

Potential Causes of the Texas Quail Decline



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Introduction

Like many grassland and shrubland bird species across North America, northern bobwhite (*Colinus virginianus*) and scaled quail (*Callipepla squamata*) have experienced severe population declines in recent decades. Over the last 35 years in Texas, bobwhite populations have declined by more than 75% while scaled quail populations have fallen 66%. Annual population fluctuations are typical for quail, with some “boom” years of high production and other “bust” years when few quail are recruited into the population. However, excluding 2016, the peaks of many boom years after 1992 have been small compared to historic peaks. During this time period, the overall populations of bobwhites and scaled quail have shown a downward trend (Figure 1). This decline is disconcerting to hunters, birdwatchers, photographers, and other outdoor enthusiasts who recognize the intrinsic value of quail as an integral part of Texas ecosystems and as an iconic species of our state.

No landowner can singlehandedly reverse the quail decline. But landowners and land managers should understand the causes of quail decline, in order to also understand how to contribute to quail conservation on their lands. Hypothesized causes of the quail decline include overharvest, invasive species, predation, disease and parasites. But where the research meets the road, none of these threats have been identified as the primary cause of the quail decline.

An important distinction missing from many quail decline discussions is the difference between proximate and ultimate causes. Although harvest, predation by native and non-native species, and disease can all affect the mortality rates of local (ranch-scale) quail populations, there is not sufficient evidence that

these proximate factors influence quail populations at an ecoregion or statewide scale. Despite the lack of supporting evidence, though, many of these purported threats are still blamed as the ultimate causes of the quail decline. “Quick-fix” techniques to increase quail populations have also remained in the toolboxes of many managers, even though most research does not support their effectiveness.

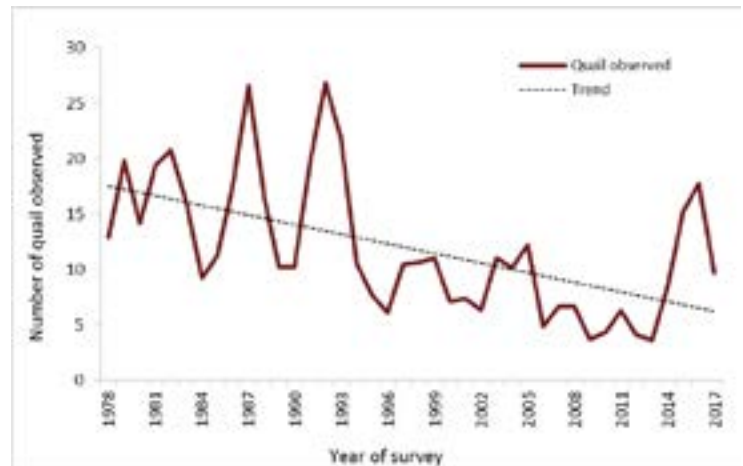


Figure 1. Mean number of northern bobwhite observed per survey route across Texas, 1978-2017. Data compiled for all available ecoregions from Texas Parks and Wildlife survey data¹.

The following pages contain an evaluation of four commonly blamed causes of the quail decline and an assessment of three quick-fix techniques. Finally, the concluding section discusses proven best management practices (BMPs) that are effective for managing good quail habitat, because declining habitat quality and quantity is the ultimate cause of the quail decline². Healthy quail populations—which can persist through natural disturbances such as drought and support sustainable hunting—are a product of contiguous, quality habitat.



Photo 1. The dappled plumage of a bobwhite provide camouflage in its habitat.

Unlikely Causes of the Quail Decline

Overharvest

Overharvesting can decimate wildlife populations, and this fact is etched into the minds of those who are familiar with the unregulated harvests that drove many North American species to near-extinction in the late 1800s and early 1900s. However, modern harvest regulations err on the side of caution to ensure that populations of game species flourish into the future.

Natural mortality of many quail species is high—an estimated 70-82% of bobwhite quail survive less than one year³, and scaled quail are similarly short-lived. But the effect of hunting on these two species differs. When managing for bobwhite, annual harvest should not exceed 20% of the local population in a good year, with limited or no harvest in bust years⁴. Scaled quail are a more challenging and less frequently hunted species than bobwhite, so hunting typically has little effect on their populations.

