State of Illinois
Department of Natural Resources

The Bobwhite in Illinois:

Its Past, Present and Future

ILLINOIS
DEPARTMENT OF
NATURAL
RESOURCES

Introduction

The northern bobwhite is one of America's most popular and widely distributed game birds. Its range extends from the Atlantic ocean west to the foothills of the Rockies, and from the Gulf of Mexico north to central Wisconsin and Minnesota. Highest populations have historically occurred within the 23 states bounded by a line from Delaware west to Nebraska thence south to Texas. There is currently widespread concern among wildlife professionals regarding the future of this species, and for good reason. From 1966 to 1999, quail populations declined nearly 4% per year in the Southeast (12) and 3% per year in the Midwest (19). If this rate of decline continues over the next 30-40 years, quail will be virtually extinct in both regions.

Despite its current problems, the bobwhite remains an integral part of our natural Illinois heritage, and its welfare should concern us all. Much has been written about the species, both popular and technical. Unfortunately, popular accounts are often more entertaining than informative, while technical articles are generally written by scientists for other scientists. Consequently, the interested laymen often finds it difficult to obtain in-depth or current biological information – we hope this booklet provides such information. In it, we discuss important aspects of quail biology, life history, and population dynamics in the context of basic ecological principles and current management concepts. In that way, we hope to share with the reader – biologist and nonbiologist, hunter and nonhunter – a better appreciation and understanding of this remarkable bird and the challenges it faces.

History and Distribution in Illinois

Pre-settlement - 1860

As the War of 1812 ended, settlers from the east and south began to arrive in the territory that was soon to become the state of Illinois. It is difficult to imagine what this area actually looked like back then. The major geologic and geographic features – the rivers, streams, hills, valleys, and plains – were pretty much the same as today, but what was in and on these features was vastly different. Except for a few small settlements and Indian villages, the landscape was virtually devoid of human influence. The southern 1/4 of the State and the counties bordering the Wabash, Mississippi, and lower Illinois rivers were covered with what must have been some spectacular mature hardwood forest. In contrast, the flat, fertile lands of east-central Illinois – now the great "corn desert" – was a vast sea of tall-grass prairie with fingers of forests extending along the rivers and streams. At the forest-prairie interface, and to a lesser extent imbedded in each, were areas of open canopy forest with an understory of prairie grasses and forbs. Early writers referred to these as barrens, now they are more commonly called savannas.

Early settlers not only encountered a different flora than exists today, they encountered a different fauna as well. The territory of Illinois was still home to elk, bison, cougars, black bear, timber wolves, and passenger pigeons. Also present were most of the familiar species that we know today including deer, turkey, and of course bobwhite. No scientific surveys had yet been conducted so we can only speculate on the bobwhite's distribution and abundance based on accounts of early travelers and our current knowledge of the species' habitat needs and preferences. While possibly locally common, quail would almost certainly not have been widely distributed or abundant throughout the entire territory. They would have been rare or absent in the wooded wetlands along the Illinois and Mississippi rivers and in the large, unbroken tracks of mature forest and tall-grass prairie that dominated the landscape. Not surprisingly, they were reportedly restricted to areas where grasslands and forest converged. According to Captain Adam Bogardus, a noted 19th century hunter from Elkhart, bobwhite were most abundant in savannas, sandy areas, and other less fertile, higher, drier locations that featured a mix of scattered hardwoods, shrubs, and short, open stands of little bluestem and various prairie forbs (6). To this day, bobwhite seek out plant communities with similar structure and diversity though species composition differs widely.

Almost immediately, settlers began to affect the landscape and the resident wildlife. As the human population of Illinois increased from about 12,000 in 1810 to almost 1 million by 1850, forests, and especially prairies, were gradually replaced by farmland. Some indigenous species simply could not withstand these changes or the increased hunting pressure. In a relatively short period of about 40-50 years, elk, bison, cougar, bear, and timber wolves were essentially eliminated from the State. Other species, however, actually benefitted from some of the early human-induced landscape changes, one in particular was the bobwhite. The bobwhite does not thrive in primitive, undisturbed areas. Instead, quail are almost always found in some kind of disturbed or manipulated setting, which explains their traditionally close association with agriculture. In pre-settlement days, they probably responded positively, but temporarily, to forest or prairie fires started accidentally by lightning or purposely by native Americans. But it was the activities of the early settlers that really began to make the landscape more suitable for quail. Initially, settlers began clearing forests to establish farm fields because they believed that forest land was more fertile than grassland, and their primitive plows could not turn the tough prairie sod (26). The small clearings created adjacent to woodland edges and the waste grain and seeds from annual weeds and grasses associated with soil disturbance provided bobwhite with abundant and accessible food supplies. Pioneer farming methods quickly exhausted the fertility of forest soils forcing farmers to abandon their fields after a few years and clear new ones. These abandoned fields were quickly occupied by plants favored by bobwhite for nesting and brood rearing. By all indications, quail thrived in this primitive agricultural setting and probably reached peak distribution and abundance in Illinois about the time of the Civil War.

1860 - 1960

The next 100 years produced tremendous cultural, technological, and economic changes including agricultural changes that altered the very face of the land. In 1860, 34% of Illinois was farmland; by 1900, the figure had risen to 90%. Much of this increase was due to the advent of the moldboard plow which allowed virtual complete conversion of the prairie to cropland. As in the forested southern portions of the state, early agricultural advances into the prairie were undoubtedly beneficial to bobwhite. Cropfields and associated annual weeds and grasses provided abundant food supplies while the establishment of osage orange hedgerows and native woody plants made possible by fire suppression provided much needed cover. As the land became settled and citizens had more leisure time, the abundant bobwhite became the favorite quarry of sport hunters with fine shotguns and beautiful, well-trained setters and pointers. By the beginning of the 20th century, bobwhite were highly valued as a gamebird and the State Legislature enacted hunting seasons and bag limits to protect this important natural resource.

During the first 1/3 of the 20th century, agriculture continued to evolve from settlement to commercial farming while still remaining rather diverse and primitive – but not for long. Rapid advances in mechanization in the 1930s allowed farming to become more efficient, while development of synthetic fertilizers and chemical pesticides around the time of World War II led to the intensive, monocultural rowcrop agriculture that currently dominates the Illinois landscape.

We cannot say with certainty exactly how quail fared throughout this period. Two prominent Illinois ornithologists, comparing their results with earlier scientific surveys, concluded that bobwhite populations in 1956-58 were roughly similar to what had been observed by their earlier colleagues in 1906-09 (34). What accounts for this apparent stability through the first half of the 20th century? Though agricultural technology was advancing, farms were still small and fields, often bordered by shrubby fencerows, were usually no larger than 20 to 40 acres. And while tractors had largely replaced horses as a power source, the production of livestock created a continuing need for permanent pastures and hayfields. Furthermore, crop rotation including small grains, legumes, and periodic fallowing was still widely practiced.

1960 - Present

Quail were probably scarce, if not absent, over much of the "Grand Prairie" region of Illinois by 1900 (32) owing to the intensity of agriculture on this flat, incredibly fertile land. In much of westcentral and southern Illinois, however, quail continued to prosper as late as the 1960s simply as a byproduct of normal farming operations. Many farms in these slightly hillier, less productive portions of the state still featured a diverse mix of rowcrops, small grains, pasture, hayfields, fallow land, and woodlots all occurring in relatively small patches and tied together by a network of brushy fencerows and woody hedgerows. The practice of regular fallowing of cropland and the maintenance of woody hedgerows was especially beneficial to quail. Fallowed fields provided the early successional weeds and grasses critical for successful reproduction and brood rearing while the brushy hedgerows provided protective cover and travel lanes that allowed the birds to safely access food supplies in the cultivated fields.

Agriculture in the Illinois quail range began to intensify and simplify in the 1960s and especially the 1970s as we entered the era of "fencerow to fencerow" farming. Cropping patterns became less diversified as farmers concentrated on 1 or 2 cash grains. Small woodlots and idle corners were cleared and planted to row crops. Fencerows and hedgerows were bulldozed out to enlarge fields in order to accommodate modern machinery and increase tillable acreage. Heavy use of fertilizers replaced crop rotation and fallowing, combines replaced old-fashion corn pickers, and fall plowing became an almost universal practice. Pasture and hayfield acreage was greatly reduced as the cattle industry moved from grassland to feedlot, and much of the grassland that did remain was converted from mixed stands to monocultures, especially fescue. On top of all this, there was a large increase in the use of herbicides and insecticides intended to eliminate the two primary sources of native bobwhite foods – weeds and insects. All of these things made farmland that once supported an abundance of quail, now basically inhospitable. The response of quail was dramatic, relatively sudden, and predictable – statewide abundance declined at least 60% from the mid-1960s to the mid-1980s (Fig. 1).

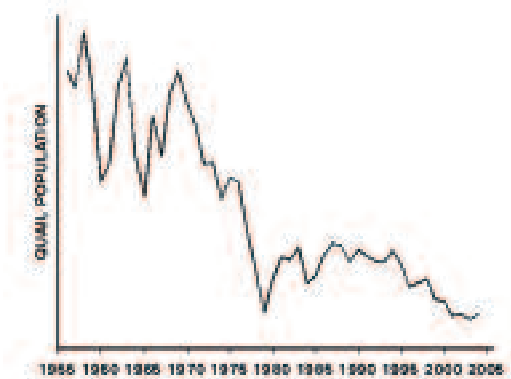


Fig. 1. Bobwhite population change from 1960 to present, short-term fluctuations are mainly due to weather; long term trends reflect habitat loss.

Emergence at about this time of the Conservation Reserve Program (CRP) carried with it widespread anticipation of positive benefits to wildlife, including bobwhite. This program was a provision of the 1985 Food Securities Act (Farm Bill) that encouraged landowners to retire highly erodible cropland for a minimum of 10 years and replace it with semi-permanent vegetation, usually grass. From the late 1980s to the present, approximately 2 to 3% of the Illinois quail range has been enrolled but despite initial optimism, CRP apparently has not benefitted regional or statewide quail populations as much as was anticipated (95). We'll discuss possible reasons and remedies for this in a later section (Bobwhite and Agriculture).

Current Distribution

The bobwhite's geographic range includes all of Illinois, although the northern 1/4 of the State, where annual snowfall averages 25-40 inches, is considered "fringe" or marginal because of unfavorable winter climate (102). While quail probably occur in every county in Illinois, they are most abundant and well distributed in the southern and westcentral portions of the State (Fig. 2). They are scarce north

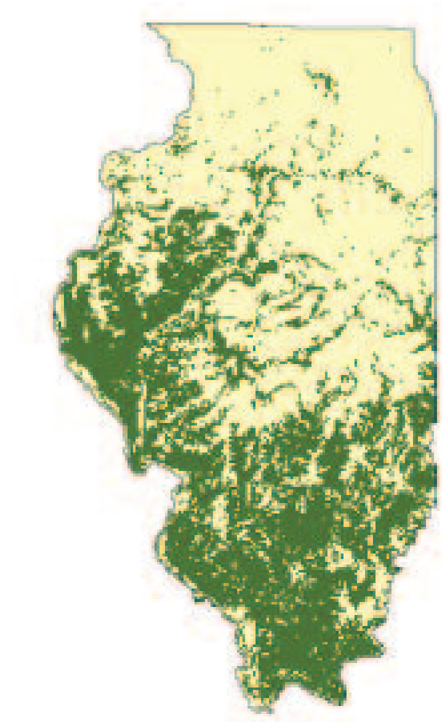


Fig. 2. Current distribution of potential bobwhite habitat (green) as determined from satellite imagery.

of this region because winters are too harsh, and east because rowcrop agriculture is too intense.

Distribution within their primary range is strongly influenced by human land use which in turn is largely governed by soil productivity and terrain. Quail habitat in Illinois is mainly limited to moderately rolling terrain with low to medium soil productivity, i.e., areas with relatively diverse, less-intensive agriculture. Flat landscapes with highly productive soils are usually devoid of quail and quail habitat because they are intensively rowcropped, whereas the steepest terrain is usually too heavily forested.

Description

Taxonomy

Because common names can vary locally, animals are given scientific or Latin names for universal identification. The bobwhite's scientific name is *Colinus virginianus.* Biologists recognize several distinct subspecies or races within the United States; *C. v. mexicanus*, or the interior bobwhite, occurs in Illinois and neighboring states. The name *mexicanus* has nothing to do with "Mexican quail" which some people mistakenly believe have contaminated our present stock. While true that releases of a small southern subspecies, *C. v. texanus* were made in the 1920s and 1930s, they failed because the birds were wholly unsuited to the midwestern climate. ***Despite popular opinion to the contrary, we can assure readers that the present-day Illinois quail is the same old "bobwhite" that has always been here.***

Taxonomically, bobwhites belong to the order *Galliformes* or "fowl-like" birds. They are related to chickens, pheasants, grouse, turkeys, and the "western quails" (e.g., scaled, Gambels, California, mountain). Most of the bobwhite's closest relatives (other members of the genus *Colinus*) are relatively unfamiliar forms living in Mexico and central America. In fact, it is from this area that the species is thought to have evolved (54). Fossil records tell us that quail-like birds existed at least a million years ago, but their appearance in what is now Illinois probably did not occur until sometime after retreat of the last glacier some 10,000 years ago.

Size and Growth

As a general rule, animals that occupy extensive geographic ranges tend to be larger in the northern than southern parts of their range, and quail are no exception. Bobwhite in Georgia and Florida average about 5.8 oz compared to nearly 7 oz in Wisconsin. As might be expected, Illinois birds are intermediate in size. Fall and winter weights of 850 birds from southern Illinois averaged just under 6 oz (178.2 g) (97). Weights of males and females are virtually identical this time of year but deviate during the breeding season as will be described in a later section (Bioenergetics). Bobwhite chicks weigh only about 6 g at hatching but gain rapidly and attain 80% of adult weight by 11 weeks of age and 97% by 21 weeks.

One of the most persistent bits of quail folklore is that present-day birds are smaller than they used to be. We are at a loss to explain the persistence of this misconception. The above mentioned southern Illinois weight study, which included samples collected from the late 1940s to 1970, showed no difference in average weight over that time. Likewise, present-day, fully-grown wild quail in southern Illinois still average a little over 6 oz, just as they always have.

Plumage and Molts

The bobwhite is a small, plump, brownish bird with stubby wings and short, dark legs. Plumage on the back, wings, and tail is various shades of chestnut brown while the underside consists of small dark bars on a whitish background. The head has a dark cap, a dark collar at the base of the neck, and a dark wide strip running from cheek to eye. Males sometimes show just a hint of a crest or topknot. Males also have a distinctive white throat patch and white stripe running from the neck over the eye to the beak. In females, these areas are buff colored. There also are slight differences in the wing markings of males and females (115). At a distance, the bobwhite appears rather drab, but in hand their subtle shadings and markings are quite attractive.

Abnormal color variation is rare, but 3 distinct phases are sometimes seen in the wild. There is partial albinism in which some or most of the feathers are white (true albinism with pink eyes and white bill is extremely rare). A second variation is the "red" phase in which some or all of the feathers are reddish or auburn in color. Finally, there is a "blond" phase in which the birds have a light camel coloration over portions or all of their body.

The bobwhite goes through a series of molts progressing from natal down to juvenile to adult plumage. Some flight is possible at 2 weeks of age. By 7 weeks, the birds are more than half grown but the sexes are still indistinguishable. At 14-15 weeks, the young are

Male Bobwhite

essentially fully grown and can be distinguished from adults only by certain wing feathers. During their first autumn of life, juveniles molt 8 of the 10 primary wing feathers, retaining the outer 2 until the following year. Juveniles also retain their primary coverts which are buff tipped and ragged in appearance as contrasted with adult's which are more rounded and have a uniform charcoal color. Biologists use these criteria to distinguish juveniles from adults. Age of juveniles to the day is then estimated from progression of molt of the primaries (Appendix A).

Vocalization

One of the most familiar and pleasing of all birds sounds is the call for which the bobwhite is named. The clear, ringing *bob-white* or *ah-bob-white* is given by males, usually unmated ones, throughout the spring and early summer. Another series of calls are variously described as group movement, scatter, or covey calls. These include a soft *hoy*, a louder *hoy-poo,*

Female Bobwhite

and a clear loud musical *hoi-lee* or *hoyee* (110). The latter is heard just after daybreak on most fall and winter mornings. It is given by one or more covey members prior to leaving their night roost. Variations of the *hoy or hoy-poo* call are given by females during the breeding season and by coveymates attempting to regroup after being flushed. Less familiar are the *squee* and "caterwaul" sound associated with agonistic behavior before and during the breeding season. Finally, there are a number of very soft, gentle vocalizations uttered among coveymates as they forage for food. To enjoy these pleasant sounds, one must be very close to an undisturbed covey.

Life History

Most people remember from their high school or college biology that evolution involves such things as "genetic variation," "struggle for existence," and "survival of the fittest." Many assume the latter refers solely to contests of strength and speed between members of different species. This is not altogether true. While such competition does play an important role in evolution, the primary arena for natural selection is intraspecific relationships. The term fitness refers to an animal's relative ability to contribute to the future genetic composition (gene pool) of its species. The type of individual that leaves the greatest number of reproducing offspring will eventually predominate if such success is due to inheritable characteristics.

Conversely, those traits that render the bearer less likely to do this will become rare or disappear entirely. It should be apparent then that the real "players" are not individual animals, but their genes. In fact, someone once said that a chicken is merely an egg's way of producing another egg. In any event, we can safely assume that natural selection produces types of individuals that are most efficient at passing on their genes. Recognizing that this efficiency is manifested not only in physical attributes, but in behavioral traits and life history patterns as well, we might well ask – what is the best way for individuals to enhance the perpetuation of their genes? Should they search for food in groups and share it, or forage alone? Should they produce many fragile young, or a few hardy ones? Should they lavish care on these offspring at their own expense, or be mainly concerned with their own welfare so as to survive and breed again (49)? Obviously, animals do not consciously scheme about such things; in fact, they have little choice in the matter as most of these characteristics are inherited and thus "hard-wired." Further, what is best for one species might not work for another. That is why there are so many different life styles in nature. Evolution, operating within an ecological framework, has produced a wide spectrum of living patterns and adaptations, the effect of which is to permit the broadest and most complete possible utilization of available resources. Each organism occupies its own functional place or ecological niche in the overall system. This chapter, and portions of those following, examine the bobwhite's niche, i.e., where it lives and how it makes a living. To do this, we will describe important events that make up the bobwhite's annual cycle (Fig. 3). starting with early spring.

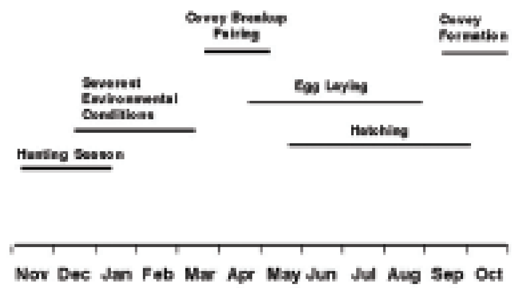


Fig. 3. Important events in the Bobwhite's annual cycle

Spring and Summer

Bobwhites spend the fall and winter months in tight social groups called coveys. As days lengthen and warm in late March, certain behavioral changes begin to occur among coveymates. Night roosts become less compact and individuals and small groups spend more time away from the main body during the day. Males are noticeably more antagonistic toward one another, and their familiar "bobwhite" call is heard for the first time since the previous summer. These are but the outward manifestations of profound physiological and hormonal changes taking place in response to the increasing daylight hours (photoperiod). The male's internal testes increase in size and spermatogenesis begins. The female's one functional ovary, which has been quiescent throughout the winter, also begins to enlarge as does her oviduct in preparation for the development and passage of eggs. Although these and related activities are primarily stimulated by changing daylength, temperature also plays a role. The timing of covey breakup and "bobwhite" calling seem at least partially dependent on late March and early April temperatures.

