively. Winter temperatures were positively correlated with the BBS index in southern ($r = 0.55$, $df = 19$, $P = 0.008$), central ($r = 0.45$, $df = 19$, $P = 0.035$), and northern ($r = 0.41$, $df = 19$, $P = 0.059$) Indiana. Winter temperature and total snowfall amounts were highly correlated (r ranged from -0.63 to -0.82) in all regions.

The best single predictor of the annual BBS index was the previous year's index. A model using the previous year's index and winter snowfall explained 70-90% ($P < 0.0001$) of the variation in BBS indices for each region for the 1966-1987 period. Adding winter temperature data resulted in less than a 2% addition to the predictive capabilities of the multiple regression models.

DISCUSSION

The distribution and abundance of bobwhite populations are constantly undergoing changes. Natural and man-induced influences are occurring that have short- and long-term consequences on the status of this species. Weather patterns, climatic changes, ecological succession, land use changes, farming practices, and other land management practices profoundly affect local and regional occurrence and numbers (Edwards, 1972; Exum, *et al.*, 1982; Klimstra, 1982). These processes are occurring simultaneously and interact with each other.

In Indiana, the distribution and relative abundance of bobwhite are influenced primarily by winter weather and habitat quality. The severity of winter weather that is more pronounced in northern Indiana causes periodic, sharp declines. In much of central Indiana, where row-crop farming is most intense, quality habitat is in short supply. In south-central Indiana, quality habitat is also suboptimal, because of large forested areas that are unsuitable for bobwhite. Currently, southeastern and southwestern Indiana appear to be most favorable for bobwhite due to mild winter weather and probably the most optimum mix of forested and open habitats.

Bobwhite benefited greatly during the period of European settlement as a result of the clearing of forests, the creation of openings, and the increase in food associated with cultivated land (Mumford and Keller, 1984). Reeves (1955) esti-

mated that bobwhite populations in Indiana were greatest just after the Civil War.

Barnes (1947) mapped the distribution of bobwhite in Indiana based on the average number of birds shot per hunter for each county during 1940-1945. Relative distribution of bobwhite was similar to that in 1987-1988. Bobwhite harvests per hunter were decidedly greater in southern Indiana. Barnes explained this as a result of three factors manifested in northern Indiana: lack of cover due to intensive agriculture, colder winters, and greater hunting pressure. No counties north of Brown County were considered excellent, and only one county north of Vermillion County was considered good. Counties rated poor were in three distinct regions: the northern tier counties from Lake to Elkhart, the three northwestern counties (Benton, Warren, and Tippecanoe), and the 16 northeastern counties. Southern counties were rated medium to excellent and were relatively uniform.

Allen (1959) mapped the relative abundance of bobwhite in Indiana based on the seasonal harvest per hunter by county for the period 1940-1957. The general pattern was similar to that presented by Barnes (1947).

Mumford and Keller (1984) noted that bobwhite were susceptible to large-scale dieoffs during winters, when ice or crusted snow remained on the ground for extended periods of time. Butler (1898) noted such declines during the winters of 1878-1879 and 1892-1893.

Trends in abundance for a bobwhite population in southern Illinois from 1953-1980 were presented by Roseberry and Klimstra (1984). Fall populations appeared to exhibit a 10-yr cycle, and the overall trend was negative. Ohio populations were affected as dramatically by the severe winters of the late 1970's as were those in Indiana, and a large area of vacant range still exists (J. Henry, personal communication).

Roseberry and Klimstra (1984) stated that prolonged snow cover is the most detrimental weather condition for midwestern bobwhites. Heavy snow, wet weather in late winter and spring, heavy summer rains, and drought during the summer adversely affected populations in Illinois (Edwards, 1972). Kabot and Thompson (1963) noted that snow cover in conjunction with winter habitat limits the abundance and distribution of bobwhite in Wisconsin.

Stanford (1972) analyzed the influences of weather on Missouri populations. In years of severe snow and cold, bobwhite suffered mortality followed by reduced production. Recovery from weather-induced declines generally occurred two or three years later.

The number and distribution of bobwhite in Indiana will continue to depend primarily on land uses as they affect the quantity and quality of habitat. Winter weather conditions, however, will cause dramatic short-term changes. If winter conditions are average or favorable in the next decade, populations in central and northern Indiana should increase as bobwhite slowly repopulate areas from which they were locally extirpated in the late 1970's.

SUMMARY

Breeding populations of bobwhite were monitored from 1976 to 1988 using annual counts of calling males along 29 to 71 statewide routes and from 1966 to 1987 using Breeding Bird Survey data on 13 to 37 Indiana routes. In 1976, bob-

white were distributed statewide with similar population levels among northern, central, and southern regions. From 1977 to 1979, a series of harsh winters caused a 75-95% reduction in numbers throughout the State, and northern populations were again reduced following the winter of 1981. Populations rebounded in southern Indiana but are still depressed in northern and central portions of the State. Harvests by hunters experienced a similar trend, but kill figures have not increased to the extent that populations have. Population trends were influenced by winter snowfall and, to a lesser extent, by average winter temperatures.

ACKNOWLEDGMENTS

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