In Texas, daily bag limits for three species of quail (bobwhite, scaled, and Gambel's) are set for the entire state. However, habitat conditions are not consistent across Texas. To ensure harvest does not negatively affect local quail populations, many private properties impose stricter regulations on quail hunting than those set by the state. For example, a ranch may set a limit on the number of birds that can be taken from a given covey or restrict hunting hours to the morning only. In years with low quail populations, some properties often forego quail hunting altogether as an investment in future populations.

To make appropriate harvest management decisions, managers need to keep track of quail populations. Population density can be estimated using surveys such as morning covey call counts, flush counts, or transects.

When coupled with harvest records, population surveys help quail managers prevent overharvest. Harvest records should document date, time, area hunted, the number of hunters, number of birds harvested, and the age and sex of each quail. The data obtained from surveys are critical for identifying progress and potential problems. Managers should also re-evaluate harvest if there are changes in land use or changes in hunting pressure on or near the property.

Daily bag limits for the three quail species may be the same throughout the state, but landowners should consider whether the habitat on their land can support the harvest of large numbers of quail. Landowners who monitor local quail populations and adjust harvest limits accordingly will benefit both hunters and quail.

Invasive Species

Wild Pigs

Negative impacts associated with invasive wild pigs (*Sus scrofa*) include competition with quail and other native species, destruction of habitat, degradation of water quality, and damage to agricultural production. In Texas, populations of wild pigs have increased dramatically over the last 30 years⁵, while quail populations have declined to record lows. Although a connection between those trends might seem obvious, quail populations have continued to decline even in areas where wild pigs are absent. Despite the negative impact wild pigs may have on local quail populations, they are not the ultimate cause of the quail decline.

Wild pigs are opportunistic omnivores. “Omnivore” refers to consumption of both plant and animal matter, while “opportunistic” indicates that wild pigs are not picky and will consume a wide variety of items. The eggs of ground-nesting birds, such as wild turkey and quail, are eaten by wild pigs during nesting season.



Photo 2. Managers should monitor local quail populations and adjust harvest accordingly so that take is sustainable.

However, research indicates that plants comprise the majority of the typical wild pig diet in Texas^{6,7}.

One study found that nest depredation rates attributed to wild pigs were low to moderate, ranging between 10-30% of all instances of nest depredation⁸. Where range conditions and nesting cover are adequate, depredation tends to be lower, whereas poor range conditions and limited nesting cover may lead to higher depredation rates. Good upland cover is especially valuable to quail, because wild pigs are typically found near riparian and other low-lying areas⁹.



Photo 3. Wild pigs cause many types of environmental damage and should be lethally controlled, regardless of their impact on quail species.

Regardless of the direct impact of wild pigs on quail species, every effort should be made to reduce populations of this exotic invader. Wild pig abatement efforts will benefit all native wildlife, including quail.

Fire Ants

Like wild pigs, red imported fire ants (RIFA; *Solenopsis invicta*) are an exotic species whose populations have increased during the time that quail populations have decreased. Red imported fire ants were introduced to the U.S. in the 1930s and can now be found across more than 573,000 square miles (1.48 million km²) and 14 states¹⁵.

Negative impacts of RIFA on quail can be direct or indirect. Direct effects include attacks by fire ants on quail eggs and young chicks^{16,17}, which can decrease production of quail in a given area. Indirect impacts include local reductions of native invertebrate populations following a RIFA invasion¹⁸, which in turn reduces the availability of insects for quail. Quail chicks rely heavily on the protein and calories offered by

insects, and although they will consume fire ants, the survival and weight gain of chicks that eat RIFA are lower than chicks that do not¹⁹.

Despite the negative impacts of RIFA on quail, fire ants do not appear to be an ultimate cause of the quail decline. There are regions without RIFA where quail populations have declined, and other places where RIFA are present but quail populations are healthy. Why, then, do we see RIFA increase while quail decrease?