Pairing sometimes, but not always, takes place between coveymates, which brings up the question of inbreeding. Those who contend that hunting is necessary to mix the birds and prevent inbreeding overlook the obvious fact that the species did quite well without our help for thousands of years. Actually, there is sufficient natural reshuffling of groups from late summer through early spring to ensure a healthy mix of genetic material. Bobwhite courtship activities and displays are perhaps less familiar to most people than those of certain other birds. When displaying to a hen, the cock puffs out his feathers and bends his fully extended wings so that the tips just touch the ground. His head is lowered and turned to show off the white throat and cheek markings. All the while, the hen keeps her tailfeathers fully spread and when ready to copulate, squats and utters a barely audible call (109). Several weeks may elapse between pairing and nest building during which time several more bouts of copulation may take place. The first nests are usually started in late April or early May and take 1-2 days to complete. Both sexes participate, but males do most of the work. The typical nest is a rounded, domed structure with an oval entrance on one side. It is built of grass stems from the previous year's growth and sits in a shallow, saucer-like depression in the ground scratched out by the birds.

The female begins laying within a day or so of nest completion and proceeds at the rate of approximately 1 egg per day until the entire clutch is deposited. During this time, she remains at the nest only long enough to deposit an egg. The eggs themselves are white, pointed at one end, and about 1" x 5/6" in size. Most clutches contain from 12 to 16 eggs; 13.7 is the average in Illinois (64). Incubation takes about 23 days to complete and usually begins within a day or so after the last egg is laid. About 1/4 of the nests are incubated by males, the remainder by females. The sexes apparently do not alternate these duties although the incubating bird often leaves the nest for several hours each afternoon to feed and relax with its mate. For the first week or so, incubating birds are easily disturbed, but as hatching time nears, they are very reluctant to flush and will tolerate close approach. About 48 hours prior to hatching, the nearly-developed chick begins to "pip" the egg with its "egg tooth." Once out of the egg, the precocial chicks are usually dry and able to move about within a few hours. If it is late in the day or raining, they may be brooded in the nest overnight. Otherwise, the incubating bird is joined by its mate and the young are quickly led away from the nest. On average, >9 of every 10 eggs hatch. Of those that don't, about 40% are infertile and 60% contain dead embryos.

Bobwhite nests are usually doomed-shaped structures, located at ground level, and constructed of dead grass stems.

Bobwhite nests, which are built on the ground, are vulnerable to a wide variety of destructive agents. In fact, only about 1/3 of them hatch successfully. During a 15-year study in southern Illinois (64), about 11% of the 860 nests examined were abandoned before hatching, and another 12% were destroyed by farming activities – primarily mowing. About 2% failed because of excessive heat and drought while an even smaller percentage were flooded out. Miscellaneous causes and research activity led to the failure of an additional 4%. The primary cause of nest losses was other animals; predators destroyed 37% of the nests, accounting for over half of all nest failures. Common predators on this particular rural study area were the house cat, striped skunk, and various snakes such as the prairie kingsnake, black rat snake, and racer. Numerous other animals including dogs, foxes, coyotes, weasels, raccoons, opossums, and crows also destroy nests on occasion and may be a problem locally. Perhaps surprisingly, the attending adult is rarely killed during nest attacks (about 1 time in 10), and usually only late in incubation when they are reluctant to flush from the nest.

Because 60-85% of the autumn population represents birds hatched the summer just ended, reproductive success plays a major role in determining fall abundance. The number of young recruited into the fall population in a given year depends on several factors including the number of breeding hens, the number of chicks hatched per hen, and the survival of these chicks from hatch to autumn. The number of chicks per hen is determined by: a) the number of nesting attempts made, b) the success rate of these nests, c) the number of eggs per nest, and d) the hatching rate of these eggs. Research has shown that year-to-year variation in clutch size and hatchability of eggs is of little importance. What is important is the total nesting effort (number built per hen) and their rate of success (98).

The bobwhite's nesting season is one of the longest of any temperate avian species. In Illinois, egg laying has been recorded as early as mid-April and hatching as late as October. Most nests though (80%) are started sometime between the 2nd week in May and the 3rd week in July with peak hatching from about mid-June through mid-August (Fig. 4).

Scientists have long known that bobwhite hens will renest 1 or more times following initial nest failure and that males sometimes incubate nests.

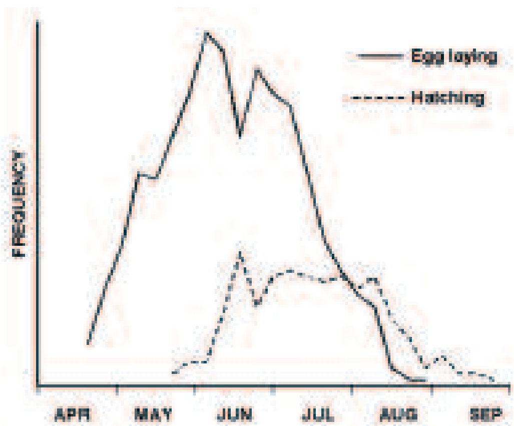


Fig. 4. Egg-laying and hatching dates for the bobwhite in southern Illinois. (Roseberry and Klimstra, 1974).

However, based on indirect, circumstantial evidence, most biologists assumed that quail were monogamous and rarely if ever produced more than one brood per season. More recent telemetry studies have shown, however, that bobwhite mating systems are much more complicated and flexible than originally thought, combining elements of monogamy, polygamy, multiple clutches, renesting, and incubation by both sexes (14, 111). For example, reproductive efforts can include monogamous pairing and production of single broods, production of consecutive clutches with male incubation of the first and female incubation of the second, or renesting after success or failure of the first nest with 1 or more mates involved. Although early biologists may have underestimated the extent of multiple broods, they did not necessarily underestimate actual reproductive output which is normally measured by comparing spring and subsequent fall population levels.

Another factor affecting overall productivity is survival of chicks from hatch to autumn. Unfortunately, this is one of the most poorly documented aspects of bobwhite life history. One reason is the difficulty in capturing and studying very young chicks in the wild to determine rates and causes of death. Based on limited telemetry studies and observations of brood shrinkage over time, it is estimated that from 50 to 70% of all chicks hatched usually survive to autumn. However, a more recent study in Oklahoma recorded <40% survival from hatch to 39 days of age (22). The heavy use of insecticides in agricultural habitats has raised concern about their effects on quail chicks, both directly and indirectly. Researchers in the southeastern United States concluded that foliar insecticides did not directly poison chicks (76). However, Illinois biologists suspect that insecticides may increase pheasant brood mortality by reducing their invertebrate food supplies (118). Whether or not the same holds true for bobwhite is not known, but the possibility certainly exists.

A current belief popular among hunters in Illinois and elsewhere is that wild turkeys destroy large numbers of eggs and chicks and are therefore responsible for the widespread decline in quail abundance. Turkeys undoubtedly eat quail eggs and chicks occasionally, but food habits studies in the Southeast and Midwest clearly show that this is a rare event. Furthermore, the decline in quail abundance in Illinois and elsewhere started long before turkeys became abundant, and it is evident in areas where turkeys are rare or nonexistent.

Therefore, we can state with absolute certainty that turkeys are not the cause of the current decline in Illinois quail populations.

Some people believe that wet weather during the nesting season is detrimental to quail production because it drowns chicks and floods eggs. In reality though, nesting quail generally avoid poorly drained areas or sites prone to flooding, and losses from heavy rainfall are rare. Actually, above-average precipitation during spring and summer is more often associated with good reproduction. On the other hand, severe drought is potentially harmful because it can result in increased nest abandonment, reduced hatchability of eggs, and possibly reduced insect food supplies for chicks. Extremely high temperatures in late summer also can result in early termination of nesting efforts (64), thereby reducing overall productivity.

Conditions prior to the breeding season also can affect subsequent reproductive efforts. Research in southern Illinois has shown that severe winters, especially prolonged snow cover, tend to be followed by summers of below-average productivity (98). The most likely explanation is that hens with inadequate winter food supplies enter the breeding season in less than prime physical condition. This theory is supported by the fact that snow cover occurring in early winter seems less detrimental than when it occurs in late winter.

Fall and Winter

As the breeding season winds down in early autumn, individuals begin to organize into cohesive social units (coveys). This behavior may help avoid and escape predators and conserve body heat during cold nights. Coveys are not strictly family groups and may contain remnants of several summer broods as well as their surviving parents and an occasional unmated adult. Not much is known about covey social structure, but there appears to be remarkably little antagonism among members. Although fall covey size is commonly overestimated from casual observation, such groups generally contain from 8-20 birds and average slightly over 13 (98). Occasionally, as many as 25-30 quail may flush from one location, but this usually represents 2 coveys temporarily feeding in close proximity, and more often than not, these large groups split in flight and go their separate ways.

Bobwhite coveys occupy more or less discrete home ranges as opposed to wandering randomly about the countryside. Because quail are often found in the same place year after year, some people assume that it is the same covey living there. Actually though, only about 15-30% of the birds alive in one autumn survive to the next, and there is no guarantee they will occupy the same covey range although this sometimes happens. Certain home ranges contain quail year after year not because they are the same birds, but because the area itself consistently attracts quail.

As autumn crop harvesting and frosts reduce available cover, there is considerable movement of quail as they settle into their more permanent winter habitat. Individual movements of several miles or more have occasionally been recorded during this "fall shuffle." Once established though, coveys are reluctant to abandon their territories unless forced out by habitat disturbance or extreme harassment from hunting or field trials. Prolonged snow coverage also may force some poorly situated coveys to abandon their ranges in search of better conditions (86).

In typical Illinois quail country, covey ranges average about 35-40 acres, but may be larger or smaller depending on habitat conditions, population density, and weather. The birds normally do not traverse their entire range each day; instead, they will occupy a portion for several days, then shift activities to another part for a time. The ranges of neighboring groups

Bobwhites are almost always found near an "edge."

may overlap to some extent, especially in feeding areas, but coveys tend to "keep their distance" when in heavy cover or roosting. In fact, their habit of calling just before leaving the roost in early morning probably serves to keep neighboring coveys apprised of each other's location and thus properly spaced (28). Coveys will, however, readily accept stragglers into the group, and it is not uncommon as winter progresses for survivors of 2 or more shrinking coveys to recombine into 1 larger group.

Bobwhite are among the most sedentary of all avian species. Under normal circumstances, daily movements total no more than 1/4 mile – often less during inclement weather. Furthermore, virtually all movement is via the ground. Except for possibly a short flight to their night roost, quail seldom fly unless disturbed. When flushed though by man or predator, they explode into the air in a burst of noise and blurred shapes. This creates a rather startling effect and makes it difficult to focus attention on a single bird – an obvious adaptation to escape predators. Upon landing, scattered individuals begin calling almost immediately in an effort to regroup. Research in Texas on the flight characteristics of bobwhites found that when flushed, coveys flew an average of about 50 yards at around 20 mph (57), although speeds up to 38 mph have been recorded (109).

At night, covey members form a circular, compact roost for warmth and protection. The birds sit with their tails in and their heads pointing out, somewhat like the spokes of a wheel. The small piles of brown and white droppings that mark these sites are a sure sign of quail in an area. Bobwhites generally feed twice daily in fall and early winter – once shortly after leaving the roost in early morning, and again in mid- to late afternoon. Midday is often spent "loafing" in moderately heavy cover. As winter progresses and food supplies diminish, the birds spend an increasing proportion of their time foraging for food. During stormy weather, they may remain on their roost later in the morning, feed only once at midday, and return to the roost earlier in the afternoon. Formation of temporary day roosts is also a common response to cold, windy weather.

Fall and winter are normally critical times for wild bobwhites. From 1/2 to 3/4 of all birds entering the fall usually perish before spring. In addition to predators and the gun, quail sometimes succumb to accidents, disease, starvation, and exposure, but these latter mortality agents are of only minor importance.

Sure signs that quail are in the vicinity.

For example, quail are sometimes killed by flying into obstacles, and bird dogs occasionally capture and kill otherwise healthy birds. There was even a recorded instance of an entire covey drowning while attempting to fly across a large reservoir (72). By and large though, accidents are a minor mortality factor in the wild. The same can be said for disease. Penned bobwhites are notoriously susceptible to certain avian diseases such as avian pox, quail bronchitis, ulcerative enteritis, and histomoniasis (blackhead). Cestodes (tapeworms) and nematodes (roundworms) are sometimes a problem too. Among wild birds though, parasites and diseases are generally of little consequence (21). There have been recorded instances of extensive mortality following heavy applications of the pesticides dieldrin and heptachlor, especially in the southeastern United States (101, 102) Consumption of DDT also may have harmful metabolic effects but thankfully, these environmental contaminants are much less prevalent now than 30 or 40 years ago. Newer insecticides such as parathion and the herbicide paraquat may cause indirect problems, however. Studies in the Southeast (11) have suggested that the former may increase bobwhite susceptibility to avian predation while other research detected a possible negative effect of paraquat on bobwhite reproduction (5).

Predation is undoubtedly the major cause of bobwhite mortality on a year-round basis although hunters may actually take more birds from fall to spring. Mammals most capable of capturing mature birds during fall and winter include coyotes, red and gray foxes, and house cats. Other mammals such as bobcats, raccoons, opossums, skunks, mink, and weasels probably capture healthy bobwhites only occasionally. Cooper's and sharp-shinned hawks, are generally considered to be the most effective avian quail predators. Northern harriers ("marsh hawks"), great-horned owls, and barred owls also take quail on occasion, but the broad-winged soaring hawks (red-shouldered, red-tailed, broad-winged) rarely do. Despite the fact that quail and their eggs are taken by a wide variety of mammals, birds, and reptiles, research has clearly shown that bobwhites are not a staple, or even contribute more than a minor part, to the diet of any single predator. In Illinois, most quail predators feed primarily on rabbits, small rodents, and to some extent other birds, and their actions may not always be entirely harmful. A study in Texas found that removal of coyotes actually resulted in an increase in more effective quail nest predators such as red foxes, raccoons, and skunks (47). It should be noted too that the proximate (immediate) cause of death is not always the ultimate (fundamental) cause. If bulldozing out a hedgerow displaces a secure resident covey into marginal range where individuals are easy targets for predators, what factor is really to blame for their loss? Similarly, prolonged snow cover may increase quail vulnerability to predation by weakening them physically, reducing effectiveness of escape cover, and forcing them to feed in exposed areas for longer periods of time. The point is that survival is often determined by the interaction of several factors, and the final agent of death may be only incidental to the primary cause.

Another example of the above is starvation and exposure which are difficult to separate as mortality agents. Bobwhites are much more vulnerable to exposure when they are undernourished; likewise, they are more susceptible to starvation at very low temperatures. Severe winters, especially the combination of deep snow cover, low temperatures, and strong winds can kill bobwhites directly. Fortunately, such blizzard conditions rarely occur in the better Illinois quail range (which partly explains why it is good range). Unquestionably, the environmental condition most detrimental to Illinois bobwhites is prolonged snow cover. Deep snow, especially when crusted, limits access to food and reduces the effectiveness of certain types of cover. Ice cover also can be harmful, but such conditions seldom last for more than a few days. How bobwhites respond physically and physiologically to harsh environmental conditions is discussed in more detail in the following section.

Winters with prolonged snow coverage are usually followed by 1 or more years of below-average quail population

Bioenergetics

All living things require some form of energy, and the ultimate source of all energy on earth is the sun. Through the process of photosynthesis, green plants convert this light energy into chemical energy or food. Herbivorous animals exist by feeding on plants and in turn provide energy for the carnivores that feed on them. This exchange of energy between and among animals and their environment is called bioenergetics, and it serves as a useful framework not only for understanding ecosystems but for practical wildlife management as well.

Bioenergetic relationships are governed by the laws of physics. For example, the 2nd law of thermodynamics states that conversion of energy from one form to another (always from more concentrated to more diffuse) is never 100% efficient. At each transfer, some energy is lost as unavailable heat. Plants are able to convert only about 1% of all incoming solar radiation into living tissue or biomass. Primary consumers (herbivores) are about 10% efficient (e.g., produce 100 kcal of tissue for every 1,000 kcal consumed), whereas secondary consumers (carnivores) are perhaps 20% efficient. This stepdown effect has important implications as it determines the length of food chains and the relative abundance of animals at each trophic level. Consequently, the total biomass of herbivores in an area will always exceed that of carnivores because the former have more potential energy available to them.

Animals are unable to utilize all of the gross energy they ingest – some is lost through bodily wastes and some is needed for the work of digestion itself. That which remains is called net energy and is used for growth, maintenance (routine bodily functions and upkeep), thermoregulation (maintenance of stable body temperature), daily activities (food gathering, predator avoidance, etc.), reproduction, and storage of reserves (deposition of fat). When energy intake is insufficient to accommodate all of these needs, there is a definite priority of use. Thermoregulation and other life-sustaining bodily processes are maintained at all cost, growth and reproduction are a secondary priority, and fat is deposited only after all other needs are met.

Depending on their diet and needs, animals have evolved a variety of feeding patterns and digestive systems for acquiring and utilizing food. Bobwhite are primarily seed eaters although they do consume some fruits, buds, and leafy material as well as animal matter. Like other gallinaceous birds, quail have a sac-like enlargement of the esophagus called the diverticulum or crop. This structure, which may have 4 times the capacity of the stomach, allows the birds to temporarily store rapidly-gathered seeds thereby reducing feeding time and consequent exposure to predators and the elements. After ingestion, food material passes from the crop into the anterior portion of the stomach (proventriculus) where digestion begins. It then moves into the muscular gizzard where hard seeds are pulverized with the aid of small particles of sand or gravel called grit. Some relatives of the bobwhite (grouse for example) have two pouches or caeca at the junction of the small and large intestine which function in the microbial breakdown of low quality, high-bulk foods. Game birds like turkeys, pheasants, and quail, that consume highly nutritious foods, have little need for, and therefore, lack well-developed caeca.

Bobwhites eat a variety of foods. A large number of crops collected from southern Illinois hunters revealed no fewer than 187 different items (67). Corn, soybeans, wheat, lespedezas, acorns, common ragweed, sassafras, tick clover, and slugs were the most common items found. Other foods taken with some regularity include jewelweed, beggar-ticks, wild bean, foxtail, crabgrass, lance-leaved ragweed, smooth sumac, ash, rush-foil, partridge pea, vetch, horse nettle, grasshoppers, leafhoppers, ground beetles, and various insect larvae.

All foods, regardless of type, consist of the same basic components: carbohydrates, proteins, lipids (fats), vitamins, and various inorganic minerals. Most dietary energy is derived from carbohydrates and fats;

proteins are used mainly for tissue building and repair, while vitamins and minerals are essential for a variety of life processes. It is sometimes said that if a wild animal is able to consume sufficient energy, then its other nutritional needs will also be met. Nevertheless, seasonal shifts in diet may reflect, in addition to availability, nutritional demands other than energy. For example, bobwhites need only about 12% crude protein in their diet for normal winter maintenance, but laying hens require up to 23% for maximum egg production, and growing chicks need at least 28%. Proteins are available from both plant and animal sources, 2 of the best in fall and winter are soybeans and Korean lespedeza. Insects and other animal matter provide even more protein and fortunately, their availability coincides with increased bobwhite demands during spring and summer. Animal matter may constitute only about 10% of the adult's winter diet compared to 25-30% in summer. Growing chicks, on the other hand, consume up to 80% insects during their first 2 weeks of life with small grass seeds making up much of the remainder of their diet.

The most vital nutrient for all life, including bobwhites, is water. Quail obtain water in 3 ways: as a byproduct of metabolizing foods (metabolic water), from moisture in foods (preformed water), and as surface (free) water. Most researchers agree that the 1st 2 sources are sufficient to meet the bobwhite's needs.

Thermoregulation is a fundamental process of life that involves a constant balancing of heat production and loss through both physiological (chemical) and physical (mechanical) means. Bobwhites and other warm-blooded animals may be thought of as consisting of an inner core and an outer shell. The core, which contains the central nervous system, visceral organs, and much of the skeletal muscles, must be kept at a constant temperature (a remarkably high 106.7^{o} F for bobwhite) (38). The outer shell of feathers, scales, skin, and some subcutaneous fat and muscle acts as insulation and is often considerably cooler near its surface than is the core.

