W1355

Tennessee Cooperative Northern Bobwhite Project: Summary of Key Results and Management Recommendations

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Photo credit: Tall Timbers

The Tennessee Cooperative Northern Bobwhite Project started in 2021 in response to concerns over the declining population of bobwhite across the state and specifically on three Wildlife Management Areas (WMAs) owned and managed by the Tennessee Wildlife Resources Agency (TWRA). The objectives of the project outlined in the scope of work were:

1. Document quail population levels on the WMAs on an annual basis,
2. Collect fundamental data related to quail reproduction, survival, and habitat use,
3. Document existing habitat conditions at each WMA,
4. Develop a comprehensive habitat improvement plan for each WMA, and
5. Evaluate the success of specific habitat management practices over time.

Background

The northern bobwhite population in Tennessee has been declining for more than 50 years (Figure 1). The bobwhite has been a focal species for conservation by the TWRA over much of this period, and it was listed as a species of conservation concern in 1987. The most reliable long-term data to assess population trends on any breeding bird is the North American Breeding Bird Survey (BBS), which started in 1966. BBS data in Tennessee indicate the northern bobwhite has declined statewide about -5.9 percent per year, representing a 97 percent population decline since 1966 (n = 47 routes, North American Breeding Bird Survey Dataset 1966–2022: U.S. Geological Survey data release). The rate of decline in Tennessee is much greater than the rangewide estimate of -3.1 percent per year. The decline of bobwhite in Tennessee and throughout most of the U.S. is primarily a result of land-use change over the past 50 years whereby bobwhite habitat has been eliminated or reduced to relatively small (less than 1,000 acres) isolated patches that no longer can support a bobwhite population. This change in land-use also has enhanced habitat for predators and enabled their populations to increase and thereby lower the survival and reproduction of remaining bobwhite populations.

In 2013, in response to the documented population decline, TWRA designated four WMAs to serve as "anchor reserves" for a larger surrounding Quail Focal Area, where management efforts are focused on maximizing bobwhite habitat quality and quantity with the goal of increasing bobwhite populations (Tennessee Wildlife Resources Agency 2021). Each anchor area was selected by TWRA staff based on the perceived opportunity for the bobwhite population to expand into surrounding public and private land. To further the bobwhite conservation effort, TWRA developed a five-year bobwhite conservation plan in 2021 (Tennessee Wildlife Resources Agency 2021).

TWRA contracted with the University of Tennessee to monitor the bobwhite population on three areas from 2021–2023, with the goal of documenting the success of the focal area strategy and providing information to support the conservation plan. The project was centered on Wolf River and Bridgestone-Firestone WMAs and Kyker Bottoms Refuge. These areas were selected because they had been designated either a Quail Focal Area or Demonstration Area, and TWRA was managing each specifically for bobwhite. Each area had an existing bobwhite population that was considered likely the most robust in the state. The field portion of the project was completed in 2025 with final data analyses and production of publications ongoing. We provide this report as a science-based foundation for adaptive habitat management decisions that are ongoing on the Quail Focal Areas and elsewhere in Tennessee.

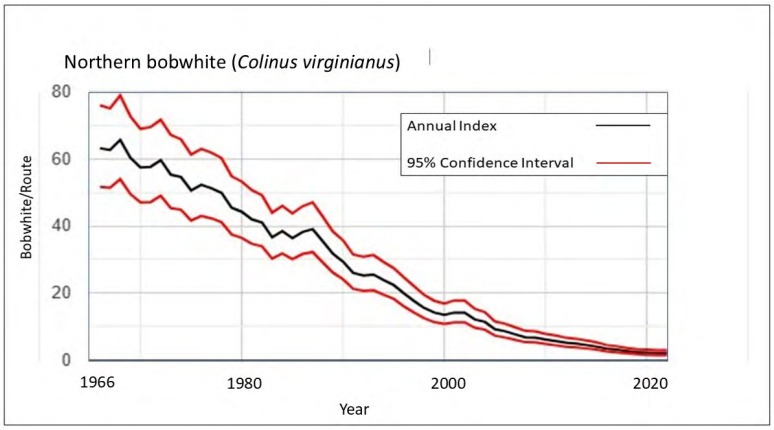


Figure 1: *Northern Bobwhite population trend — North American Breeding Bird Survey (BBS) data for Tennessee, 1966–2022.*

Key Project Findings

1. Bobwhite populations on the three focal areas are low but increased at Bridgestone-Firestone during the 3-year period.