Part of the answer is that the same disturbances that have allowed fire ants to thrive have decreased the suitability of the land for quail. Fire ants do well in areas with a high rate of disturbance and are found in much higher densities along roadsides, recently flooded land, tame pastures, and plowed fields²⁰. While quail may occasionally be found in those habitats, none are ideal places for them to live.

Instead, quail are more likely to occupy patchy landscapes with a mixture of brush and bunchgrasses, cover and open ground. Even high-quality quail habitat can be invaded by RIFA, but overall there is little overlap between their preferred habitat types.

Careful consideration should be taken before landowners initiate expensive chemical control of RIFA on their property. Resources are likely better spent on the creation and maintenance of suitable quail habitat.



Photo 4. Red imported fire ants are an exotic species that harm native wildlife.

Predators

Wild Turkeys

Wild turkey (*Meleagris gallopavo*) populations have increased across much of their range during the same time that quail have declined. As with wild pigs, many people have tried to connect the increase in turkey numbers to the decrease in quail numbers. However, quail populations have decreased even in areas where wild turkeys are not present. Anecdotes of turkeys eating quail eggs have contributed to this theory. Herbert Stoddard, considered by many to be the father of bobwhite management, wrote in 1931 that wild turkeys “had a fondness for quail eggs” because he had observed a domestic gobbler eating eggs “with evident relish.”¹⁰ Although wild turkeys do feed opportunistically^{11,12}, no studies have shown evidence that they consume quail, their eggs, or their chicks. In 2014, researchers in the Rolling Plains Region of Texas examined the crops and ventriculi (gizzards) taken from 93 wild turkeys throughout the bobwhite nesting season¹³.

Wild turkeys were harvested at various times of the day and across different habitat types to ensure a representative sample of wild turkey diets. The study area supported high densities of both wild turkeys and bobwhites at the time, thus offering a high probability of documenting turkey consumption of quail if indeed such behavior was occurring. No evidence of quail eggs or chicks was found in the upper digestive tracts of wild turkeys in the Rolling Plains.

If given the opportunity, a wild turkey may consume quail eggs or chicks. However, research indicates that this would be a rare occurrence and therefore an insignificant factor in the quail decline.



Photo 5. Male wild turkey in breeding display.

Roadrunners

The range of the greater roadrunner (*Geococcyx californianus*) has expanded over recent years and this species can now be found throughout Texas. Like wild pigs, roadrunners are opportunistic omnivores. Unlike wild pigs, roadrunners are primarily carnivorous. The voraciousness of roadrunners as predators—they will even eat rattlesnakes after pecking the snake in the head until it dies—has led some to suspect there is a connection with the quail decline in Texas.

A study conducted on the Chaparral Wildlife Management Area examined the digestive systems of nearly 120 roadrunners¹⁴. Researchers documented a wide variety of prey, including arthropods, reptiles, amphibians, mammals, and birds. Among the bird remains, biologists identified two northern bobwhites. The most common prey by far, however, was grasshoppers (*Orthoptera*), which were found in 93% of roadrunner stomachs. Reptiles were the second most common prey, eaten by 35% of roadrunners sampled.



Photo 6. Greater roadrunners eat insects and lizards far more often than occasional quail.

Although roadrunners occasionally consume adult quail, as well as their eggs and chicks, this occurs at such a low rate that roadrunners are unlikely to play any significant role in the quail decline. Quail and roadrunners have coexisted for thousands of years and will continue to do so as long as quail are provided adequate habitat to hide from roadrunners and other predators. Also, roadrunners are protected by state and federal laws, and therefore cannot be legally taken by any means.

Diseases and Parasites

The hypothesis that diseases and parasites have played a role in the quail decline has become popular in recent years, especially following perceived outbreaks of maladies such as eyeworms or Avian Influenza Virus (AIV). Bobwhites are susceptible to AIV, as well as 20 other diseases and some 98 species of parasites²¹. However, research on this wide range of pathogens has only scratched the surface of understanding potential impacts on quail.

A review of the effects of helminths (parasitic worms) on bobwhites and other birds suggested that, under good habitat conditions, helminths do not significantly affect quail populations²², though research in this area is still ongoing. While more information is needed regarding the population effects of parasites on quail, general parasite biology suggests that they are unlikely to be the driving force behind the quail decline. Successful parasites do not kill their definitive (final) host directly; although the host may be weakened and impaired, a parasite only benefits from a live host.