Animals exchange heat with their environment in a number of ways. Heat is lost through radiation (directly into the air), conduction (contact with cooler objects), convection (wind effect), and evaporation. Heat is gained through direct solar radiation, radiation from surrounding objects, and from the conversion of chemical food energy to heat. The rate of heat exchange depends primarily on the difference between ambient (air) temperature and the animal's surface temperature, but is also related to body size. Large animals have proportionately less surface area in relation to volume, and therefore lose relatively less heat by radiation and convection. Bobwhites partially compensate for their small size by spending the night in tightly formed, circular roosts – a behavior that reduces the total amount of exposed body surface and thus heat loss for all members of the covey.

Of course an animal is not always trying to retain heat, sometimes the goal is to dissipate as much heat as possible. Both situations require expenditures of energy. For all warm-blooded animals, however, there exists a range of ambient temperatures that do not influence metabolism. Maintenance of a constant core temperature within this thermal neutral zone requires little or no energy and is accomplished by minor adjustments in the insulation properties of the outer shell (e.g., fluffing feathers, standing or squatting, etc). One study set this zone for bobwhites at 86-104^{o} F (70). If true, this would be quite high in relation to reported ranges for other gallinaceous birds and may reflect the species' subtropical evolutionary heritage.

As air temperatures fall below the neutral zone, thermoregulation is achieved mainly through increased metabolic activity and changes in behavior designed to minimize heat loss (e.g., covey roosting). The energy cost of thermoregulation can be appreciated by comparing it to the basal or standard metabolic rate, which is the amount of energy required to exist (not grow or reproduce) under thermal neutral conditions. This rate can be expressed in a number of ways, perhaps the most common being kcal of energy needed per kg of body weight per day. One study determined that bobwhites weighing about 190 g needed 24 kcal per day just to survive in cages at 86^{o} F under a 10-hour photoperiod (15). About twice as much energy was required at 32^{o} F. The important question to wildlife managers is how difficult is it for bobwhites to acquire this necessary energy day after day. Several things must be considered. First of all, life in the wild takes considerably more energy than does life in a cage – perhaps 50%

more. Secondly, Illinois bobwhite often encounter temperatures below freezing which impose even greater energy demands. For example, a temperature drop from 50 to 32^0 F increases energy demands by 28%. Under normal late-winter conditions in the Midwest, bobwhites may need to forage almost constantly during daylight hours in order to consume sufficient energy (83). When intake fails to meet demands, the birds may temporarily subsist by metabolizing fat reserves, or as a last resort, catabolize protein from their own tissues. Such depletion of fat reserves may, however, jeopardize reproductive performance the following summer. It is possible, of course, for temperatures to drop so low that quail cannot balance heat loss no matter how much they consume (especially if the cold is accompanied by strong winds). When this occurs, body temperature declines (hypothermy) and the birds generally cease all activity in a desperate attempt to conserve body heat. Death is usually imminent at this point. Fortunately, this situation is not common in Illinois and bobwhites are surprisingly tolerant of cold temperatures per se. Anecdotal evidence from field studies in the Midwest suggest that temperatures as low as -30^o F do not necessarily result in heavy quail loss (98).

Nevertheless, the importance of adequate and accessible food supplies to wintering birds cannot be overemphasized. Not all foods are of equal quality. Yellow corn was once considered the most complete quail food, but feeding trials during one study ranked it below millet, sorghum, and sassafras in sustaining value (73). Soybeans and common ragweed were not tested, but are known to be highly nutritious for quail. On the other hand, such items as smooth sumac, multiflora rose, and Japanese honeysuckle fall into the category of emergency foods that may be taken occasionally, but have little sustaining value.

Bobwhites are considered generalists rather than specialists in their feeding habits – in other words, their diet depends primarily on what is available. Nevertheless, some items such as corn, soybeans, wheat, acorns, sassafras, beggar-ticks, and common ragweed may be selected for, i.e., taken in amounts disproportionate to their availability (7). In contrast, the popular quail food Korean lespedeza may be consumed more in relation to its abundance. This is perhaps not surprising since studies have shown that even though a good source of protein, this legume is not especially high in metabolizable energy, and has only moderate sustaining value (73, 82). Of course, other factors, such as palatability and durability, also influence food selection in the wild.

Although winter is potentially the most stressful season for bobwhite, significant energy "costs" also are associated with reproduction. Demanding activities can be divided into behavior (courtship, territory establishment and defense, nest building), gonadal development, egg production, incubation, and brooding. The gross body weight of both males and females

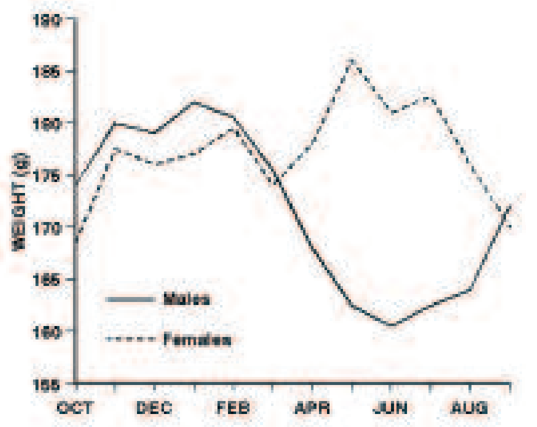


Fig. 5. Annual weight fluctuations for male and female bobwhite (Roseberry and Klimstra, 1971)

remain generally stable throughout autumn and early winter, then declines in late winter as food supplies diminish (Fig. 5). Males continue to lose weight until early summer whereas females gain during April and May, then decline throughout summer to a low in early autumn. Spring weight losses among males probably reflects physiological and possibly psychological stresses associated with courtship, territorial establishment, and competition for mates. In contrast, females gain weight during the pre-breeding period due to growth of reproductive organs and accumulation of fat. The caloric "cost" of developing a functional oviduct and ovary is probably not great, but egg production requires a considerable expenditure of energy. Because developing young of oviparous (egg-laying) animals are not attached to the mother via a placenta, sufficient nutrients must be stored in each egg to permit development of the embryo to term. Incubation time is longer in birds like quail that hatch precocial (more fully developed) chicks, consequently the energy content of their eggs must be higher. A bobwhite egg contains about 16-19 kcal of energy, which may approximate 25% of the hen's total daily intake (61). In fact, the energy content of a complete clutch of about 14 is roughly equivalent to the caloric value of the hen's entire body. According to one study, however, the energy necessary for egg production and existence at normal summer temperatures does not exceed that required for existence alone in winter, and therefore should not impose undue hardships (15). However, this study did not consider the energetic costs of incubation, brooding, and the post-nuptial molt, nor the fact that hens may renest 1 or more times. The major function of incubation is to provide a suitable thermal environment for eggs to hatch. To accomplish this, most birds develop a brood patch where the transfer of heat is uninhibited by feathers. Early in incubation, the adult bird must supply most of the heat necessary to maintain proper egg temperatures. As incubation progresses, an increasing proportion of this heat is supplied by the embryo's own metabolic activity. Avian physiologists disagree as to whether incubation poses a significant energy demand on the adult. Some pheasant researchers, however, feel that the entire process of egg production, incubation, and brooding constitute a serious physical drain on the female (8, 55). Additionally, the post-nuptial molt (also an energy requiring process) begins immediately after reproduction has ceased. Based on weight loss and suspected mortality rates during this period, it does appear that late summer is a stressful time for bobwhite hens. And, as noted earlier, extremely high temperatures may cause early cessation of nesting

Habitat

activities.

The term habitat refers to the physical setting that an animal occupies. Good habitat must provide essential life requisites (food, shelter, breeding sites) in such a way that they can be successfully utilized by the animal. Different species have their own unique habitat requirements and preferences, and how well these are met in a particular area determines whether or not the species will be present and in what abundance. Some wildlife species have very specific requirements. For example, Kirtland's warbler, a small songbird, nests only in groves of young jack pines in northern Michigan. Other species, such as the bobwhite, are able to satisfy their basic needs from a variety of vegetative communities thus enabling them to occupy a wider geographic range.

Bobwhite are found in a wide variety of ecological settings throughout their range including open pinelands in the Southeast, grass/brush rangeland in Texas, native prairie in Kansas, and of course, agricultural settings in the Midwest. This wide range of habitats may lead some to conclude that quail are adaptable with flexible demands, but in fact, they are not. They require a rather specific set of conditions at both the site and landscape levels, and if these conditions do not exist in a particular area, then neither will quail. The types of plant communities that can meet these needs appear varied to us humans, but from the bird's perspective, they are probably much more similar than we realize with respect to such things as bare ground exposure, stem densities, and canopy cover. The fact that a number of different plant communities can meet these fundamental needs does not mean that the requirements themselves are flexible or that the birds can alter them in order to adapt to changing conditions.

Experienced hunters and biologists can usually differentiate between excellent and poor quail habitat and perhaps 1 or 2 intermediate categories. Most of us, however, know of mediocre-looking spots that hold birds year after year while other seemingly more attractive areas go unused. Obviously we do not perceive habitat exactly as animals do. How then do animals select a place to live? First of all, it must be stressed that their selection process is instinctive and inherent, i.e., it represents "evolutionary wisdom" not conscious thought. For quail, habitat selection is probably based not so much on the species of plants present, but on their structural properties. Primary cues might include such things as litter depth, light penetration, relative obstruction of visibility and movement (including flight), and thermal properties.

Quail seek and utilize settings where they can forage effectively while remaining relatively secure from

The close interspersion of cropland, herbaceous vegetation, and woody cover provides ideal fall/winter habitat for bobwhite (top), whereas good summer habitat requires a more open mix of grasses and forbs (bottom).

predators and the elements. The types of situations that meet these criteria are limited by the behavioral and physical limitations of the birds themselves. Quail eat mainly seeds and insects located on or just above the ground, but they are ill-equipped to scratch or dig through thick litter to reach these food items. Consequently, foraging areas must be relatively open at ground level.

Also, because raptors are their primary predators, quail show a strong preference for sites providing some degree of overhead concealment. And finally, because their anatomy precludes sustained flight, all usable habitat must be relatively close to protective cover. In the Midwest, this set of requirements is usually met in diverse, patchy, predominately open landscapes with abundant woody edge and early successional vegetation. Biologists in both Missouri (18) and Illinois (100) found that highest quail populations occurred in settings that were approximately 10-25% wooded and 75-90% open. Despite the relatively small amount required, the presence of woody cover is clearly the most important factor in determining the distribution of quail in Midwestern landscapes. Bobwhites are not forest dwellers, but they seldom stray far from forest edges, wooded ravines, or shrubby fencerows. To be useful, however, such sites must have sufficiently dense understory vegetation to provide the birds both cover and concealment. Frequent flooding, heavy grazing, and insufficient light penetration all greatly diminish the value of woodlands for quail.

Whereas woody cover provides necessary protection for bobwhite, more open habitats are essential for reproductive activities and feeding.

Non-breeding Season

Primary requisites during the fall and winter months are adequate protective cover and an accessible, reliable food supply. These essentials are not necessarily mutually exclusive. Some of the vegetation that provides cover and concealment also supplies or harbors food and vice versa.

Individual covey ranges generally contain 1 or more dense, woody or brushy patches that provide escape from predators and protection from severe weather. These "headquarters" are usually about 1/10 to 1/2 acre in size and may consist of bramble patches or even large brushpiles. In southern Illinois, most

Diversity and edge characterize both non-breeding (top) and breeding (bottom) habitat.

covey headquarters are in the Japanese honeysuckle understory of woodlots, wooded ditches, or hedgerows. When growing prostrate, honeysuckle has little value for quail, but if supported by other vegetation or structure, its protective value is unsurpassed. Honeysuckle is especially valuable during heavy snow cover because it retains leaves throughout winter thus forming a protective canopy for the birds.

Another essential ingredient of winter habitat is an adequate and accessible food supply. Plant foods utilized by bobwhite are found in a variety of successional stages; however, early stages associated with soil disturbance, particularly row crop agriculture provide the greatest abundance of plant foods for Illinois bobwhite including both waste grains (e.g., corn, soybeans, milo) and seeds from annual grasses and broad-leafed weeds (e.g., foxtail, ragweed). Certain types of woody plants also supply food items in the way of hard and soft mast (i.e., acorns, berries, fruit, etc.).

A 3rd requirement for wintering birds is roosting cover. Quail spend most nights in sparse, short vegetation with little surface duff and little or no overhead cover (65). Favored sites are lightly to moderately grazed pastures, wheat stubble fields, and early old-fields. One of the few uses that quail make of fescue pastures is for roosting. During periods of severe weather or prolonged snow coverage, quail will shift their roosting sites to heavier cover, especially Japanese honeysuckle.

The ability of a particular area to support quail depends not only on the presence of essential habitat components, but on their distribution or interspersion as well. One of the more important concepts in wildlife management is edge effect. Wildlife is generally most diverse and abundant in the transitional zone where 2 or more distinct vegetative communities come together. There are exceptions of course. Some species prefer large unbroken forests or grasslands. By and large though, game and other wildlife are apt to be found at or near the borders of adjacent cover types where there is a distinct change in vegetative structure. Such areas usually offer richer, more varied plant communities thus providing for the needs of more species. For individual species, these areas provide "simultaneous access" to multiple habitat components. This is especially important to relatively sedentary forms like the bobwhite. Quail are very reluctant to venture more than a few dozen yards or so from protective cover in order to feed. Consequently, high populations can be achieved only where food and cover patches are small (preferably no larger than 10-20 acres) and within 100-200 feet of each other.

Nests are generally found in relatively dense ground cover (top), whereas brood foraging areas are somewhat more open (bottom).

Breeding Season

Habitat utilization during the spring and summer is dictated not only by specific needs associated with nesting and brood rearing, but possibly also by the need to avoid extremely high temperatures.

Researchers in Texas (33) found that bobwhites generally avoided sites with operative (basically unshaded) temperatures >102º F. Prime breeding habitat is generally somewhat more open than winter range and usually contains proportionately less woods and cropland and more grassy and herbaceous cover. While a reasonable mix of breeding and nonbreeding habitat is desirable, the interspersion of cover types that satisfy seasonal requirements need not be as tight as those which accommodate daily needs. Research in southern Illinois suggested that nesting habitat up to 1/2 mile distant from winter range was well utilized (98).

An earlier study in southern Illinois examined over 750 nest sites to determine the type of setting preferred by nesting bobwhites (64). Virtually all nests were constructed of dead grass stems. Typical nesting sites were well-drained and in moderately dense stands of herbaceous and grassy ground cover with scattered small shrubs or brambles. Within such areas, nests were usually located close to more open, often bare, ground and often near some type of edge. These conditions may be found in a variety of settings including idle fields, weedy fencerows, unmowed roadsides, unimproved pastures, and some hayfields and CRP fields. Quail may also occasionally nest in weedy cropfields, and notill areas but tend to avoid dense monocultural stands of legumes or grasses (especially fescue).

Habitat needs of growing chicks are less well documented than the summer and winter requirements of adults. In general though, successful brood rearing habitat must have an abundant supply of insects and be open enough at ground level to permit the small chicks to move freely about without continually encountering dew-soaked vegetation. The thin stands of annual grasses, broad-leafed forbs, and legumes that provide a desirable substrate may be found in early oldfields, early CRP fields, and some hayfields.

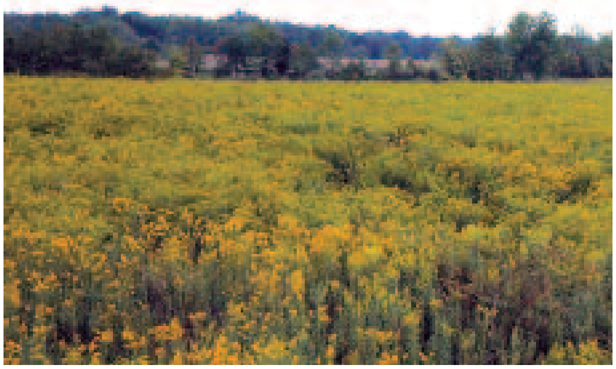
The Critical Role of Plant Succession

It should be clear to the reader by now that quail are completely dependent upon weedy/grassy (i.e., herbaceous) vegetation for their very existence. It not only provides much of their natural food items (both seeds and insects), but it is absolutely essential for both nesting and brood rearing. The problem, however, is that under natural conditions, this type of vegetation is transitional, not permanent – and that brings us to the subject of plant succession. Plant succession is the natural, progressive change in vegetative composition and structure that takes place over time.

When an area is cleared to bare soil and left unplanted or undeveloped, annual weeds and grasses such as foxtail, common ragweed, pigweed, beggarticks, cocklebur, etc. will begin to appear during the 1st growing season. After another year or so, perennials such as aster and goldenrod start showing up. Then in a few more years woody shrubs and small trees (e.g., briars, poison ivy, sumac, sassafras, persimmon, winged elm, etc.) begin to invade. In time, a mature forest develops. The rate at which these changes take place and the duration of each succession or seral stage depends mainly on soil fertility and annual rainfall. In southern Illinois, the usual pattern is annual weed stage (1-3 years), perennial weed stage (3-10 years), shrub and bramble stage (7-15 years), pioneer tree stage (10-25 years), and later tree stage (after 30 years) (116). The 1st 3 stages are particularly important to bobwhite; the annual and early perennial weed stages for brood rearing, later perennial and early shrub and bramble for nesting, and late shrub and bramble for protective cover. The earliest stage provides optimum brood rearing habitat because it typically harbors good insect populations and is still open enough at ground level to permit young chicks to move about easily and find food. This stage, however, normally lacks sufficient accumulation of dead grass stems for nest building and sufficient standing vegetation for nest concealment. Consequently, most nests are found in slightly later seral stages characterized by scattered shrubs and briars interspersed with a moderately dense ground cover of weeds and grasses. Unforunately, prime brood rearing and nesting habitat is ephemeral. Through the natural process of succession, brood habitat will ulti-





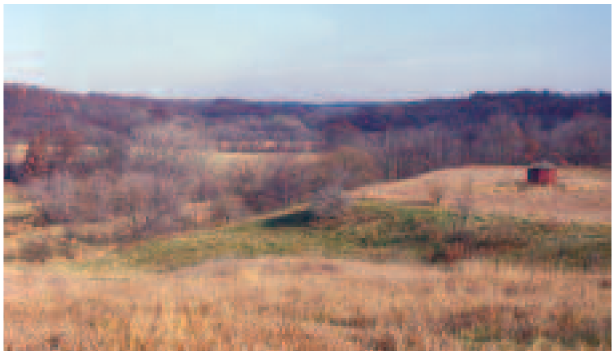



Left undisturbed, plant communities naturally progress from bare ground through annual, perennial, shrub/sapling, and forest stages.

mately become too rank and nesting habitat too woody. In fact, it can be safely stated that **left undisturbed, good quail habitat will inevitably progress toward something less desirable.** To keep this from happening, there must be some type of regular disturbance every few years to restart or retard succession either by fire or some type of soil disturbance. We will discuss this in more detail in a later section (Habitat Restoration).

Habitat From Various Perspectives

Bobwhite habitat can be described and evaluated at spatial scales ranging from site level (e.g., nest site or field), to local (e.g., covey range or farm), to landscape (e.g., several sections). Specific requirements



Successful bobwhite management must address habitat needs at the landscape (top), farm (middle), and field (bottom) level.

exist at each scale. At the field level for example, are there enough dead grass stems to build a nest, or enough litter-free ground for chicks to forage effectively, or sufficiently thick forest understory to serve as covey headquarters? At the farm level, are all essential habitat components present and well interspersed? And finally, at the landscape level, is the habitat patch large enough to support a viable population? Because habitat formerly existed in larger blocks, and because individual birds and coveys normally utilize ranges measured in acres rather than square miles, early quail biologists did not pay particular attention to landscape conditions. As human developments and intensified agriculture began to dissect and fragment existing quail range, some populations were forced into smaller, more isolated patches of habitat. Quail researchers at Southern Illinois University (SIUC) voiced concern early on that these types of situations may put quail at risk for a variety of reasons (93, 98). Subsequent research has, in fact, suggested that habitat blocks or connected patches need to total at least 5,000 acres or more to support viable, sustainable bobwhite populations (39). We repeat that individual birds do not need this much space. However, as we will talk about in the following section on demographics, there may be a critical minimum population size which will ensure viability, and that minimum population size may require as much as 5,000 or more acres of contiguous habitat.