Photo 7. Scaled quail (top) and Northern bobwhites (bottom) are both susceptible to eyeworm infections. Red arrows indicate locations of parasites.

However, quail with high parasite loads may be more susceptible to predation or less capable of coping with environmental extremes. In habitat that lacks sufficient protection from predators and natural disturbances, parasites may have a stronger negative impact on quail populations.

Preliminary research on the prevalence of AIV and other bacterial and viral diseases in wild quail has indicated that disease is not a significant concern in most populations²³. However, continuing research on diseases will provide new insights on quail biology that in turn will guide quail management.

"Quick-Fix" Techniques: Easy but Ineffective

To some extent, all managers are limited by resources such as time and money. These limitations make "quick-fix" techniques enticing, because these practices are promoted as easy, fast, low-cost ways to boost quail populations. However, none of the following techniques have been shown to increase quail populations, and some may have unintended consequences that actually harm quail. These management actions are typically a waste of resources because habitat is not improved and quail numbers are not increased.

Releasing Pen-Raised Birds

A common question of land managers is, "If quail are declining, why not simply increase their populations by introducing pen-raised birds?" Despite the best efforts of many quail enthusiasts, introducing pen-raised quail has not been successful for increasing quail numbers. A variety of methods have been attempted since research on pen-raised bobwhites began in the 1930s, including use of surrogates, release of chicks and adults, soft releases, and hard releases. All studies have concluded that pen-reared quail simply do not survive long in the wild, and even routine stocking is not a viable method for augmenting wild populations²⁴. For a population to persist over time, the seasonal survival of bobwhites should be no lower than 43%²⁵, but best-case seasonal survival of pen-raised quail is just 14-18%²⁶. Furthermore, releasing pen-raised quail can actually

be detrimental to wild bobwhites due to the potential for disease transfer, negative social interactions, and attraction of predators²⁶.

During years with low quail populations, some managers release pen-raised bobwhites to replace wild quail harvest while still providing hunting opportunity. If this strategy is used, pen-raised bobwhite should only be released at designated sites that have low potential as bobwhite habitat. Furthermore, bobwhites should be released shortly before each scheduled hunt and the number released should match the anticipated hunting pressure to help ensure a high return of pen-raised birds. However, a better strategy during low quail years is to refrain from hunting them.



Photo 8. Quail raised in captivity have very low survival rates in the wild.

Providing Supplemental Feed

A common quail management technique, regardless of local population trends, is the use of feeders. Although sufficient quantity and quality of food are critical to quail survival and reproduction, food is rarely a limiting factor for quail. An exception may occur in areas where habitat conditions become poor and food is less available or accessible, such as during a severe drought or extreme weather event (e.g., snow and/or ice storm). In such instances, some evidence indicates that quail survival can be higher in fed areas versus unfed areas^{27,28}. Quail reproduction does not appear to benefit from supplemental feeding, irrespective of habitat conditions²⁹.

When considering whether to provide supplemental feed via traditional barrel feeders, quail managers should weigh the benefits and drawbacks of this practice. Quail are attracted to supplemental food^{28,29,30}, so they will concentrate in an area where food is provided. Natural predators of quail do not typically reduce year-to-year quail population levels, but predators can quickly learn to associate quail feeders with an easy meal^{31,32}. The risk of overharvesting from hunting may also increase because high concentrations of birds around feeders can give managers a false sense of high quail densities.

Another risk of supplemental feeding is exposure to aflatoxin, which is a toxin produced by fungi that can grow on feed and suppress the immune systems of quail. Even low levels (100 ppb) of aflatoxin can suppress a quail's immune system and increase susceptibility to disease³³. Quail managers who provide feed should purchase small quantities and store the grain in a cool, dry environment to reduce the risk of quail exposure to this potentially deadly toxin³⁴. Providing milo instead of corn may also reduce the risk of aflatoxin development in feed³⁵. A possible danger of feeding that has not yet been studied in quail is the potential for increased disease transmission. Research has shown increased risk of disease related to supplemental feeding of mammals³⁶ and other birds³⁷ due to increased contact among animals.