A recent study examined satellite imagery to determine if such remotely-sensed data could be used to identify and differentiate between landscapes that were potentially suitable for bobwhite and those that were not. As it turned out, the researchers found that in Illinois, bobwhites were usually associated with diverse, patchy landscapes that contained moderate amounts of grassland and rowcrops and abundant woody edge (100). More specifically, they seemed to prefer areas with about 15-30% grassland, 30-65% cropland, and at least 30 meters of woody edge per hectare (preferably more). In addition, they preferred landscapes with a variety of cover types occurring in small, well-interspersed patches. A later study (112) also found that bobwhite abundance was seemingly highest in landscapes featuring relatively large amounts of small grains (i.e., winter wheat). Whether this reflects direct positive benefits of the wheat fields themselves, or is merely indicative of general landscape conditions favorable to quail is not yet clear.

The Question of Water

The importance of permanent surface water to bobwhite habitat is a question that comes up from time to time. Like all animals, quail need water in some form to survive. However, bobwhite in the Midwest are apparently able to satisfy most or all of their requirements from succulent vegetation, insects, and dew. Some experts believe that quail can live for several weeks without free water (102), while others doubt that they require surface water at all for drinking (38, 109). In any case, the absence of permanent

Demographics

surface water does not appear to limit the distribution of bobwhite in Illinois.

The primary interest of most sportsmen and other laymen often centers on the individual animal – its size, appearance, behavior, etc. Professional wildlifers, on the other hand, are generally more concerned with the entire population. A population may be defined as an assemblage of individuals in which each has a reasonable chance of mating with any member of the opposite sex. In the preceding sections, we dealt with characteristics, living habits, and needs of individuals, pairs, and coveys. We now focus on demographic attributes that are unique to the population as a whole including birth rates, death rates, sex-age ratios, and abundance. Despite a shifting emphasis from single species to an ecosystem approach in wildlife conservation, populations generally remain the basic unit of management.

Mortality and Reproductive Rates

Whether a population increases, declines, or remains stable over time depends on the relationship between mortality and reproductive rates. If births consistently exceed deaths, the population will increase; if more animals die than are produced, numbers will decline – neither situation can be permanent. Under stable living conditions, mortality and reproductive rates tend to produce a relatively stable population size consistent with the carrying capacity of the habitat occupied. Different species arrive at this balance in different ways. Some, like elephants and humans, tend to be long-lived with relatively low mortality and reproductive rates. Others, like bobwhite, are short-lived with high mortality rates balanced by high reproductive rates. Mature bobwhites normally suffer a 65-85% loss annually, making them among the shortest-lived of all vertebrate species. Most of this loss occurs during late fall and winter when non-hunted populations in the Midwest are normally reduced by about 50% and hunted populations by 65% or more.

Fortunately, the bobwhite's high reproductive capacity is generally adequate to cope with these heavy losses. Quail biologists measure annual reproduction as percent summer gain (net summer production expressed as a percentage of the breeding population). A 26-year study of one hunted bobwhite population in southern Illinois revealed that summer gains most commonly ranged from 100 to 300% (mean = 205; range 17-383) (98). For any given amount of fall to spring mortality, there is a specific amount of reproductive gain necessary to exactly balance the losses. This is not, however, a simple 1:1 relationship, at least not in terms of rates or percentages (Fig. 6). The reason for this is that each bird dying in winter increases the amount of summer recovery needed while decreasing the base (breeding stock) from which that recovery is made (98). Thus, it becomes progressively harder for populations to compensate reproductively for previous fall and winter losses as those losses increase. This has important implications for management. For example, even though an increase in fall-spring mortality from 50 to 60% is relatively greater than going from 60 to 70%, the latter is considerably more serious in terms of potential recovery. In fact, researchers found that the

Fig. 6. Summer gain/winter mortality relationship necessary to maintain population stability.

study population mentioned above lacked sufficient reproductive capacity to consistently make up for prebreeding losses >70%.

The Phenomenon of Density Dependence

As with most wildlife species, bobwhite reproduction and mortality tends to be density dependent. In other words, their rates vary depending on the relative size of the population. Specifically, percent summer gains tend to be lower when breeding populations are high in relation to carrying capacity. Conversely, fall populations at or near carrying capacity usually suffer higher mortality rates during the subsequent winter than populations below carrying capacity. Obviously, this phenomenon does not represent a conscious effort on the part of the animals to balance births and deaths. Instead, density dependence is likely an incidental consequence of many factors – particularly social interactions within the population and the competition for preferred space. We know, for example, that when numbers are high, some coveys are forced to occupy marginal, less secure ranges. Conversely, a greater proportion of individuals from small populations are usually able to find suitable territories. Therefore, it would not be unexpected for survival rates to be higher for these smaller populations. Likewise, it is not hard to imagine how crowding during the breeding season could interfere with reproductive activities either through harassment, attraction of predators, or inequities in the distribution of prime nesting sites.

Density dependence is more than just an academic curiosity – it is a key reason why bobwhites are able to successfully absorb heavy losses from predation and hunting year after year. Density dependence affords populations a kind of built-in stabilizer such that winters of above-average losses are often followed by summers of above-average gains, and vice versa. However, it is important to remember that this phenomenon is just a tendency evident over time, not a hard, fast rule. In other words, reproductive and mortality rates do not automatically and completely adjust to density each and every year. If they did, population size would never vary, which of course it does. Furthermore, certain conditions (e.g., severe winters) can cause heavy mortality or depress reproduction regardless of current population density. And finally, the compensatory nature of density dependence is only partially effective. Even though the per capita rate of reproductive gain might be somewhat less for large breeding populations, generally the greater the number of breeders, the greater the absolute number of young produced.

Sex and Age Composition

Owing to their rapid population turnover, autumn quail populations in the Midwest typically consist of about 65-85% juveniles (birds hatched the previous summer), and about 15-35% adults (birds that have gone through at least 1 breeding season). A 50-year collection of hunter-harvested birds from Illinois revealed an average fall age ratio (juveniles:adult) of 4.9:1 (112). Traditionally, such ratios have been considered an index of productivity the previous summer. The rationale being that good nesting years should result in proportionately more juveniles in the fall population. As with many biological parameters though, correct interpretation of age ratios is not as simple as it might first appear (87). It turns out that autumn age ratios are actually more indicative of annual population change than population size. This is because high recruitment rates, and thus high young:adult ratios, are often associated with low breeding populations owing to density dependence. Consequently, they do not necessarily imply maximum total production or large fall populations. In addition, the absolute ratio of young to adult in the fall overestimates actual production for 2 reasons. First, it is inflated by adult mortality following the breeding season, i.e., it is not a ratio of young per breeding adult, but young per surviving adult. Secondly, research has shown that juveniles are almost 25% more vulnerable to the gun than are adults and thus are over-represented in harvested samples (99).

Bobwhites hatch at about a 50:50 ratio but females suffer slightly higher mortality thereafter, especially during and after the breeding season. Therefore, fall populations normally have about equal numbers of males and females among young birds, but a preponderance of males (60:40) among adults. Data from hunter harvests suggest relatively little annual variation in sex ratios, especially among juveniles, and no discernable long-term trends. The data also show that females of both ages are slightly more vulnerable to the gun than their male cohorts but the difference is so small as to be biologically unimportant (99).

Metapopulations

Just as a population is a group of interacting individuals, a metapopulation can be thought of as a group of interacting populations. Metapopulations occur when habitat is moderately fragmented, i.e., when occupied patches do not form a contiguous block, but are not so greatly separated as to preclude occasional interchange among neighboring groups. This exchange probably takes place mainly during the "fall shuffle" and spring covey breakup. Habitats can, however, become so fragmented that remnant populations are truly isolated and at greater risk than normal. This risk is primarily determined by two factors: size of the population and degree of isolation from neighboring groups. Small populations may simply go extinct due to normal population fluctuations. This is especially true of species such as bobwhite which typically suffer 50-80% mortality from fall to spring. Isolation means that compensatory adjustments to severe winters, or excessive predation or hunting via ingress is limited or non-existent making these factors much more critical than they normally would be. Finally, hunters and predators may be more effective when cover is limited and obvious. Additionally, isolated groups may lose genetic heterozygosity through excessive inbreeding and genetic drift. Ecologists speak of minimum viable populations, i.e., the number of breeders necessary to ensure continued survival of the population. According to one leading quail biologist, the minimum viable fall population may be at least 800 birds (44). Another unknown is what exactly constitutes an isolated pop-

Abundance

ulation, i.e., what is the effective dispersal distance of bobwhite? Several studies have suggested that populations separated by much more than 1.25 to 1.5 miles may be effectively isolated (112).

Relative numbers of quail present at any time or place is of interest to sportsmen and biologists alike. This section discusses abundance across space (regional, local) and time (short-term, long-term). Distribution and abundance of quail nationwide is determined by basic vegetative patterns and by the frequency and duration of potentially detrimental environmental conditions. To a large extent, both are determined by climate. Within potentially suitable range, local variation in abundance reflects the availability and quality of essential resources such as food, cover, and reproductive opportunities, which, to a large extent, are determined by human land use practices.

A basic tenet of wildlife management is that a given piece of land (unit of range) can support only so many animals of any one kind. The maximum number of individuals of a particular species that an area can support on a sustained basis is called carrying capacity. This capacity depends primarily on 2 things: the amount and quality of usable habitat, and the species' inherent tolerance to crowding. Biologists often express quail densities in terms of birds per acre, or some other land unit. Obviously, this is a somewhat artificial concept which does not reflect actual distribution patterns, but it is useful for comparative purposes. It was once thought that their own intolerance to crowding would limit bobwhites to no more that about 1 bird per acre even in the best habitat. Studies in northern Florida have now shown that this limit can be exceeded under ideal conditions (59). In good Illinois quail range, populations may average about 25 birds per 100 acres, with local densities reaching >100/100 acres (98). By comparison, prime quail range in the Southeast consistently supports 60-90 birds per 100 acres (24, 102), and managed local areas may have densities as high as 270/100 acres (58).

Both hunters and biologists are keenly aware that bobwhite abundance can vary over time. There are 2 distinct types of population change: short-term fluctuations and long-term trends. Short-term fluctuations are those periodic highs and lows that quail populations typically go through. These ups and downs normally last only a few years and are primarily related to weather conditions although there may be a cyclic component as well. Long-term trends are changes in prevailing densities over several decades and are generally habitat related (Fig. 1).

Short-term Fluctuations

Short-lived species with high mortality and reproductive rates typically show considerable fluctuation in year-to-year abundance, and quail are no exception. One local population occupying 2+ square miles near Carbondale fluctuated an average of about 25% per year over a 26-year period. Maximum annual increase and decline was 80 and 60%, respectively (98). The various population phases (highs, lows, increases, declines) each tended to persist for several years suggesting at least a moderate "carryover" effect from year to year. The dominant factor influencing short-term quail population fluctuations in Illinois is winter weather – especially snow cover. Long-term records clearly show that annual population change is strongly related to duration of snow cover the previous winter. Furthermore, particularly hard winters can result in major population declines. This was especially evident during the late 1970s when 3 consecutive severe winters drove quail populations to all-time lows throughout the Midwest. Population responses to summer conditions are much less noticeable or frequent although occasionally, extreme heat/drought can negatively impact production and fall abundance (91).

No discussion of bobwhite population fluctuations would be complete without mention of cycles. The fact that some wildlife species fluctuate between abundance and scarcity on a more or less regular basis has long fascinated and puzzled wildlife biologists. Two predominant types of cycles are recognized: the 3-4 year microtine (e.g., voles, lemmings) cycle and the 9-10 year cycle of snowshoe hare, Canadian lynx, and ruffed grouse in boreal habitats. The bobwhite is generally not considered a classic cyclic species, although earlier workers did not dismiss the idea entirely (29, 60), and a long-term study of a local bobwhite population in southern Illinois revealed a distinct 8-10 year cyclic pattern in abundance (98). Recently, SIUC researchers statistically examined over 70 long-term population records and found evidence of cyclic behavior (4-17 years) in the northern and western portions of bobwhite's United States range but not the southeast (114). They speculated that this behavior resulted from a combination of external influence (i.e., weather) and internal mechanisms such as delayed density dependence and momentum. Even if present, cyclic behavior in bobwhite is at best an underlying tendency, not a dominant force, and can be easily masked by weather events and habitat loss. In fact, both simulated and real observations suggest that as habitat declines, cycles become less pronounced primarily because the high phase is depressed (98).

Long-term Trends

The temporary ups and downs in quail numbers described above are clearly evident from a half-century record of estimated quail abundance in Illinois (Fig. 1). Underlying these short-term fluctuations, however, is an obvious long-term, downward trend. Present day quail numbers in Illinois may be only about 1/3 to 1/4 of what they were 40 years ago. This situation is evident in all parts of the Illinois quail range (Fig. 7). There are multiple reasons for this, some of which may not as yet be fully understood. The primary reason, however, is that there are simply not as many places for quail to live as there used to be. Some of this "quail space" has been lost to our ever expanding human population and insatiable demands for more living area. From 1964 to 2002, some 2.7 million acres of Illinois farmland were converted to other uses including housing, shopping malls, factories, airports, and roads. While we cannot assume that all of this agricultural land was quail habitat, some of it certainly was. Farmland that once supported several coveys of quail may now be the location of a sporting goods store where Illinois hunters purchase supplies for their next bird hunting trip to Kansas. Several species of Illinois wildlife (e.g., deer) have adapted to these suburban/exurban developments and are doing quite well, but the same cannot be said for bobwhite. Human residents generally won't tolerate the weedy, unmowed vegetation that quail need, and quail won't tolerate the constant disturbance from humans, vehicles, and pets. Consequently, suburban or rural developments, whether carved out of forested areas or expanded into formerly agricultural lands, generally offer little or no quail habitat. Quail hunting opportunities also have been affected by the expansion of dwellings and businesses into formerly rural areas. According to a recent SIUC study, 30% of rural Illinois is within 275 m of a structure thus making it legally closed to hunting without permission (46).

Despite the above, nearly 75% of Illinois is still farmed so there can be little doubt that the major factor in loss of quail habitat has been changes in the way we farm the land. Forty to 50 years ago, most farmland in westcentral and southern Illinois was usable by quail; today, much of it isn't. The trend away from diversified, chemical-free, small-scale farming to intensive, chemically-dependent, row-crop agriculture has negatively impacted quail habitat at all levels and spatial scales – field, farm, and landscape. Site (field) level conditions have been adversely affected mainly

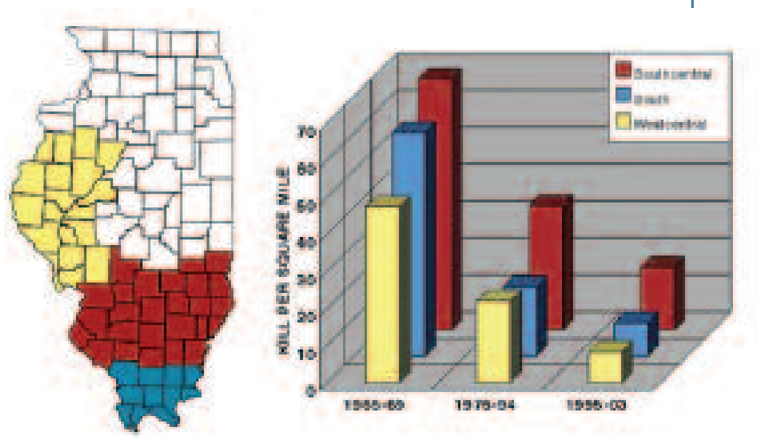


Fig. 7. Population trends in the three quail management regions of Illinois.

by technological advances. Valuable quail foods in the form of waste grains have been greatly reduced or eliminated by the combination of more efficient crop harvesting and fall plowing, while natural foods (annual weeds and insects) were being reduced by herbicides and insecticides. Advances in agronomy eliminated the need for periodic fallowing or idling of cropland thus eliminating essential nesting and brood rearing cover while the widespread use of fescue coupled with earlier and more frequent mowing have limited the usefulness of agricultural grasslands for this purpose. At the farm level, the shift from diversified cropping patterns to 1 or 2 row crops grown in large, borderless fields meant that certain components of quail habitat were often missing, and the destruction of literally thousands of miles of brushy fencerows and woody hedgerows not only eliminated critical protective cover, but often made remaining food supplies unaccessible to the birds. Finally, overall simplification of the landscape itself not only eliminated much usable space, but tended to fragment and isolate that which remained.

Certain types of wildlife (e.g., waterfowl) can be successfully managed on relatively small public holdings such as refuges. This is not an option for quail. To be a viable game species, it is not sufficient for quail to be only locally abundant – they must be reasonably abundant over relatively large portions of the landscape. Clearly, public areas such as refuges, wildlife areas, or sanctuaries are too few and too small to impact statewide or even county-level populations. Furthermore, such areas often provide inferior quail habitat for a variety of reasons. Paradoxically, bobwhite habitat can be adversely affected by either too much or too little human disturbance. The former problem usually exists on private lands whereas the latter most often prevails on public lands such as parks, natural areas, or nature preserves. For this reason privately-owned farmland often has too little cover for bobwhite whereas public land often has too much (98). When formerly agricultural areas are acquired for conservation or recreational purposes, quail habitat is often initially improved as cultivated fields are abandoned and early successional vegetation predominates. However, if there is not a commitment to regularly maintain these areas by fire or soil disturbance, they quickly become too thick or rank for quail. In most cases, these types of management practices are not used, or used too infrequently, to maintain suitable quail habitat on state or federal holdings. Many public areas are intended for multiple uses, and early successional vegetation and its management is often not compatible with these uses (including management of other species), or considered as aesthetically appealing as closed canopy forests or open grasslands.

Local Extinction and Recolonization

Another type of population fluctuation that can be either short- or long-term is when local populations go extinct. Plant and animal species have been going extinct for eons but modern-day conservationists warn that extinction rates have accelerated to an alarming degree. We are talking here though, not about species extinction, but about the temporary or permanent extirpation of local populations, specifically bobwhite populations. As we suggested earlier, isolated or semi- isolated populations are generally at greater risk than those living in large blocks of contiguous habitat. This is especially true for bobwhites because 1) their dispersal capabilities are limited, 2) they are subject to large numerical fluctuations owing to random weather events, and 3) they occupy primarily ephemeral habitats. Indeed, a recent study of bobwhite counts from 81 North American Breeding Bird Survey routes in Illinois (112) revealed that local populations along 12 of these 20-mile routes went extinct, most following the severe winters of the late 1970s. Five were later recolonized, but only 1 permanently. All of these populations were north of the primary quail range in Illinois. Interestingly, recolonizations

Bobwhite and Agriculture

took place only during years of below average snowfall suggesting that such conditions may have increased survival of immigrants.

The connection between bobwhite and agriculture is inescapable. How we humans use the landscape to produce food and fiber determines its' vegetative composition and pattern, which in turn determines the quantity and quality of bobwhite habitat. Because agriculture is the major force influencing land use in Illinois today, the bobwhite's ultimate fate is inexorably linked with farm practices and policy.

Three-fourths of our State is farmland, so most quail habitat must exist on agricultural lands if it is to exist at all. Furthermore, agriculture is the only land use in Illinois capable of creating and maintaining quail habitat on any meaningful scale. Even on non-farmland, successful quail habitat management usually employs agricultural methods. Unfortunately, the quail-friendly farming techniques of the past are for the most part just that – a thing of the past. Present-day farming techniques and agricultural practices commonly produce fields and landscapes that are inhospitable to quail. This section describes current conditions across the Illinois agricultural landscape and the problems and opportunities they present for bobwhite.

Regional Differences

Traveling through the State of Illinois, even the casual observer notices differences in topography and plant communities. Ecologists separate the state into 14 natural divisions based on topography, soils, bedrock, climate, natural vegetation, and wildlife (103). The most rugged landscapes are generally covered by deciduous forest, largely in private ownership. The land beneath these woodlands is too steep and infertile to be used as cropland. Illinois forests are concentrated on uplands along the Wabash, Ohio, Mississippi, and Illinois rivers and in the valleys of their major tributaries. In addition, there is a large band of upland forest on the unglaciated hill country extending across southern Illinois from the Ohio to the Mississippi River (the Shawnee National Forest). In contrast, the flat, fertile lands formerly occupied by upland prairies and floodplain forests have been almost entirely converted to row crops (corn and soy-

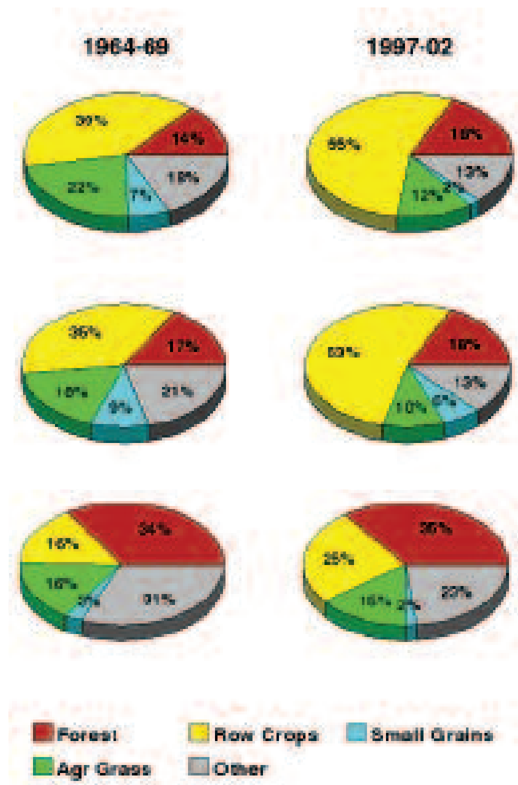


Fig. 8. Land use changes in west-central (above) south-central (center) and south (bottom) quail management regions in Illinois over the past 40 years.

beans). The Grand Prairie natural division occupies east-central and north-central Illinois from Sangamon County east to Coles County on the south to Bureau and Kankakee counties on the north. Aside from some narrow corridors of forest along streams, this region is virtually 100% cropland and provides little or no quality bobwhite habitat. Between these extremes are regions of the state with moderately rolling topography that support more diverse agricultural systems with intermediate amounts of forest. The Western Prairie Forest natural division runs from the Mississippi River east to the Illinois River and from Calhoun and Pike counties on the south to Hancock, McDonough, Fulton, and Peoria counties on the north. The Southern Till Plain natural division extends eastward from Madison County to Crawford County on the north and south to the Shawnee Hills. The 3 bobwhite management regions in Illinois (Fig. 7) generally correspond to natural divisions as follows: Westcentral (Western Prairie Forest plus counties immediately east of the Illinois river), Southcentral (Southern Till Plain), and South (Shawnee Hills). Overall land use (Fig. 8) is similar in the Westcentral and Southcentral management regions with 53-55% rowcrops, 18% forest, and 10-12% agricultural grasslands, but small grains are less common (2%) in the former than the latter region (7%). In contrast, the rugged terrain of the South region is more heavily wooded (35%), with more agricultural grassland (15%) and less cropland (25%).

Changes Over Time

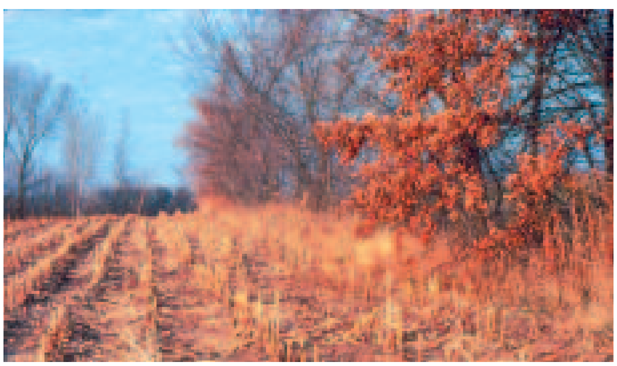
Farming practices and agricultural land use have undergone major changes in Illinois since quail were last abundant in the 1960s. Some of the changes are obvious while others are more subtle. All, however, have been detrimental to bobwhite. One obvious change in the rural landscape is that there is less of it. As we noted earlier, some 2.7 million acres of Illinois farmland have been converted to other uses over the past 40 years. Much of this conversion, though not all, has been to human dwellings or other developments which has resulted in a net loss of quail habitat and/or hunting opportunities. Even when abandoned farmland is used for recreational purposes, it is generally not maintained in such a way as to provide optimum bobwhite habitat.

Another significant change has been a large increase in land devoted to corn and soybean production. In the 1960s, there were about 5.6 million acres of rowcrops in the Westcentral and Southcentral quail range; today there are more than 8 million (Fig. 8, Appendix B). Although more corn and soybeans are grown now than in the past, the availability of these potentially important food sources to bobwhite has actually declined. In the 1960s, most of the grain produced in the quail range was available to bobwhite because it was grown in relatively small fields (20-40 acres) bordered by brushy fencerows and woody hedgerows that provided access for the birds. Today, most grain is produced in large (40-80+acre), borderless fields making it inaccessible to quail because the distance to protective cover is too great. In addition, former harvesting and tillage practices left much waste grain and weed seeds in the fields for overwin-

In the past, waste grain and weeds in harvested cropfields (top) provided a valuable overwinter food source for bobwhite. Today's cropfields (bottom) are generally unusable by quail during the critical fall-winter months.

tering bobwhite, but today's chemically-treated fields and efficient harvesting methods do not. On the positive side, there has been a general increase in the use of "conservation tillage" methods which has increased the amount of overwinter cover on cropland (currently 28% of cropland is no-till and another 15% reduced tillage). However, large fields and absence of protective borders still renders most cropland inaccessible to quail. Even where cropland is accessible, the 2-3 fold increase in insecticide and herbicide use has effectively eliminated most of the weed seeds and insects formerly available to bobwhite.

Veteran quail hunters recognize that there are far fewer woody hedgerows and brushy fencerows now than in the "good old days." They realize too that the destruction of just a few hundred yards of this type of cover usually means the permanent disappearance of 1 or more coveys of quail. Linear strips of woody or brushy cover are critically important to bobwhite for several reasons. Not only do they provide valuable protective cover themselves, but without them, other habitat components such as feeding and nesting areas may no longer be accessible to the birds. Although no definitive quantitative estimates are available, examination of past and current aerial photographs and personal observations indicate that the loss of this type of cover has been enormous over time and it continues today. This, despite the fact that the total amount of forested area has actually increased throughout the quail range (Fig. 8). This increase does not, however, compensate for the aforementioned loss of hedgerow and small woodlot cover. Most gains in forested acreage result from advancing succession in places where there is already more than enough heavy cover. In contrast, the destruction of small woodlots, or linear strips of woody vegetation along field edges and riparian zones often represents loss of the last vestiges of protective cover in a particular area.



Brushy hedgerows (top) provide protective cover and access to fall/winter food supplies; unfortunately, thousands of miles of this valuable habitat component have been destroyed over the past 30-40 years (bottom).

Still another major landscape change with important ramifications for bobwhite involves agricultural grasslands, a critical component of habitat for ground nesting birds. Over the past 40 or so years, the combined acreage of hayfields, permanent and rotational pastures, and diverted acres (fields temporarily retired from crop production) in Southcentral and Westcentral quail regions has declined from almost 3 million to just over 1.5 million acres (Fig. 8, Appendix C). Even more importantly, the composition and character of these grasslands have changed from quail-friendly vegetation to that which is mainly unusable by quail. For example, hayfields formerly provided more usable habitat than they presently do owing to the use of different forage species. Clovers and lespedeza, which were the primary hay species in the 1960s, grew more slowly and less densely than modern varieties of alfalfa, and were harvested later in the summer (late June) and less frequently (twice per season). Alfalfa, now the prevalent hay crop, is harvested as early as May and may be cut 3 or 4 times during the growing season if rainfall is abundant. This level of disturbance makes it difficult if not impossible for bobwhite to successfully nest in such fields. In the 1960s too, many permanent pastures consisted of bluegrass, lespedeza, and various native forbs and grasses, along with scattered shrubs and briars and

Diverse, mixed stands of grasses, forbs, and legumes (top) once offered prime nesting and brood rearing habitat for bobwhite, but today's agricultral grasslands often feature dense, monotypic stands of fescue (bottom) which are of little or no value to quail.

provided excellent nesting habitat for bobwhite. By 1990, most remaining pastures had been cleared of woody plants, fertilized, and planted to durable, thick growing grass species such as smooth brome and tall fescue which are of little or no use to bobwhite.

Rotation pastures may still provide valuable brood foraging and roosting habitat but are also harvested more frequently at present or may be heavily grazed thus reducing their utility for quail.

Another major change in the Illinois landscape may not be obvious to the untrained eye, but has nevertheless been critical for bobwhite. We refer to the general absence of early successional annual forbs and grasses so necessary for quail abundance. In the past, this essential habitat component was routinely created by timber clearing, wildfires, abandonment of marginal farmland, and most importantly, the widespread practice of temporary fallowing cropfields for 1 or 2 years. Now, however, cleared timber land is usually converted directly to cropland or homesites, wildfires are rare, and fallowing and crop rotation are no longer part of normal farming operations. It is no accident that peak quail populations in the Midwest coincided with the early days of agriculture when periodic crop-

Habitat fragmentation (top) and human developments (bottom) have caused further loss of bobwhite habitat.

Early-successional vegetation, essential for bobwhite abundance, is often lacking in present-day agricultural landscapes.

land fallowing was a routine farming practice. This produced large amounts of prime brood rearing cover and winter foraging areas for quail on a regular basis. Today, however, most of Illinois is either intensively row-cropped, or developed for human habitation, or left relatively undisturbed. **There are no current land use practices that result in sufficient amounts of early successional vegetation necessary to support quail at their former level of abundance.**

In addition to conditions at the field level such as described above, changing agricultural practices and policies have altered the very composition and pattern of the overall Illinois landscape itself. A comparison of aerial photographs from the 1960s to the present clearly reveal these changes. The earlier, less-intensive agriculture created a mosaic of small, diverse fields interconnected by a network of woody hedgerows, brushy fencerows, and vegetated waterways. Today's agricultural landscape is simpler, more expansive, and has a generally more open look from the air. The consequences of this for bobwhite are that not only has there been a net loss of habitat, but some of the habitat that does remain now exists in smaller patches that are more or less isolated from neighboring patches. The negative implications this has for quail were discussed earlier under the heading Metapopulations.

In summary, the Illinois landscape has undergone dramatic change since quail were last abundant, and it is these changes (listed below in no particular order) that account for most of the decline in quail numbers over the past 40 or so years:

1. Permanent destruction of woody hedgerows and brushy fencerows.
2. Increase in rowcrops and corresponding decrease in agricultural grasslands.
3. Conversion of remaining agricultural grasslands to fescue.
4. Enlargement of cropfields and elimination of waste grain, weed seeds, and insects.
5. Lack of early successional vegetation.
6. Human development of former farmland.
7. Advancing plant succession in undisturbed areas.
8. Fragmentation and semi-isolation of remaining habitat.

While these problems are general throughout the Illinois quail range, they do not all exist to the same degree in every part of every region. For example, the loss of formerly rural quail habitat to human development has been greatest in the more metropolitan counties of St. Clair, Madison, and Peoria, although other counties have been affected too, especially those with high rural human population densities such as Williamson and Franklin. Destruction of woody hedgerows and brushy fencerows has been most noticeable in the Southcentral quail region while the shift from grassland to rowcrops has occurred in both the Southcentral and Westcentral zones. A rather different set of problems exist in the South region. In many parts of this region, the landscape lacks the diversity and complexity characteristic of good quail range. Extensive tracts of mature forest blanket the hilliest terrain while large, borderless rowcrop fields dominate the floodplains. In between, most of the small, irregularly-shaped cropfields formerly nestled in generally woody terrain have been replaced by fescue-dominated pastures or CRP fields. In each of these settings, there is a notable lack of early-successional grasses and forbs necessary for quail abundance.

Federal Agricultural Programs

History

Until the Great Depression in 1929, farm operators produced livestock and crops that were best adapted to their region and yielded the greatest return for resources invested. Their fortunes were made or lost depending on their skills, but they were totally at the mercy of the economy and the weather. A protracted drought and the Great Depression forced the failure of a large number of farm operations in the 1930s. This economic catastrophe was so widespread that Federal officials were concerned that the nation's food supply could be jeopardized. They determined that legislation was needed to protect farmers from economic disasters and to conserve the productivity of the nation's farm land.

Aside from natural forces such as climate, soils, and topography, Federal agricultural policy is the major factor influencing land use in Illinois today. In our nation's history, some industries have come to be regarded as crucial to national survival. For this reason legislation has been enacted to secure adequate supplies of energy, food, and other vital commodities. Federal agricultural policy is rooted in this concept with the goal of ensuring an abundant, reasonably priced food supply by providing economic incentives to farmers for the production of certain crops and for conservation of farm land. At various points in our history, economic incentives have been used to stimulate or reduce production of various crops based on market demands. Over the same period, a much smaller portion of the resources available have been used to encourage practices that conserve soil productivity on farm land.

During the mid-1950s to the mid-1970s, increasing agricultural production often surpassed demand for many agricultural commodities. Market prices for feed grains fell below the cost of production prompting the Federal government to use economic incentives to encourage farmers to idle cropland to reduce production. These programs, which were operative from 1956 to 1970, involved millions of acres nationally and were often beneficial for bobwhite. For example, the "Soilbank" program of the 1960s had options that encouraged farmers to idle cropland for up to 10 years and either plant it to grass/legume mixes or allow it to grow into annual grasses and forbs. The "Feed Grain" program of the 1960s and early 1970s also idled large acreages of cropland with annual contracts that required no planting of cover crops. The natural, early- successional grasses and forbs that volunteered in these fields provided excellent habitat for bobwhite and populations remained at relatively high levels throughout the State.

By the early 1970s, domestic utilization was consuming less than half of our total agricultural production, leading to a fundamental shift in the goals of Federal farm programs. Government and agricultural leaders decided to stimulate agricultural production for the rapidly growing world export market. Idle land went back into production and nationally hundreds of thousands of acres of rangeland, woodland, and wetlands were plowed, cleared, or drained and converted to production of corn, cotton, soybeans, and wheat. This was the era of "fencerow to fencerow" farming that in Illinois alone, led to the destruction of literally thousands of miles of woody hedgerows and brushy fencerows that previously held bobwhite. As we said before, the negative impact on statewide quail populations was almost immediately evident (Fig. 1).

In less than a decade, the economic and environmental ramifications of maximum agricultural production for the export market became apparent. Foreign demand fluctuated widely from year to year causing large swings in prices that strained budgets of both producers and the government in years when large income support payments had to be made. Artificially high prices for commodities drove up production costs and land prices. Farmers in other countries increased production and began to compete with the United States for export market share. On the environmental side, many thousands of acres of grasslands, forests, and wetlands were converted to cropland resulting in a tremendous loss of wildlife habitat. Water quality was negatively affected by the runoff of sediment, fertilizers, and pesticides from marginal cropland and the conversion of highly erodible fields to production greatly increased soil erosion. By the early 1980s a shift in the direction of agricultural policy was being discussed among various governmental and private groups, but it took a series of years with very high world grain production and very low domestic grain prices to bring action.

The Food Securities Act (Farm Bill) enacted by the Federal Government in 1985 was intended to address some of the problems created by full production agricultural policies. In particular, there was renewed effort to limit production of excess commodities. In addition, greater emphasis was given to soil conservation, water quality improvement, and wildlife habitat restoration. The major wildlife conservation program of the 1985 Farm Bill was the Conservation Reserve Program which encouraged landowners to convert highly erodible cropland to semi- permanent cover for a minimum of 10 years. Participants in the program were allowed to select among several optional cover types for initial planting including various grass monocultures, grass/legume mixtures, or trees. The threefold objectives of CRP were to control production of excess commodities;

reduce runoff of sediment, nutrients, and pesticides into waterways; and restore wildlife habitat. The program proved to be quite popular among landowners nationwide. In Illinois, enrollment reached a maximum of about 880,000 acres by the mid-1990s. As of 2003, enrollment was about 645,000 acres with approximately three-quarters of the acreage located within the State's quail range.

The next major change in agricultural policy that affected bobwhite occurred in 1996. World grain supplies were at low levels and the 1996 Farm Bill (aka. "Freedom to Farm") provided large economic incentives for full production farming. The Conservation Reserve Program was continued, but

The potential value of CRP fields to bobwhite depends on their vegetative composition and structure (top), and their location with regard to other habitat components (bottom).

enrollment requirements became more stringent and some land was returned to crop production or used for hay or pasture. The 2002 Farm Bill continued the strong economic incentives to maximize production, but also contained new programs and alterations to CRP that could potentially benefit bobwhite. These will be discussed in the following section.

Opportunities for bobwhite

Programs that idle cropland to reduce grain production have great potential to enhance habitat for open land wildlife like bobwhite. Whether or not this potential is realized, however, depends on a number of factors including amount and location of land diverted, the type of vegetation established on the retired acreage, and its subsequent management.

Most authorities agree that CRP has been at least regionally successful in reducing soil erosion and enhancing habitat for certain wildlife species (1). However, despite initial optimism (52), tangible benefits for bobwhite have been somewhat disappointing, both in Illinois (95) and nationwide (9). This is not to say that individual CRP fields are not used by quail on occasion - clearly they are (13). Furthermore, it is likely that certain local populations have benefitted from CRP in terms of increased production. However, it is obvious that the program has not prevented regional and statewide populations from continuing to decline.

To understand why the Conservation Reserve Program has not had a more positive impact on Illinois bobwhite, we need to consider the nature of individual CRP fields and how they fit into the overall habitat picture. Many CRP fields were of little or no value to quail because of the type or structure of vegetation they contained. This situation resulted from a number of factors including initial establishment of unfavorable vegetation such as fescue, excessive and untimely mowing, and lack of provision for management practices to retard succession. During the 1st 5 or so years of the program, 87% of all CRP acreage was planted to introduced cool season grasses and legumes (CP1) (20). Many of these fields quickly developed into dense stands of fescue or orchard grass that were of little or no value for quail. Other fields were rendered useless to quail by excessive and unnecessary mowing. Early in the program, as many as 40% of all CRP fields in Illinois were mowed even though there was no requirement to do so (20). As time passed, farmers began to use more quail-friendly vegetation in initial CRP plantings. Currently, >25% of CRP vegetation is native warm season grasses or "permanent wildlife habitat" compared to only 3.5% during the early years of the program. Potentially beneficial introduced grass/legume mixes such as timothy, redtop, and lespedeza also are more commonly used. Nevertheless, even when preferred vegetation is initially established, CRP fields can rapidly lose their value to quail through the natural process of plant succession. During the 1st few years after planting, many CRP fields contain relatively open stands of planted grasses, legumes and volunteer annual forbs which provide valuable brood foraging cover. As succession progresses though, fields become more rank, and grasses begin to crowd out the legumes and annual forbs making the fields less useful as brood habitat. Once the legumes, forbs, and small patches of bare ground disappear, the field's value for quail becomes virtually nonexistent.