Another factor to consider before feeding is the economic cost of purchasing supplemental feed relative to its benefit for quail. One study on traditional quail feeders estimated that for every \$250 spent on feed, only \$1 worth reaches the crops of quail³⁸. Most of the food is consumed by other animals, such as raccoons (*Procyon lotor*), mice (*Cricetidae*), squirrels (*Sciuridae*), and other non-target species^{38,39}. Increased populations of these non-target species may result in detrimental effects on quail, such as increased populations of nest predators. Aflatoxins can develop in both corn and milo supplemental feed during storage. Small quantities of feed are easier to keep cool and dry, which will reduce the likelihood of aflatoxin development.



Photo 9. Using feeders is not typically an effective tool to benefit quail populations.

A more effective method of providing supplemental feed for quail is the technique known as broadcast feeding. Broadcasting supplemental feed (milo) is preferable to using feeders, because quail will feed over a large area and under the concealment of adjacent vegetation. This practice reduces the risk of predation and does not appear to affect home range sizes when applied correctly²⁸.

Planting a food plot is a third method for providing supplemental food for quail. Bundleflower (*Desmanthus spp.*), ragweed (*Ambrosia spp.*), and sunflower (*Helianthus annuus*) seeds are commercially available for planting; once established, many forbs will reseed so that the area does not need to be replanted every year. Native legumes such as partridge pea (*Chamaecrista fasciculata*) are also beneficial in food plots. Food plots are preferable to feeders because they allow quail to spread out more naturally across the landscape, but a major drawback of food plots is that when really needed (e.g., during drought), they are difficult to establish. When weather conditions are suitable for planting, native food items are usually abundant, negating the potential benefits of a food plot.

Any manner of supplemental feeding should not be viewed as a stand-alone management practice. Even in an area where food is limiting, supplemental feed is not a substitute for good habitat: no amount of food will make up for insufficient nesting cover or a monoculture of exotic grasses^{28,29}. Furthermore, supplemental food does not increase chick survival, because the diet of quail chicks consists almost entirely of insects²⁹. Supplemental feed, preferably in the form of broadcast feeding, should only be an “add-on” practice, going above and beyond what is necessary to support quail populations on a property.

Supplemental feed, preferably in the form of broadcast feeding, should only be an “add-on” practice, going above and beyond what is necessary to support quail populations on a property. Thus, supplemental feeding should be exclusively viewed as one part of strategic program—with habitat as the foundation—for landowners who would like to manage intensively for quail. Even during times of nutritional stress, carefully consider the positive versus negative consequences of using supplemental feed.

Predator Removal

Quail adults, chicks, and eggs fall prey to coyotes (*Canis latrans*), bobcats (*Lynx rufus*), foxes (*Vulpes vulpes* and *Urocyon cinereoargenteus*), raccoons (*Procyon lotor*), skunks (*Mephitis mephitis* and *Spilogale spp.*), opossums (*Didelphis virginianus*), and many other animals⁴⁰. Given that quail are potential prey for so many animals, predator management may seem like a logical fix to increase quail populations. The effectiveness of predator management can vary depending on local conditions, but most research has indicated that predator control has little or no effect on quail populations, while also being very costly and labor intensive^{41,42,43,44}.

One major issue with predator management is that the predators that are easiest to control may not be the same as those eating the most quail. Hawks (*Buteo spp.* and *Accipiter spp.*) are a primary predator of quail throughout Texas, but all hawks and other birds of prey are protected from lethal removal by state and federal law. Snakes (Colubridae and Viperidae) are a predator of quail that can legally be killed but removing enough snakes to benefit quail populations is impractical on most properties.

Even if predator control might be effective in a local area, reducing the population of one predator can have a variety of unintended consequences. Relationships between predators and prey, and relationships among different species of predators, are complex and not entirely understood. For example, coyotes occasionally predate quail, but coyotes also reduce the number of smaller predators that commonly raid quail nests.

Similarly, nest predation by snakes and other non-mammalian predators may increase when mid-sized mammalian predators are removed, such that the total nest mortality remains the same⁴⁴. These interwoven relationships warrant careful evaluation of whether predator control is a viable tool for managing local quail populations.



Photo 10. Cooper's hawks (*Accipiter cooperii*) are the main predators of quail and all birds of prey are protected by state and federal law.

Perhaps the strongest argument against predator management is that predators and quail have co-existed on the landscape for thousands of years. Some of the same behaviors that quail have developed to avoid predators—such as fast, explosive flight—are the same behaviors that we cherish in them as game birds.

In good-quality habitat, physiological and behavioral adaptations of quail allow them to maintain healthy populations despite the presence of predators. Rather than spending resources on predator control, a land manager's time and effort would be better spent on habitat improvements. One study of south Texas bobwhite populations suggested that quail populations may increase by 55% with predator control but decrease by 75% if suitable nest clumps were lacking⁴⁵. Managing to improve nesting habitat is almost always a better investment than predator control. To attain any benefits from predator control, this management technique should be considered only once good habitat is established⁴⁶.

Habitat Management: A Sustainable Investment in the Future of Quail

Ultimately, regardless other factors, quail cannot thrive without sufficient suitable habitat¹. Across the entire 38-state range of northern bobwhite in the U.S., populations have fallen in concert with loss of habitat. Large-scale habitat fragmentation and degradation have reduced the availability of continuous, usable grasslands and savannas that can support quail.

From 1997 to 2012, more than 1.1 million acres of working lands in Texas were lost to urbanization and non-agricultural uses⁴⁷. On average, large operations (500 – 2,000 acres) were lost at a rate of 225 per year during this time period, while the number of tracts <100 acres increased by more than 20%. Many small land parcels, especially those near cities, are used for houses, shopping areas, and other developments that are completely unsuitable for quail. Some parcels have retained good habitat, but lack sufficient connectivity to allow for diffusion and relocation across the landscape. Populations subjected to habitat fragmentation are not as resilient to changes as well-connected populations⁴⁸. One approach for small acreage (<500 acres) landowners to consider is the formation of quail cooperatives that encourage multiple landowners to join together in establishing and managing good quail habitat.

Texas is comprised of 10 ecoregions, and the quail habitat in each of these areas may, at first glance, look very different from place to place. However, there are elements of consistency to note across the landscapes where quail occur. For example, bobwhite in southwest Texas prefer to nest in clumps of little bluestem (*Schizachyrium scoparium*), while those in the southeast choose broomsedge bluestem (*Andropogon virginicus*), but the essence of both nesting habitats is a bunchgrass that provides adequate screening and shelter⁴⁹. Another consistent element is abundant, high-quality resources available within a relatively small radius (150-200 yards) and arranged in a “patchwork” fashion⁵⁰. Interspersion of resources allow quail to meet all of their survival needs without traveling far—an ideal situation for a bird that spends most of its time on the ground and is in constant danger from both mammalian and avian predators.

The overarching goal of habitat management is to provide the spatial-temporal continuity of resources (food, water, shelter, and space) that meet the needs of quail throughout the year.



Photo 11. Patchwork quail habitat includes a mix of native forbs, bunchgrasses, brush and bare ground.

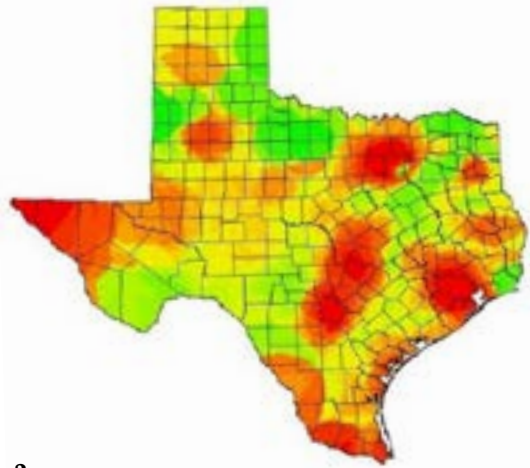


Figure 2. Loss of agricultural lands (farms, forests and rangelands) in Texas from 1997-2007. Red areas indicate high conversion rates⁴⁷.