Even when site conditions are favorable, typical CRP fields cannot be expected to provide year-round habitat for bobwhite unless there is a woody/brushy component which is generally not the case. The best that can be hoped for is that the CRP acreage will provide or enhance a habitat component that is otherwise lacking, usually nesting and/or brood foraging cover. Thus, the location of CRP fields with respect to existing quail habitat becomes an important issue. To investigate this, researchers from SIUC mapped every CRP field (>8,800) in 11 representative counties within the Illinois quail range and examined how they related spatially to other habitat components (119). The majority of CRP exists within landscapes that are generally suitable for bobwhite because both are largely confined to moderately rolling terrain. Nevertheless, researchers found that almost 25% of the CRP acreage occurred in areas with insufficient woody edge to support high quail populations. Additional CRP acreage provided limited benefits to quail because it was located in areas where nesting/brood rearing cover was apparently not the limiting factor. In some parts of hilly southern Illinois, CRP probably had a negative effect on bobwhite because it replaced small cropfields that were providing vital food supplies.

It was perhaps unrealistic ever to assume that CRP could return Illinois bobwhite to the "good old days" because the acreage involved simply is not great enough. The amount of agricultural grassland in Illinois is currently 1.1 million acres less than during the late 1960s when quail numbers were still high. Even doubling the acreage of existing CRP would not make up this difference.

Despite the aforementioned limitations, there is still some justification for optimism regarding the program. As noted in the previous section, the 2002 Farm Bill contained new conservation-oriented measures that could potentially benefit bobwhite. One of these is the Conservation Security Program which rewards producers for adopting conservation practices (viz., crop rotation) to reduce soil erosion, improve soil and water quality, and create wildlife habitat. Farmers would receive payments for following corn or soybeans with wheat or oats and then a mix of clovers, alfalfa, or lespedeza that would be left unharvested for 2 years. Such a program could add much-needed diversity to the agricultural landscape. Another new initiative, the Grassland Reserve Program would promote restoration of native grassland and prevent conversion of existing grassland to cropland. Of particular importance to bobwhite, farmers would receive incentives to convert pastureland from tall fescue to native grasses and forbs. Two changes in the Conservation Reserve Program are also being viewed with optimism by quail biologists (16). One is the addition of a new CRP practice commonly referred to as "bobwhite buffers" which would establish much-needed grassy/herbaceous buffer zones around the perimeter of crop fields. The second, referred to as "mid-contract management", is a requirement that 20- 30% of each CRP field be disced or burned annually to reduce litter, expose soil, and stimulate growth of legumes, annual grasses, and forbs. If successful, such measures could alleviate the previously-described situation in which advancing succession progressively reduces the value of CRP fields to bobwhite.

Conservation implies preservation or "wise use" of a resource whereas management implies manipulation of that resource and/or its users for a specific purpose. Wildlife management generally attempts to manipulate animal populations and/or their habitats. Objectives might include production of harvestable populations, control of nuisance situations, or restoration or protection of threatened populations and habitats. Traditionally, bobwhite management has focused on maintenance of suitable habitats to produce and sustain huntable populations. As both populations and habitats continue to dwindle, issues of conservation and restoration also are beginning to emerge (9). In the remainder of this section, we will discuss various approaches to quail management as they relate to current and projected conditions. We will attempt to explain the theory behind the practice because, as a respected quail biologist recently said (40): "Management in a theoretical vacuum is successful [only] when it is lucky."

Stocking

Many sportsmen ask: "Since we don't seem to have enough quail, why doesn't the State just release (stock) them the way they do turkeys?" Before we address this question and talk about what stocking can and cannot accomplish, we should point out that there are 3 basic types of stocking each with its own specific objectives. These are: 1) release of pen-reared birds for controlled shooting or field trial purposes (i.e., "put-and-take"), 2) release of pen-reared birds to augment native wild populations, and 3) relocation of wild or semi-wild birds to repopulate depleted range.

Put and take

Two chronic, related problems associated with using artificially-propagated (pen-reared) quail for recreational purposes are low post-release survival and lack of natural behavior. The degree of wildness exhibited by "game farm" quail can vary greatly, depending primarily on their degree of isolation from humans during the rearing process. Behavior may become more natural with time spent in the wild (96), but survivorship declines. For example, harvest returns from >5,000 pen-reared quail in southern Illinois was <1% for birds released in spring, 8% for those released 7-12 weeks before hunting, 13% for releases made 2-3 weeks before, and 55% for birds put down during the hunting season (62). Similar results were noted in Indiana where returns from 8,000 released quail ranged from 3 to 16% depending on time of release (81). A Georgia study reported 18% harvest return of 6,700 birds released 3 weeks prior to hunting (71). "Gentle releases" into heavy protective cover provided with several days supply of grain may discourage premature scattering and enhance early survival. Relatively elaborate "call back" systems have been developed for this purpose (45). Nevertheless, we agree with a southern colleague that to maximize returns: "pen-reared birds should be released as close to the beginning of the hunting season as possible and [because] year-to-year survival is minimal, [harvested] without regard to 'carry over' for the following year" (71).

Supplemental

Whereas, put and take stocking may be justified under certain circumstances, there is virtual unanimous agreement among quail experts that releasing pen-reared birds to augment wild populations is not only futile (23, 96), but possibly harmful as well (9). The futility of such efforts stems from the extremely poor survival of pen-reared quail that has been documented again and again by scientific studies. Potential harm to resident wild stock may arise from several sources including genetic contamination, introduction of disease, attraction of predators, and general disruption of routine activities. Although more research of these issues is warranted, at least 2 studies (in Kansas and Georgia) reported increased mortality among wild quail following releases of pen-reared birds (104, 106), and several groups of leading quail biologists have recommended against large-scale stocking of pen-reared quail because of the potential adverse affects on resident wild birds (51, 66).

Translocation

At this point, readers may be wondering if there is a place for any kind of stocking in science-based quail management – the answer is: maybe. Relocation of birds to accelerate recovery or reestablish populations in depleted but suitable habitats might be a viable option in local situations, but more research is needed. In the past, it was assumed that suitable habitats would naturally contain quail, but as we earlier noted, small populations in fragmented range can be decimated by severe winters with little or no opportunity for recovery due to their isolation. In other instances, islands of newly created habitat might remain empty because distance to neighboring populations is too great for effective immigration. In such cases, a viable management option might be to transplant or translocate wild birds into the area (9). Transplanted stock might include captured wild quail or pen-reared offspring from 1 or 2 wild parents. Pen- reared offspring of 2 wild parents reportedly performed better when released than did standard "game farm" birds during an Indiana study (4). However, researchers in Ohio (48), Illinois (96), and Texas (77) all found that pen-reared quail with wild parentage were inferior in terms of survival and behavior to relocated wild quail that never experienced prolonged confinement. In fact, the latter 2 studies found that wild or semi-wild quail reared in captivity performed no better than standard game farm birds.

And now, back to the original question of why stocking works for turkeys but not quail. The restoration of the eastern wild turkey across its former range in North America is among the great success stories of modern wildlife management. To accomplish this, wild (not game farm) turkeys are livetrapped where they are abundant, transported to areas of vacant but suitable habitat, and released. Usually a release of 15 birds (12 hens and 3 adult gobblers) is sufficient to establish a new population given their relatively high annual survival rate and considerable ability to disperse. There are several factors that make bobwhite a less likely candidate for relocation. For one thing, their survival is only about 1/2 to 1/3 that of turkeys and their dispersal ability is much less so initial stockings of several hundred birds would probably be necessary to have any chance of success. However, the main reason that turkey relocations were successful is that birds were released into suitable but vacant habitat. In Illinois, there is little, if any, vacant suitable habitat for bobwhite. Virtually all habitat that will support quail is currently occupied. If an area has no quail, it is almost certain that it is lacking one or more critical habitat components, and relocating birds into such an area would be doomed to failure.

Harvest Management

Theory

An inherent capacity for rapid population growth permits quail and other small game to sustain annual hunter harvests year after year without apparent effect. Note the word *apparent*, however. Until perhaps 20-25 years ago, the "annual surplus" theory (69) formed the basis for most upland game hunting including bobwhite. Briefly, this theory held that game populations generally produce more offspring than can survive, and that regulated hunting merely removes this excess production without affecting the breeding stock. More recent research, however, has indicated that this view of hunting, and its impact on populations, is oversimplified, and can lead to misconceptions about harvest and harvest management. Field studies in Illinois and elsewhere have shown that protected quail populations in the Midwest normally suffer about 50% reduction from fall to spring (98) whereas hunted populations may lose between 60 and 80%, thus indicating that hunting can indeed increase total mortality and lower breeding densities. Fred

Guthery reached a similar conclusion for Texas bobwhites (35). But – and this is an important but – the loss of potential breeders caused by hunting is less than the actual number of birds shot; furthermore, a moderate reduction in breeding densities can actually stimulate production.

It is important to understand how these 2 things can be, so let's examine them separately. First of all, hunting is not completely additive to natural mortality because some of the birds shot would have died anyway just as the old "annual surplus" theory held. Biologists refer to this as competing risks. It's just a fancy way of saying that even though an individual has a chance of dying more than one way, it can in fact only die once. This relationship can be approximated by the simple equation: $T = H + N - (HN)$ which states that total fall-spring mortality rate (T) is equal to the harvest rate (H) plus the natural mortality rate in the absence of hunting (N) minus that portion of the harvest that would have died anyway (HN). In addition to this purely numerical compensation, birds that survive the hunting season tend to suffer slightly less late-winter mortality than nonhunted birds (98), probably because as hunting thins out the population, more food and cover is available to the remaining birds thus increasing their chances for survival. The fact remains, however, that everything else being equal, hunted populations generally have fewer birds left at the end of winter than non-hunted populations. As it turns out though, this is not necessarily a bad thing because of the phenomenon of density-dependent reproduction which we talked about in an earlier chapter. When breeding densities are temporarily reduced below carrying capacity, as in the case of hunting, they tend to respond with increased individual production. This increased reproductive output partially mitigates the fact that there are fewer breeders in the hunted population.

To put it another way, populations at carrying capacity tend to be sluggish with lower annual turnover, higher proportion of older individuals, and reproductive output just enough to match mortality. In other words, there's little or no excess production because the population is no longer growing. By contrast, populations below carrying capacity tend to be vigorous and productive, with a high potential for growth. By forcing breeding densities to this lower but more productive level, hunting actually stimulates excess production, thereby producing a "harvestable surplus." The relationship between annual harvest rate, population size, and total yields can be visualized in Fig. 9. If hunting pressure is very low, the standing crop remains high but yield suffers because only a small proportion is taken each year. Conversely, excessive hunting pressure can reduce standing densities to the point where yields suffer. An intermediate harvest rate that promotes high individual productivity while maintaining an adequate number of breeders generally produces the greatest long-term yields and is the aim of management.

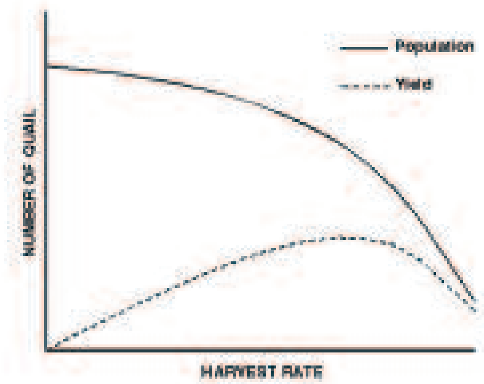
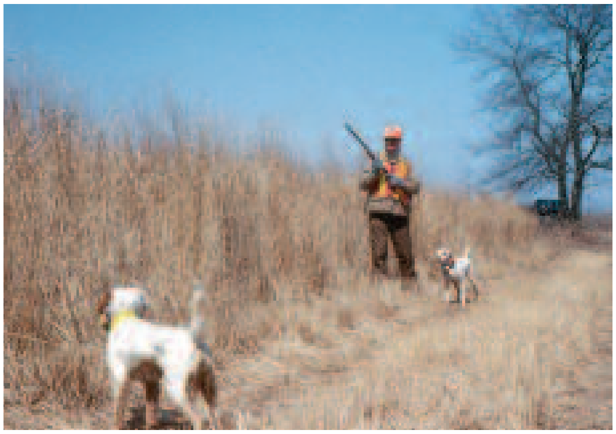


Fig. 9. General relationship among harvest rate, yield and population size.

The next logical question is what constitutes a reasonable harvest rate and how can it be achieved? A recent book on quail management (40) recommended harvesting to reduce fall populations to spring levels that would maximize percent summer gain. Theoretically, such an approach would achieve maximum sustained yields (MSY), i.e., permit the largest numerical harvest year after year by keeping the population at its most productive level (88, 89). In Illinois, MSY could probably be achieved by removing about half the fall population each year. However, this level of harvest would leave little margin for error, especially when crippling losses and periodic hard winters are considered A more prudent harvest might be around 40-45% (90, 92). Even this more conservative offtake is somewhat higher than generally recommended by quail biologists in the Southeast (102) and Southwest (105). Actually, there is no single rate of harvest appropriate for all situations or places. Statewide, the goal is generally to provide some recreation for the maximum number of hunters, whereas on private or commercial areas, the goal is often to provide quality hunting for fewer individuals. The latter situation clearly calls for lower hunting pressure and harvest rates. Allowable harvest also can vary geographically, e.g., northern populations can generally sustain higher rates of harvest than southern populations (36). This may seem counterintuitive given that natural mortality rates are higher for northern birds. However, as we can easily demonstrate with the previous equation $T = H + N - (HN)$, the higher the natural mortality rate, the less additive hunting losses are to it. Furthermore, northern populations, with their normally higher annual turnover, have naturally higher reproductive rates allowing them to better compensate for the additional mortality caused by hunting.

Practice

As a practical matter, statewide quail populations cannot be estimated, nor hunting regulated, closely enough to achieve specific harvest rates. The goal of statewide harvest management is simply to provide reasonable recreational opportunities for sportsmen while ensuring the continued welfare of the resource. Depending on the species, recreational hunting in Illinois is generally controlled by regulating a) number of hunters afield, b) daily or seasonal bag limits, and/or c) season length. With regard to quail, only the latter 2 apply. Over the past 50+ years, the bag limit for bobwhite in Illinois has gone from 10 to 8 to 6 and (since 1988) back to 8 (Appendix D). According to surveys taken in the 1990s (2, 3) approximately 60% of Illinois quail hunters would like to see the bag limit reduced to 6, while only 6% would like it increased to 10. In reality, adjusting the current bag limit would probably have negligible effect on overall harvest. For example, even if 1/4 of the total harvest resulted from hunters taking a limit of quail (8), reducing the limit to 6 birds would lower the total harvest by only 6%.



The goal of harvest management is to provide reasonable recreational opportunites for sportsmen while ensuring the continued welfare of the resource.

A more viable approach to regulating the total harvest is by adjusting the length, and to a lesser extent, the timing of the open season. Bobwhite hunting seasons in Illinois have gotten progressively longer over the years. They were only 30-40 days long during the 1950s but currently range from 63-69 days in the northern zone and 70-76 in the southern zone (Appendix D). Since 1989, opening day has been the 1st Saturday in November. A majority of hunters are satisfied with this date, but some (16-25%) feel it is too early (2, 3). They argue that early November weather can be too hot and dry for good dog work, some birds aren't yet fully grown, and crops are often still in the fields making it difficult to locate birds. Records show, however, that over 85% of all quail are at least 4/5 grown by November 1. Furthermore, the number of birds available for harvest is higher than it would be later in autumn. Whereas, most hunters are satisfied with an early November starting date, 56% of those surveyed in 1991-92 wanted regional seasons extended beyond January 1 and January 7 (2). Even when closing dates were subsequently extended to January 8 and 15, 37% still thought the season ended too early (3). Despite popularity with some hunters, late-season hunting has negative biological implications prompting several quail biologists to go on record against it (17, 92). The main problem is that the later in the year that hunting losses occur, the more they reduce the breeding stock (80, 84). To put it simply, a bird bagged in November probably wouldn't have survived to breed anyway, whereas a bird shot in late January probably would have. Some would argue that hunting pressure typically declines as the season progresses, thus providing a built-in safeguard against overharvest. However, those avid hunters who do persist are often the most experienced and skilled. Furthermore, quail are more vulnerable to hunting as the season progresses because escape cover is being continually reduced by crop harvesting and breakdown of natural vegetation. Finally, late-season hunting may affect even those birds that escape the gun, i.e., the breeding stock. Waterfowl biologists recognize the importance of sending females to the breeding grounds in the best possible physical condition. The same holds true for bobwhites – they must come through the winter in good shape if they are to reproduce at maximum capacity, a necessity for heavily hunted populations. Some biologists worry that late-season disturbance by hunters and dogs can disrupt normal feeding patterns during a critical time of the year. Such disturbance can be particularly damaging during severe weather or periods of prolonged snow cover. Given all these considerations, we do not believe it wise to extend quail hunting in Illinois much past the 1st week in January.

It has been suggested that perhaps quail hunting seasons should be adjusted according to the anticipated size of the fall crop, i.e., liberalizing the harvest during good years, and reducing it during poor ones (35). Computer modeling in Illinois showed that such a strategy might be marginally beneficial (88). In actuality, hunting pressure and thus harvest intensity is probably at least partially self-regulatory, i.e., interest and participation may rise and fall with quail abundance, both short- and long-term (56, 79). However, management cannot and should not rely solely on voluntary actions to safeguard the resource (90).

It is becoming increasingly apparent that long-held assumptions and traditions regarding quail hunting may have to be reevaluated in the face of declining populations and deteriorating habitat (9, 12, 93). Much of the natural resilience that quail populations have to hunting, predation, and weather, results from the numerical and physical security that characterize large, thriving populations in prime habitat. Unfortunately, wildlife managers no longer have the luxury of always working with such populations. They now find themselves dealing more and more with birds living, as the late long-time Missouri quail biologist Jack Stanford (108) put it, "closer to the edge." Quail in smaller, more isolated pockets of habitat are simply not as resilient to routine pressures from hunting, predation, and weather as are larger populations occupying extensive tracts of prime habitat. In recognition of this fact, some quail biologists have suggested that specific harvest regulations be applied at geographic scales smaller than statewide (121), or that more restrictive regulations be employed for at-risk populations that do not greatly impact hunting opportunities elsewhere (42).

Predator Control

Theory

Predation, and the effect it may or may not have on quail populations, is an emotionally charged issue that evokes much debate among quail enthusiasts (12, 74). Many hunters operate on the assumption that since predators kill quail, fewer predators would mean more quail. Biologists argue that it is not that simple. Complicating the issue further is that many non-hunters do not believe that predator control is justified regardless of whether or not game populations would benefit. In any case, we should not lose sight of the fact that bobwhites have successfully coexisted with predators throughout their entire evolutionary history, and in the process have developed effective life history strategies (large clutches, renesting, etc.) to cope with routinely heavy annual losses (10). Furthermore, many of the very behavioral traits that make bobwhite a prized gamebird (holding for pointing dogs, explosive flushes, rapid flight, etc.) undoubtedly evolved as responses to predation (107).

In the classic predator-prey relationships of the far north (e.g., lynx/hare, wolf/deer) the prey generally represents the predator's main food source while the predator is the prey's principal enemy. Such is not the case with bobwhites, however. Quail are preyed upon by a wide variety of birds, mammals, and even reptiles. Predation of adult bobwhites during fall and winter is mostly from hawks and owls, whereas mammals of one kind or another are primarily responsible for most nest predation. None of these, however, rely on quail as their primary food source. Quail predators, especially the mammals, tend to be generalists in their feeding habits and quail are normally just incidental (and often rare) items in their diet. As we shall see later, these are important considerations when assessing the pros and cons of predator management.

The renowned pioneer of quail research, Herbert Stoddard, felt that predation played a significant role in quail population dynamics (109), but it was the writings and opinions of his even more famous contemporary, Paul Errington, that influenced quail biologists for decades. Errington, working with quail populations in Wisconsin and Iowa, advanced the "threshold of security - doomed surplus" theory which tended to minimize the impact of predation (and hunting) on breeding populations. Errington believed that late winter habitat conditions acted as a sort of bottleneck so that the number of birds surviving to spring was rather uniform regardless of how many entered the fall (31). He reasoned that predation seriously affected only "surplus" birds that exceeded their "threshold of security" (i.e., carrying capacity), and that breeding densities were therefore regulated by habitat conditions and not predator populations (30).