Fragmented habitat	Contiguous habitat
Isolates quail from resources that may be spread across the landscape	Allows quail to access more resources during times of scarcity
Less connectivity among populations decreases opportunities to interbreed	Quail can move to other areas to breed, increasing genetic diversity
A population that is decimated by a catastrophic event cannot be replenished (local extirpation)	Quail can eventually repopulate an area after a disaster, if there are excess individuals in another area

Table 1. Comparison of fragmented versus contiguous habitat for use by quail populations.

Nesting Cover

Annual mortality of quail can be greater than 70%, so high rates of reproduction are crucial for maintaining populations². Reproductive success for quail depends heavily on access to plenty of quality nesting substrates. Bunchgrasses that are about the diameter of a basketball and at least 9 inches in height make the best nesting substrate for quail⁵¹. Low-growing shrubs and prickly pear (*Opuntia spp.*) can also be used for nesting, although they should not be the primary nesting substrate on the property. The more nesting sites on the landscape, the more challenging it is for predators to determine where a quail nest might be concealed. A minimum density of 250 nest clumps per acre is recommended for bobwhites in semiarid regions of Texas⁵⁰, although appropriate densities vary across Texas ecoregions and should be much higher in areas such as the Gulf Coast prairies. Prescribed grazing can be an effective way to manage large areas of land for suitable quail habitat. If a certain property is improperly grazed and lacking cover, then removing or reducing grazing

pressure and giving the area a chance to recover may be the most appropriate action. Full recovery of bunchgrasses can take 3 years or longer⁵². In some cases, reseeding with a native seed mixture may be required. On other properties, grass may be so thick that it limits plant species diversity and impedes quail movement. In that case, dormant season, rotational grazing at a conservative stocking rate can provide substantial benefits for the land and the landowner. Disking and prescribed fire are other options to open up the landscape.



Photo 12. Native bunchgrasses, such as little bluestem, are ideal for quail nests.

Brood-rearing cover

Once a quail nest has hatched, the chicks will need open ground where they can feed, with overhead vegetation as shelter from predators and the elements. Forbs that form a leafy canopy while remaining relatively open near the ground—such as croton (*Croton spp.*), western ragweed (*Ambrosia psilostachya*), and sunflowers—are ideal because they provide corridors that allow quail to move around easily while minimizing exposure. Habitat comprised of native forbs will also harbor an abundant quantity and diversity of insects, which are the primary food source for quail chicks. Forbs that constitute brood-rearing cover should be dispersed throughout the landscape.



Photo 13. Moderate prescribed grazing can benefit quail and the landowner.

Many plants that are ideal for brood-rearing cover are early successional species, meaning they are some of the first species to grow following a significant disturbance. Creating a disturbance can therefore encourage the growth of these forbs. Proper grazing is an excellent tool to maintain brood-rearing cover because cattle reduce grass competition with forbs while disturbing the soil through hoof action.

Another recommended method for managing brood-rearing cover is strip disking, in which the soil is overturned along strips or patches using a tractor and disk. This gives forbs a chance to colonize the recently disturbed soil while leaving adjacent areas alone to meet a quail's other habitat needs⁵². Strategic creation of disk strips near escape cover will allow quail to avoid predators when needed.

Cool-weather strip disking will promote the growth of many desirable native forbs, such as croton and western ragweed. A caution with disking is that some invasive

plant species can become problematic following disturbance. Landowners should evaluate the local plant community and consider disking a small area first to determine which species are likely to regrow. Prescribed fire is another technique that can be used to set back succession and promote forb growth.

Escape/loafing cover

Mottes of woody vegetation that grow low to the ground, have dense overhead branches, and are about the size of a pickup truck provide quail with a safe haven from predators. This brush structure conceals quail from hawks while allowing them to watch for mammalian predators at ground level. Woody cover also helps protect quail from the elements by providing shade in the summer months and insulation in the winter months. Mottes should be spaced no more than a softball's throw apart (about 40-50 yards)—which is about the distance a quail will fly, on average, when it flushes to escape from a predator⁵⁰.

Most properties in Texas have plenty of brush, but not all brush provides suitable escape cover for quail. Woody shrubs with low-growing limbs provide ideal cover. Species such as huisache (*Acacia farnesiana*), hackberry (*Celtis spp.*), and oaks (*Quercus spp.*) are less suitable because their branches do not reach to the ground. Mesquites (*Prosopis spp.*) and junipers (*Juniperus spp.*) can have a good growth form but are problematic because they can easily invade the land, crowding out the grasses and forbs that are also essential components of quail habitat.

To manage invasive brush, consider the density and species before choosing a tool/method. If there are only a few patches or individual trees that need to be culled, mechanical brush removal methods like grubbing, chaining, or roller chopping will work best⁵³, although the majority of brush species will quickly regrow unless the roots are removed. For widespread overgrowth, chemical methods like herbicides may be required. Prescribed fire works well for species that do not re-sprout, such as Ashe juniper (*J. ashei*). Take caution not to be overzealous; landowners should communicate with the equipment operator(s) to ensure that non-invasive brush species are not removed and that sufficient cover is left for quail.



Photo 14. Creating and improving usable space should be a priority for any landowner who wants to increase quail populations.

Food

As explained previously, food is not usually a limiting factor for quail. As long as the other habitat needs of quail have been addressed, this resource will be available. Quail primarily eat four types of foods: seeds, insects, fruits, and leafy greens. High forb diversity contributes to ample seed production and a thriving insect community, and many of the woody plants that serve as escape or nesting cover are also fruit producers. Prolonged droughts and harsh winters are challenging times for quail in terms of food availability, but these are also conditions that they can endure given quality habitat. Consider a broadcast supplemental feeding regimen only during drought or extreme weather events, or during winter if food is truly limited.



Photo 15. Insects are an excellent source of protein, fat and water in the diet of quail.

Water

Quail need water, especially in the semi-arid rangelands covering much of Texas. In the South Texas Plains, over 90% of the annual variation in bobwhite productivity may be driven by the cumulative rainfall from April through August⁵⁴. However, rainfall can only benefit

quail if large tracts of quality habitat are available first. Properties in East Texas still suffer from low quail populations even though this area has high annual precipitation, because habitat has become fragmented by urbanization and other land-use changes. On the other hand, bobwhite populations in the Rolling Plains soared as a result of abundant rainfall in 2014-2016, because many areas of contiguous habitat still exist in this region. Good habitat management prepared landowners in the Rolling Plains to benefit when the rains arrived.

Whether or not quail need a source of freestanding water in their environment remains a matter of debate. There are three ways quail can meet their water needs: 1) freestanding water, such as a creek or pond, from which they can drink directly; 2) pre-formed water, found in vegetation and insects, which is ingested when they eat those foods; and 3) metabolic water, which is created during digestion. Quail will readily take advantage of option #1 whenever it is available, but so will their predators. In most cases, options #2 and #3 together are sufficient for a quail to satisfy its water needs.

Management that promotes forb and insect diversity—in other words, good overall quail habitat—will generally meet the water requirements for quail, but a surface water source can be established with stock tanks, troughs, or rain catchments. Spreader dams along roadsides can also help to slow and capture runoff, which can increase water resources by promoting the growth of lush vegetation and insect biomass. To construct a spreader dam, simply pile up earth along the road to direct water along a particular path.

For more information on managing land to benefit quail, helpful publications include “Habitat Monitoring for Quail on Texas Rangelands,” “Habitat Guide for Northern Bobwhite,” or “Habitat Requirements of Texas Quail,” all available at the AgriLife Bookstore^{55,56,57}, or contact a local biologist from Texas Parks and Wildlife Department.



Photo 16. Northern bobwhite.

Acknowledgements

Funding was provided through the Reversing the Quail Decline Initiative and the Upland Game Bird Stamp Fund based on a collaborative effort between the Texas Parks and Wildlife Department and the Texas A&M AgriLife Extension Service. We thank L. Brennan, J. McLaughlin, and T. Dailey for editorial review of this manuscript.

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Potential Causes of the Texas Quail Decline