This theory of game bird population dynamics remained popular and accepted for decades, even though certain aspects were being challenged by long-term population studies of both ring- necked pheasants in Wisconsin (117) and bobwhite in southern Illinois (98). Specifically, these studies found that relationships between fall densities and rates of winter loss and subsequent spring populations did not necessarily support the idea of a "threshold of security" and "doomed surplus" of birds. The implications of this was that both hunting and predation may exert a greater effect on quail abundance than was previously suspected. Furthermore, Illinois researchers (63, 98) as far back as the early 1980s were warning that changing landscape and habitat conditions might be altering relationships between quail and their predators (both animal and human). More recently, other researchers, especially in the Southeast and Southwest, have proposed that under certain conditions, nest predation can limit bobwhite recruitment and thus negatively affect fall abundance (50, 75, 85).

Various factors (all human-related) have altered bobwhite/predator relationships over the years. For one thing, certain predators are more abundant now than 30-40 years ago. This is particularly true for medium-sized mammals (potential nest predators such as racoons, skunks, and opossums) probably because of declining fur prices, less recreational trapping and hunting, and possibly landscape changes. Raptor numbers also have increased due to elimination of organochlorine insecticides, increased law enforcement, and public education.

More important still are landscape changes that have drastically altered the amount and spatial patterns of remaining bobwhite habitat. Nesting cover in particular has been greatly reduced and now often occurs in small, isolated patches or narrow strips that make for easier hunting by nest predators. Additionally, fragmentation of much year-round habitat has likely increased the vulnerability of resident birds to all forms of mortality including weather, hunting, and predation.

Practice

In the view of many hunters, the most direct and logical method of controlling predation would be to reduce the number of predators. However, there are several problems with this approach. First, there is no single, dominant quail predator on which to focus control efforts. As we said, quail are taken on a year-round basis by a wide variety of animals, none of which "make their living" from quail. Secondly, killing hawks and owls is not even an option. It is socially unacceptable and it is illegal! Thirdly, high populations of certain mammals may be related more to economic and social than to biological factors, and thus not readily addressable on a regional or statewide basis by natural resource agencies. Individuals or groups of landowners might consider encouraging legal trapping and furbearer hunting on their properties although there is no guarantee that quail numbers would increase. Furthermore, reductions of certain predators might actually produce negative results. Coyotes, for example, are often blamed for low quail numbers when, in fact, they may tend to suppress more effective quail predators such as red foxes, raccoons, and skunks (10, 47, 85) .

Alternatives to reducing predator abundance might involve habitat manipulation to limit their effectiveness. For example, increasing the size and number of nesting habitat patches may help reduce nest predation, while increasing understory cover within hedgerows and providing brushy buffer zones between mature woods and cropfields may reduce pressure from avian predators. The most effective predator management, however, would simply be to increase the amount of bobwhite habitat in general. Predation normally poses little threat to large, vigorous quail populations inhabiting extensive tracts of quality habitat; it becomes a potential problem only in situations of reduced habitat quality, fragmentation, and population isolation (107). Past research has clearly shown that good habitat can produce good quail populations even when predators are abundant. Conversely, quail cannot exist in the absence of habitat regardless of the predator situation. In other words, predator management cannot be substituted for habitat management (10).

Habitat Management

Throughout this booklet we have attempted to stress one simple, but all-important, fact: the key to quail abundance is habitat. For bobwhite, as for all other wildlife, habitat is not a luxury, it is an absolute necessity. There can be no substitute – not stocking, not closed seasons, not predator control. If we want to have quail, we have to provide them with a place to live, and if we want to have lots of quail, we have to provide them with lots of places to live. And that in a nutshell, is why we don't have as many quail as we used to – there simply aren't as many places for them to live as there used to be. The heyday for bobwhite in the Midwest was when they existed as a normal byproduct of routine farming operations. In those days, much of the rural landscape provided excellent quail habitat, not because it was managed for quail, but because the diverse, low-impact, chemical-free agriculture provided a naturally ideal setting for quail. Today, however, most high-quality quail habitat must be created and maintained via specific management efforts that rely on 3 key elements: knowledge, commitment, and opportunity.

Because bobwhite/habitat relationships vary across spatial scales (i.e., field, farm, landscape, region, state), management must do likewise. At the field level, management usually involves manipulating plant succession to create and maintain favorable conditions. Almost invariably, this means retarding or setting back succession to an earlier stage either by fire or some type of soil disturbance. The knowledge and expertise to do this is readily available from various natural resource agencies. Commitment becomes an issue here because the dynamic nature of successional vegetation requires a concerted effort to maintain it at the proper stage. Quail habitat cannot be created and then ignored – it will inevitably progress to something less desirable, and this progression can be remarkably quick, just a few years in some cases.

Management at the next larger scale (i.e., farm level) obviously includes field-level habitat manipulation, but must also incorporate the concept of limiting factors. Just as a chain is only as strong as its weakest link, habitat is only as good as its poorest (most limiting) component. For example, a farm lacking adequate winter cover cannot be improved for quail by adding food plots. Here again, knowledge of what habitat component is most lacking and how it can be provided is generally available from natural resource agency professionals.

Despite its importance, management at the farm and field level may not always be sufficient to produce viable quail populations in today's landscapes. Management at broader geographic scales involving groups of adjacent landowners may be necessary to address current bobwhite needs (121). As we said earlier, quail populations may require as many as several thousand acres of habitat to ensure successful long-term persistence. It is at this landscape level where opportunity (or lack of) for management becomes paramount. Clearly, if habitat is to be provided at this spatial scale, the bulk of it must occur on privately-owned farmland which makes up 75% of Illinois. As we have repeatedly pointed out, modern-day agriculture no longer routinely provides a favorable setting for bobwhite as it once did. Quail habitat must now be specifically planned and provided for within the context of production agriculture, and to a lesser extent, forestry practices. Those portions of Illinois that are flat and fertile will likely remain inhospitable to bobwhite barring major, unforseen changes in land use. Hopefully though, there will be opportunity to improve conditions within less-intensively farmed landscapes with existing or emerging conservation-oriented agricultural programs, contingent of course, on the willingness of landowners to cooperate in these efforts.

Whereas much practical knowledge exists regarding the mechanics of bobwhite management at the field and farm level, less is known about habitat relationships and management needs at larger spatial scales (93). For example, it is not entirely clear how large contiguous habitat tracts must be to ensure population viability, or at what distances do populations become dangerously isolated, or how landscape structure impacts population responses to hunting and predation (12).

Questions also arise as to where management efforts should be concentrated within landscapes. One strategy would be to focus on rapidly declining populations to prevent possible extirpation; an alternative would be to focus on currently stable populations to maintain their strength and prevent future deterioration (113). Most wildlife professionals agree that management should concentrate on the current Illinois quail range. The logic here is that the intensively row-cropped east-central portion of the State is so lacking in basic necessities for bobwhite that isolated management efforts would be futile. Even within the established quail range, there are areas so intensively farmed or heavily wooded that attempts to manage for quail would probably be a waste of time. Researchers at SIUC (100, 111), using habitat modeling and satellite imagery, recently produced statewide maps identifying those landscapes potentially suitable for bobwhite (Fig. 2). It is hoped that results from this, and similar, research will enhance and focus future bobwhite management in Illinois and elsewhere.

Finally, there is the question of whether management should emphasize improvement of existing habitat or creation of new habitat. It has long been held that bobwhite habitat quality represents a continuum from excellent to average to poor. Recently, however, a respected quail biologist (37) advanced the argument that if a particular piece of land is already occupied by quail, then it cannot actually be improved, and that the best way to "improve" an area is to make additional space usable by quail, either more of it, or for longer periods of the year. Regardless, creation of new habitat is clearly desirable so long as the addition is not so small or remote that it cannot attract and support viable quail populations. In this regard, we recommend new habitat be established adjacent, or in very close proximity, to existing habitat, thereby enhancing the value of both. Keep in mind, however, that even if occupied habitat cannot be improved, it still must be maintained, i.e., there must be frequent management attention to control succession.

To summarize, the presence or absence of plant communities that make up bobwhite habitat reflects the interaction of climate, topography, soils, and human use of the land. Currently, decisions about land use are the most important forces determining the distribution and abundance of such habitat. Of the major categories of land use, agricultural enterprise occupies the greatest land area and has the most potential to produce usable habitat for bobwhite. The primary objective of most agricultural land owners and land users is to manipulate that land in such a way

Habitat Restoration

as to produce an income sufficient to support them-

selves and their families. Fortunately, bobwhite habitat

Bobwhite management is much more likely to succeed in landscapes featuring a mix of woody edge and small, open fields (top) as opposed to unbroken tracts of cropland (middle) or forest (bottom)

and profitable, sustainable agricultural land use are not mutually exclusive. The preceding few paragraphs described some of the theoretical considerations of restoring and maintaining habitat for bobwhite. The next section describes, in a more practical way, just how this can be accomplished in today's landscapes.

Private Lands

Because bobwhite likely occur in nearly every county in Illinois, landowners could theoretically attempt habitat restoration anywhere in the State. However, probability of success would be much higher in the milder climates of central and southern Illinois where bobwhite are more uniformly distributed over the landscape. Tracts isolated from existing populations may be hard to improve. A covey or 2 might get started, but if they were eliminated by a severe winter storm there would be no opportunity for new birds to move onto the site. It is nearly impossible to start from nothing and build a sustainable bobwhite population unless birds are able to move from surrounding areas to the tract selected for habitat improvement. Furthermore, bobwhite management is much more likely to succeed in landscapes already containing a suitable mix of woody edge and open fields as opposed to vast unbroken tracts of cropland or closed canopy forests. In other words, start by selecting a suitable area for management. Do not attempt to turn a forest or wetland into habitat for bobwhite.

Another important consideration is the primary objective of the land. Most often the production of grain, forage, or timber is the reason for land ownership, although a growing number of acres are being purchased for recreational use including hunting for bobwhite. The primary ownership objectives determine if habitat restoration for bobwhite is feasible and the amount of land that can be devoted to management. Many guides to management state that 20 to 40 acres of habitat will support 1 or 2 coveys of bobwhite. This should not be interpreted as meaning that 20 to 40 acres of farmland must be retired from production for each covey desired by the landowner. Bobwhite will utilize many of the plant communities existing on the farm. In some cases, habitat restoration may be accomplished without removing a single acre from income producing uses. Often all that is needed are minor adjustments in farming practices or timing of agricultural activities.

As an example, consider an average 300-acre farm in southcentral Illinois with 160 acres of row crops, 30 acres of small grains, 10 acres of permanent pasture, 20 acres of rotation pasture, 20 acres of hay, 15 acres of CRP grassland, and 40 acres of woodland plus 5 acres occupied by the farmstead, fencerows, ravines, and field roads. Land in row crops (corn, soybean, grain sorghum) will provide shelter and escape cover during the growing season and a source of waste grain and weed seeds after harvest if a no-till or reduced tillage system is used. The winter food source could be enhanced by deferring harvest of a few rows of grain adjacent to woodlots or shrubby fencerows until spring. Small grain fields also provide shelter and escape cover during the growing season and a source of insects for foraging broods. After harvest, untilled stubble provides waste grain, weed seeds, insect forage and roost cover. Permanent, monotypic fescue pastures provide little or no usable habitat for bobwhite. Such pastures can be improved as forage and brood habitat by interseeding with leguminous forage species such as red clover or ladino clover. Rotation pastures provide an additional source of insects for broods even if hayed or grazed. Legume hayfields also provide brood foraging areas after harvest, but fescue hayfields are of no value to bobwhite. Conservation Reserve Program grassland will provide nest cover for bobwhite if planted to native warm season grasses and forbs or thin stands of fine-stemmed cool season grasses and legumes such as redtop and Korean lespedeza. Woodlands and fencerows with brushy understory will provide shelter from weather and predators.

From this example, it is obvious that the "building blocks" of bobwhite habitat are present on many farms in Illinois. Small adjustments in agricultural operations are usually all that is needed to significantly increase habitat for bobwhite on the farm. If land must be retired from crop production, it is often eligible for CRP which will compensate the landowner for income lost from the cessation of farming. Costs of planting grasses, forbs, and shrubs will be shared by the U.S. Department of Agriculture, the Illinois Department of Natural Resources, or conservation groups such as Quail Unlimited (QU). ***The important message is that habitat restoration for bobwhite can be both economical and compatible with normal farming operations in most regions of Illinois.***

Perhaps you are fortunate enough to own land that can be devoted completely to habitat restoration. What should you do? You might start by subdividing large blocks of open land into fields 10 to 20 acres in size. Field borders should be designed to provide a combination of shrub habitat, native warm season grass/forb nest cover, and legume brood foraging habitat. For example, the center could contain a double row of native shrubs 10 feet wide. On either side of the shrubs, there could be a 10-foot wide strip of clover or Korean lespedeza which, if mowed in August of each year, would provide brood foraging habitat and a protective firebreak for the center strip of shrubs. The outside edges of the field border could be 35-foot wide strips of nesting cover in the form of native warm season grasses and forbs. Such a field border would be 100 feet wide and provide 12 acres of habitat per mile (1 acre per 435 feet). If agricultural fields are farmed in continuous row crops, the cropping system should be changed to a rotation of corn or grain sorghum followed by oats or wheat followed by clover or lespedeza for 2 years. If legumes are harvested for hay, 50-foot borders should be left unharvested for escape cover for broods. About half of the remainder of the field could be harvested alternating harvested strips with unharvested strips. Areas of permanent pasture should be converted to a mix of native warm season grasses and forbs.

After the planting is established, about 1/3 of the acres should be burned each year in March or disced in October if burning is not feasible. Woodlots should be thinned to at least 50% canopy closure, removing shade tolerant species such as maple and ash. Existing fencerows should be allowed to grow up in shrubs, vines and briars, and strips of lespedeza and native warm season grasses, and forbs should be planted on each side of already established fencerows as previously described. Large trees should be removed from existing fencerows.

Be sure to inventory the plant communities on the parcel selected for management. The "building blocks" of bobwhite habitat are woodland and wooded edges, grassland (in a variety of growth forms and structures), and cropland or early succession idle land that provides a source of plant and insect foods. All 3 "building blocks" must be present. If any 1 is missing, the parcel is not bobwhite habitat. Also take note of any useful plant communities on adjacent lands. If close enough, bobwhite may utilize habitat on neighboring lands making it unnecessary to duplicate the habitat on the parcel proposed for management. The importance of inventorying existing plant communities cannot be overstated. It is not unusual to see a milo food plot planted on the edge of a corn field. Wouldn't it have been more economical to leave a few rows of corn unharvested at the edge of the field? Following is a discussion of the "building blocks" of habitat for bobwhite.

Woodlands and wooded edges

In terms of plant communities, the presence of woodlands and wooded edges seems to be the most important in determining the distribution of bobwhite in Illinois. Quail are not forest dwellers, but they seldom stray far from forest edges, wooded ravines, or shrubby fencerows. Woodlands and wooded edges provide shelter from severe weather and escape cover from predators as bobwhite move about the landscape to feed, nest, roost, and raise their broods. These plant communities are vital, but they should not occupy a large portion of the area available for management. For winter cover in Illinois, a 2 to 5 acre woodlot should be adequate. As previously mentioned, woodlots should be open in character (50% or less canopy closure) with a ground cover of grasses, forbs, and shrubs. The common mix of upland hardwood species (oaks and hickories) is suitable.

Many woodlots and forests in Illinois are overstocked with large, shade tolerant tree species such as hard maple, ash, and hackberry as a result of many years of fire suppression. Due to heavy shading, these forests usually have sparse, poorly developed shrub layers and ground cover, the very zones most important to bobwhite. Forests in this condition may be greatly improved by thinning. Species such as ash and maple should be removed in the thinning process. Reducing the canopy to 50% coverage or less will allow development of shrubs, grasses, and forbs necessary to create wintering areas for bobwhite. In some instances, planting native warm season grasses and forbs adapted to open forest or savanna conditions such as little bluestem (1 pound of pure live seed/acre), sideoats grama (1 pound of pure live seed /acre), and partridge pea (2 pounds of pure live seed /acre) may be desirable (plant in April or May with a no-till native grass drill). In other situations, the forest floor may already contain a seed bank of desirable

Woodlots must have suitable understory (top) to be considered potential quail habitat. Closed canopy forests with little or no ground cover (bottom) are of no value to bobwhite.

plants adequate to re-establish ground cover naturally. Many farms are comprised almost entirely of cropland and woodlots. Thinning woodlands on these farms may be the best way to create additional habitat for bobwhite.

Prescribed burning is an excellent tool for maintaining quality grass/shrub cover in open woodlands.

Shrubby fencerows allow bobwhites access to feeding and nesting areas (the tall trees in this example should be removed).

When woodlands are returned to the desirable condition of scattered large oaks and hickories with an understory of shrubs, grasses and forbs, some form of periodic disturbance will be necessary to maintain this ecological stage. Prescribed burning in late February or early March every 3rd year should be adequate. Burn only 1/3 of the area each year to leave residual cover for nesting and shelter. Discing or mowing in October may be substituted for prescribed burning. Rotate treatments so that only 1/3 of the area is treated each year.

Wooded areas utilized for shelter and escape cover must be connected to cropland and grassland by field borders of shrubs that provide overhead protection with an open understory to facilitate movement by bobwhite. Many species of shrubs are suitable for establishing field borders. Some of the common "fencerow" species include crab apple, hawthorn, wild plum, gray dogwood, silky dogwood, and hazelnut. Shrub field borders are usually established by planting small, bare root seedlings in single or double rows on a 5-foot by 5-foot spacing in March or April. In several years, shrub rows will begin to widen as additional stems grow up from the roots. Shrub clumps provide excellent resting areas for coveys of bobwhite. Shrub field borders are preferable to large trees because they are low growing (10 to15 feet tall) and less competitive with adjacent crops for moisture and nutrients. In addition, they do not provide hunting perches for avian predators. Shrub field borders require some maintenance. Periodically inspect them and cut out seedlings and saplings of large trees such as oak, ash, hackberry, mulberry, and osage orange. Also important, is the distribution of wooded edge. It should be adjacent to every field that contains food or cover that bobwhite need to use. Research in Illinois found few bobwhites present in areas with less than 40 feet per acre of wooded edge (100). On a larger scale, that translates to 1,600 feet per 40 acres, a little more than one side of a square 40-acre field.

Agricultural grasslands

The distribution of bobwhite is primarily dependent on woody cover, but their abundance seems mainly determined by the amount and quality of nest cover and brood habitat. Bobwhite are a short-lived species with an annual mortality rate of 75 to 80%; therefore, long-term survival is predicated upon high rates of productivity. Without the plant communities necessary for successful nesting and brood rearing, bobwhite cannot persist. Some agricultural grasslands have the potential to provide safe nest cover while others are better suited to providing brood foraging areas. Most of Illinois' bobwhite range is deficient in both.

Portions of agricultural landscapes that have potential to provide nest cover include grass field borders, roadsides, pasture (active and idle), and fields, contour buffers and filter strips enrolled in the Conservation Reserve Program. Nest cover should occupy 20 to 30% of the farm because nest densities seldom exceed 0.5 to 1 nest per acre, and hatching success seldom reaches 50% (64). It is encouraging that highest nest densities are usually found in strip cover such as field borders and roadsides (64) because strip cover is far more common in modern agricultural landscapes than large grass fields. To ensure maximum nest production, nest cover should remain undisturbed from April 1 to August 1.

Unfortunately, very few existing grasslands provide nest cover suitable for bobwhite. Grass must have the proper density and structure or it cannot be used. The most common problems are excessive thickness, lack of diversity, and disturbance (mowing, haying, grazing) during the nesting season. Dense, monotypic stands of fescue, smooth brome, or reed canary grass simply cannot be used by bobwhite. Fescue fields in CRP that are mowed like lawns every year are of no value to bobwhite. Stands such as these must be killed before more desirable species can be established. To convert existing fescue sods in strips or fields, it is necessary to kill the sod with herbicides (usually fall and spring applications of Roundup® or a fall application of Roundup® and a spring application of Plateau®). Spraying should be preceded by close mowing. Allow the stand to grow a few inches before spraying to improve uptake of the herbicide. Following herbicide treatments, a light seeding of native warm season grasses and forbs such as little bluestem (2 pounds of pure live seed/acre), sideoats grama (2 pounds of pure live seed/acre), and forb mix (1 pound of pure live seed/acre) should be planted with a no-till native grass drill in April or May.

Once established, the stand should be burned once every 3 years in March to maintain the proper density and structural diversity. Remember to treat no more than 1/3 of the nest cover each year. Bobwhite build their nests from residual plant materials from the previous year's growth. Stands of nest cover may be disced in October if burning is not feasible. A few species of introduced grasses and legumes such as redtop (1 pound of pure live seed/acre) and lespedeza (3 pounds of pure live seed/acre) also can provide suitable nest cover. Planting should be done

Grasslands must have proper density and structure to be used by quail. A mix of bunch grasses and forbs (top) is ideal, but dense monocultural sods (bottom) are of little or no value.

in March or April. Disturbance is also necessary every 3rd year in the form of light discing in October.

Larger fields (>10 acres) of native warm season grasses and forbs or introduced grasses and legumes should be subdivided into 3 equal sized units by planting 30 to 50-foot wide strips of legumes (clover, lespedeza or alfalfa) to serve as firebreaks when pre-

Herbicides must be used to kill fescue (top) before warm-season grasses can be successfully established using specialized grass drills (bottom)

scribed burning is used to maintain fields. Strips also provide brood foraging habitat. In another variation, the strips may be used as foodplots as well as firebreaks. The strip should be disced in October before a burn the following March. After the burn, corn or milo may be planted in the firebreak. The following spring in February or March, lespedeza may be broadcast on
the corn or milo residue. The plot should be left undisturbed during the 3rd spring to permit the growth of annuals and lespedeza. Fields, field borders, and filter strips in CRP may be established and managed in a similar fashion. For CRP grasslands, a written plan will be prepared by U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) or Illinois Department of Natural Resources (IDNR) personnel for each field under contract. Be sure to inform the individual preparing the plan that your objective is to provide the best possible nest cover for bobwhite. Active pastures may provide some additional nest cover if 30 to 50-foot wide strips of native warm season grasses and forbs (little bluestem, sideoats grama, and broad leaf mix) are planted around the edges of grazing lands. A 40-acre pasture with 50-foot borders on all sides would pro-

Legume fields (top) provide an excellent source of insect foods for bobwhite chicks (bottom).

vide 6 acres of nest cover. Prescribed burning, necessary to maintain the grass/forb stand, would also reduce the invasion of pasture edges by trees and shrubs.

Brood habitat may be similar to nest cover but it is

usually thinner with more broad-leafed plants, legumes and annual grasses, and less perennial grass. A number of common crops can provide brood foraging areas with little or no modification. Hayfields of alfalfa, clover, or lespedeza usually support high insect populations. After cutting, stands are usually opened to the point where chicks can move through the field and locate insect foods. Small grain fields after harvest also provide suitable brood habitat, especially when seeded with a companion crop of red clover. Even soybeans, no-till planted into wheat stubble, can provide some brood foraging areas. In larger CRP grasslands, brood habitat can be created by discing strips in the grass stand in October. Disced strips should be about 50 to 75 feet wide and cover about 30% of the field. Discing should be no deeper than 3 inches and should leave 50% of the ground covered by plant residue. Untreated areas of grass and legumes twice as wide as the treated areas (100 to 150 feet) should be left between disced strips for nesting cover. Each year discing should occur on the strips that were
not disced the year before. If desired, Korean lespedeza may be broadcast on the disced strips in late winter at a rate of 5 lbs/acre. In 3 years, the entire field should have been covered.

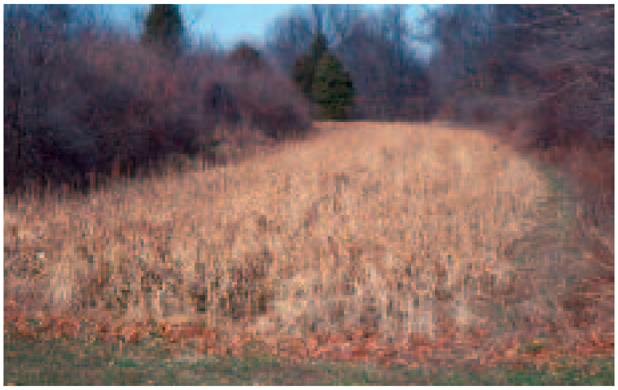
Cropland

In Illinois, row crops (corn, soybeans, and milo) and the weed seeds associated with their production are the primary sources of plant foods for bobwhite. During the summer, row crops also provide considerable shelter from severe weather and predators. With current farming practices, there is an excess of row crops in most landscapes, but they are under-represented in some areas of the Shawnee Hills where forest and pasture have replaced general farms. Some counties with high enrollments of CRP have areas which may be deficient in plant foods because of the retirement of row crop fields. The best way to manage cropfields to provide over-winter food for bobwhite is to leave a few rows of unharvested grain next to woodlands or wooded fencerows. Leaving an undisturbed fallow strip at least 30 feet wide between crops and protective woody cover also is very beneficial. Finally, adopt a no-till farming system if possible. If no-till is not feasible, use conservation tillage or at the very least, avoid fall plowing.

Where row crops are unavailable, establish a sys-

Strip discing is an excellent way to restore legumes and annual seed producers in fields with dense grass sods.

Leaving a few rows of unharvested crops next to secure winter cover is the best way to provide an emergency food supply for bobwhite,.



Where access to grain fields is limited, it is important to plant annual foodplots adjacent to good winter cover.

tem of rotated foodplots on the best soils available. Five percent of individual CRP fields may be planted to foodplots, which is usually adequate if care is exercised in locating the foodplots. Use foodplots to divide fields into 3rds for prescribed burning or discing as previously described. Always plant foodplots on contour in fields with >5% slopes. Planting rates vary by method of planting. When a corn planter is used, plant seed at a rate of 20,000 per acre. Milo should be drilled at 10 pounds per acre. Use higher rates if seed is broadcast and covered with a disc or harrow. Apply a balanced fertilizer at a medium rate and plant in April or May.

Sources of assistance

Assistance is available for restoration of bobwhite habitat. The NRCS can provide technical assistance and financial assistance for planning and implementing habitat restoration for bobwhite. The Farm Services Agency is the unit of the USDA that operates the CRP. This program provides both land rental and cost sharing for habitat development. Offices of both USDA agencies are usually found at a common location in each county. You should contact the county office in which your property is located. The IDNR Division of Wildlife Resources also provides technical assistance, limited free plant materials, and some cost sharing. District Wildlife Biologists usually serve a 3 or 4-county district. You can locate your district biologist by calling the Division of Wildlife Resources office in Springfield (217) 782-6384.

The Illinois Department of Natural Resources provides assistance in restoring habitat for bobwhite.

Assistance also is available from QU, a private organization devoted to the conservation of quail throughout North America. Currently, there are 18 active chapters located throughout westcentral, southcentral, and southern Illinois. These groups may also provide some financial assistance with bobwhite habitat restoration projects. To locate the chapter serving your area call (812) 536-2272.

Public Lands

The IDNR currently owns or leases approximately 356,000 acres at 391 sites of which 116 (30%) offer public hunting for bobwhite. Unfortunately, population trends for bobwhite on Illinois' public wildlife management areas are very similar to those on private land over the last 30 years. With a few exceptions, management efforts on public land in Illinois have been largely unsuccessful in establishing and maintaining high numbers of bobwhite. Research biologists and wildlife managers believe this lack of success is attributable to the inability to maintain large portions of sites in the early successional habitats required by bobwhite for nesting, brood foraging, and roosting. Establishment and maintenance of these habitats require intensive application of a variety of practices including native warm season grass/forb planting, prescribed burning, strip discing, establishment of wooded field borders to provide corridors for safe movement, as well as chemical and mechanical brush control in oldfields. Cultivated land with an appropriate crop rotation (row crops, small grains, legumes) also is an important component of bobwhite habitat. Cropping systems that contain only row crops

Large amounts of early successional vegetation are necessary for successful bobwhite reproduction.

provide a very limited spectrum of benefits to bobwhite.

In the mid-1960s, Illinois researchers (27) conducted a classic habitat improvement demonstration on Sam Dale Lake Conservation Area in Wayne County and Stephen A. Forbes State Park in Marion County. High quail populations and sustained harvests were maintained through a program of herbaceous vegetation management that featured crop rotation via sharecropping and prescribed burning. Despite the success of this approach, most management efforts on Illinois public lands continued to focus on increasing escape cover and over-winter food supplies. Management to provide herbaceous habitats essential for reproduction has been largely ignored resulting in grasslands on public areas that are often of little or no value to bobwhite. Most consist of thick stands of introduced species such as smooth brome, fescue, or reed canary grass. Even where native warm season grasses have been established, the stands are often too thick for bobwhite because they were planted at high seeding rates and without forbs or legumes. These grasslands generally receive little or no disturbance after planting in the form of burning, discing or herbicide treatments to reduce grass density, expose bare soil and increase forbs and legumes. Ideally, 30% of each unit of grassland should receive appropriately timed (fall discing or spring burning) disturbance each year.

For bobwhite, site management objectives should be to increase and better distribute nest cover, brood habitat, shelter/escape cover, and winter food supplies

Without periodic disturbance of grasslands, woody invasion will ultimately eliminate its value as nesting and brood rearing habitat.

over as much of the site as is feasible. Habitat improvement should focus on renovation of large blocks of grass sods and better utilization of cropland on site by dividing large fields (>40 acres) with shrub field borders and adopting a crop rotation including corn or milo, oats or wheat, and 2 years of legumes that are unharvested or partially harvested. A few rows of corn or milo should be left standing adjacent to all woodland edges and shrub field borders. If legumes are harvested, a 50-foot border should be left around all field edges. In addition, half of the hayfield could be harvested by alternating 50-foot wide harvested strips with 50-foot wide unharvested strips.

Three IDNR sites currently have relatively successful bobwhite management programs. These are the Jim Edgar Panther Creek State Fish and Wildlife Area in Cass County, Pyramid State Park in Perry County, and Ten Mile Creek State Fish and Wildlife Area in Hamilton County. These sites have at least 3 things in common: relatively large size (5,800 - 19,400

Edges of legume fields adjacent to protective cover provide excellent brood habitat for bobwhite.

acres), an emphasis on management for nesting and brood rearing habitat, and hunting programs that limit pressure to some degree. The latter factor is important because the abundance of bobwhite on public land may be adversely affected by excessive hunting pressure. Because many public hunting areas exist as islands of suitable habitat in a matrix of row crops, there is little opportunity for repopulation of excessively exploited sites through ingress from sur-

Native warm season grass field borders provide excellent nesting areas for bobwhite.

rounding areas. In most cases, sites are available for bobwhite hunting throughout the season by unlimited numbers of hunters. Hunting pressure undoubtedly exceeds levels consistent with maximum sustained yield of bobwhite at most sites. Depending on size of the area, the number of hunting parties per day should be limited to perhaps 1 party of 4 per 300 acres of open land. In addition, the number of days open to hunts should be limited to 2 or 3 per week.

The Shawnee National Forest, managed by the U.S. Forest Service, has exciting potential for restoration of bobwhite habitat if management efforts can be updated and improved. On many national forests including the Shawnee, decades of fire suppression, planting of exotics, and severely limited timber harvest has resulted in a buildup of fuel similar to those that led to recent catastrophic wildfires in the western United States. Currently, the Forest Service is reexamining its policies and prescribed fire and increased harvesting are being considered to reduce fuel loads on national forests. These activites have the potential to restore thousands of acres of habitat for bobwhite. Thinning or eliminating stands of exotic pines planted in the past would provide large openings usable by bobwhite. Prescribed burning would stimulate remnant stands of native warm season grasses and forbs and oaks and hickories known to have occupied the Illinois Ozarks at the time Illinois was settled.

Humans dominate the landscape in a populous, agricultural state like Illinois, and how we humans use the land will ultimately determine the bobwhite's future. To be honest, this future does not look particularly bright at the present time. To suggest otherwise would be to ignore current facts and trends. As we earlier noted, if downward population trends continue, bobwhites may be all but eliminated from the Southeast and Midwest in the next 30-50 years. This is a sobering projection to be sure, but is it inevitable, or can it be reversed, or at least slowed?

To address these questions, we must first examine projected trends in those factors that are contributing to the bobwhite's decline.

One trend that certainly does not favor bobwhite is the continued growth and expansion of the human population, coupled with our seemingly insatiable demands for more and more living space (94). Illinois has lost nearly 2.7 million acres of potential quail habitat to non-agricultural uses over the past 40 years and this trend can only be expected to continue. Quail obviously cannot use land covered by concrete or asphalt, but vegetated suburbs also are usually inhospitable to quail. Even where usable habitat remains near expanding developments, hunting opportunities are often lost.

Despite continued conversion of rural land to urban uses, Illinois' land base remains predominantly agricultural, and the bobwhite's fate will mainly depend on how this land is farmed (9). Future farming practices and agricultural policies, in turn, will depend on a number of factors including global economics, federal policies, technological advances, and possibly even climate change. Although changes in agriculture are almost inevitable, the nature of these changes, and their potential effect on bobwhite are very speculative (19). As the proportion of row crops increases, the quality of bobwhite habitat generally declines, although an increase in row crop production might actually benefit quail in the more heavily wooded, less intensively cultivated portions of southern Illinois. Quail in our State seem to prefer landscapes with about 30-65% rowcrops. It is hard to envision scenarios that would reduce the intensity of agriculture to this level on the flat, highly fertile portions of the State. Thus, the bobwhite's potential future will be determined by what happens on farmland of intermediate to low quality on slightly rolling topography (i.e., the current quail range; Fig. 2). Undoubtedly, the greatest pressure for increased row crop production will come from an ever-expanding human population. As the world population continues to grow, and less developed nations continue striving to raise their standard of living which often includes increasing the amount of red meat in their diets, there will be increased demand for feed grains such as corn, soybeans, and grain sorghum. Expanded use of alternative fuels such as ethanol also could stimulate increased corn production, although perennial plants such as native warm season grasses could be used for biomass production of ethanol without the expense of annual planting.

There are other factors, however, that might work to reduce corn/soybean acreage, at least on less productive areas of the state. For example, an increasing number of foreign countries are beginning to export these products and there is growing opposition from these producers to the U.S. government subsidizing grain production for the export market. Future trends toward larger, corporate farms also might reduce agricultural use of "marginal" lands. The opposite trend toward more diversified, "sustainable" agriculture could have the same effect (19). The latter could be promising for bobwhite, especially if it meant returning to such quail-friendly practices as crop rotation that included small grains, legumes and regular, periodic short-term fallowing. However, if fescue or something similar continues to dominate agricultural grasslands, then benefits would be minimized.

There will continue to be scientific advances leading to higher yields and more efficient production of crops. Just how this will impact bobwhite is unclear. Conceivably, better efficiency could allow greater production on the same or less acreage; conversely, it could result in even more acres devoted to agriculture (19). Likewise, increased development and use of genetically modified crops (e.g., Bt corn and Roundup Ready soybeans) could potentially benefit quail by reducing use of insecticides and herbicides. However, such advances could also promote additional grain production which might not always favor bobwhite.

Another factor that could impact quail directly or indirectly is climate change. Several biologists have already speculated on the potential biological effects of global warming on bobwhite distribution and abundance (43), but perhaps the greatest impact on quail would come from land use and agricultural changes resulting from altered climatological patterns (91).

The environmental/land use changes we have been talking about could conceivably affect quail over the next 20-50 years or so. More important for the immediate future are the kinds of federal agricultural programs that are initiated or maintained. As we have noted, land-retirement programs such as CRP can benefit bobwhite, but only if there are specific provisions designed to maintain early successional vegetation. Recently added, potentially quail-friendly CRP practices such as strip discing, controlled burning, field borders, and incentives for mid-contract management are encouraging. However, CRP regulations are subject to political pressures and will require continued effort by quail enthusiasts to promote beneficial practices.

This leads us to the troubling question of just who will speak for quail interests in the future? Census figures tell us that the United States population is becoming increasingly more urban and less rural. And while there may be a superficial increase in public awareness and concern about conservation issues (12), the number of people with direct experience or knowledge of bobwhite and their habitat needs is declining (19). The traditional base of public support for wildlife conservation and management has come from hunters. However, the proportion of United States citizens that hunt is dwindling, with the trend especially pronounced among upland game hunters. In Illinois, for example, the number of quail hunters has declined from >155,000 in the late 1960s to <35,000 currently. Equally troubling is the fact that university students, our future wildlife managers and researchers, increasingly do not hunt and thus will have less interest in game bird management and hunting issues (19). How bobwhites will fare in the emerging "ecosystem/biodiversity" conservation agendas of the future is not yet clear (93).

On the positive side, organizations such as QU remain popular and active. Currently, QU has approximately 300 chapters and 48,000 members nationwide (18 chapters and 1,900 members in Illinois). These organizations are not only actively involved in habitat restoration, but provide a base of public support for state and federal programs affecting quail (120). Also encouraging is the fact that there is now in place a nationwide plan for quail population recovery called The Northern Bobwhite Conservation Initiative (25). This plan seeks to promote cooperation between private land owners, state and federal agencies, and other conservation organizations for the purpose of restoring bobwhite habitat on a landscape scale throughout the species' range. Plans for implementing such efforts in Illinois are currently being developed (16).

Despite a rather pessimistic outlook by some (41, 94), the future can still provide opportunities to increase or at least stabilize bobwhite abundance in Illinois. But unlike the past, it will require strong, focused, well-directed effort instead of benign neglect. We cannot help bobwhite if we are unwilling to recognize the reasons for population declines or the actions necessary to reverse these declines. We must stop blaming predators, turkeys, or the closure of game

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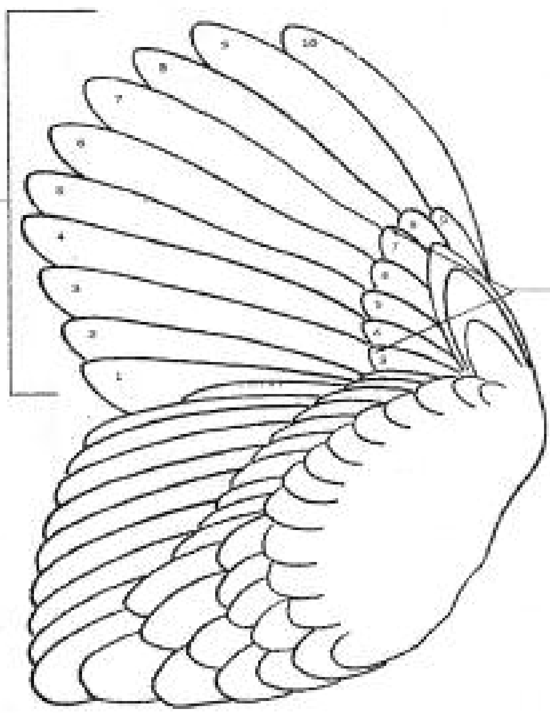
Appendix A. Age determination of bobwhite using wing feather criteria.



Approximate age in days of juvenile bobwhite based on growth of primary wing feathers (78)

Status	Primary Number							
	1	2	3	4	5	6	7	8
Dropped	28	35	42	47	54	62	74	101
¼ grown	33	42	47	53	60	68	83	111
½ grown	41	47	51	57	65	74	93	119
¾ grown	45	52	56	62	73	82	105	127
Full	56	58	62	73	85	103	124	150+

Juvenile with molt in progress

Juvenile with molt complete

Adult with molt in progress

Adult with molt complete

Notes

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Notes

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