We captured 365 birds (Wolf River = 113, Bridgestone-Firestone = 169, Kyker Bottoms = 83) and collared 312 (WR = 103, BF = 130, KB = 79) individuals from January 2021 to May 2023. We monitored 42 coveys (2021 = 12, 2022 = 18, 2023 = 16). We calculated an average home range of 82 acres (±6 SE) during the breeding season and 47 acres (±7 SE) during the nonbreeding season. Population levels, based on fall covey counts, were low, especially at Wolf River and Kyker Bottoms. Assuming a detection distance of 250 yards and an average covey size of 10 birds, bobwhite fall densities in 2023 averaged 1 bird per 8 acres (Wolf River), 1 bird per 5 acres (Kyker Bottoms), and 1 bird per 2 acres (Bridgestone-Firestone). Fall densities have exceeded 1 bird per acre historically on some areas in Tennessee, such as Ames AgResearch and Education Center.

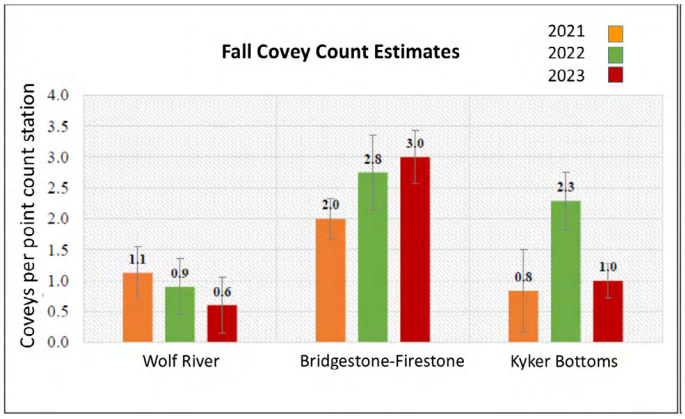


Figure 2: *Average number of coveys heard per observer during fall covey counts at Wolf River WMA, Bridgestone-Firestone WMA, and Kyker Bottoms Refuge, 2021–2023.*

2. Habitat use differed among the three focal areas.

Bobwhite resource selection differed across study sites at the landscape scale because of differences in availability of vegetation types (Table 1). The resource selection index, a measure of the probability that bobwhite would use a given acre of the focal area, was 60 percent greater at Bridgestone than at Kyker Bottoms or Wolf River for both breeding and nonbreeding seasons. Bobwhite consistently selected early successional vegetation types (early succession, early succession woody, open woodland), which provided vital food resources, such as seeds and insects, as well as sufficient cover to mitigate predation risk. Forest was strongly selected against (Table 1) and should be transitioned to early successional vegetation types where bobwhite is a focal species.

Table 1. Northern bobwhite use versus availability of key vegetation types during the breeding (B) and nonbreeding (NB) seasons at the three focal areas in Tennessee, 2021–2023.

Values in parentheses for available early succession at Kyker represents what was available during the nonbreeding season when various areas had been flooded for waterfowl. Deciduous forest was represented by mature mixed hardwood forest. Early succession was represented by vegetation comprised of various shade-intolerant forbs and grasses. Early succession woody was represented by various early successional plant species with woody stem encroachment exceeding 50 percent, but not more than 75 percent. Young forest was represented by areas dominated by regenerating tree species less than 10 years old. Woodland was represented by areas with 30-70% overstory tree cover with an understory dominated by herbaceous plants. Savanna was represented by areas with 5-30 percent overstory tree cover and shade-intolerant herbaceous plant species dominating the groundcover.

	Wolf River			Bridgestone-Firestone			Kyker Bottoms		
Vegetation type (%)	**Available**	**B Use**	**NB Use**	**Available**	**B Use**	**NB Use**	**Available**	**B Use**	**NB Use**
Deciduous forest	28.5	12.1	11.3	3.1	0.7	5.8	31.0	19.2	11.6
Early succession	33.8	33.2	33.6	68.8	71.7	57.3	28 (15.1)	33.3	27.9
Early succession-woody	9.0	27.4	28.0	13.2	16.2	24.9	16.2 (12.3)	12.5	17.6
Young forest	7.2	6.0	13.5	0.0	0.0	0.0	5.7	16.5	26.6
Woodland /Savanna	10.1	8.4	7.0	7.7	4.9	8.9	5.9	7.1	9.8

Early Succession

Figure 3: *Northern bobwhite require early successional plant communities dominated by shade-intolerant forbs and grasses.*

Early Succession—Woody

Figure 4: *Early successional plant communities with more than 50 percent cover of encroaching trees and shrubs provides bobwhite with protective cover, but succession must be set-back before trees dominate the site, within 3 years on most sites.*

Young Forest

Figure 5: *Young regenerating forest cover often harbors mammalian predators that suppress quail populations.*

Woodland/Savanna

Figure 6: *Open oak and pine woodlands and savannas are selected by bobwhite and require frequent fire to maintain herbaceous groundcover.*

3. **Northern bobwhite survival differed among the three study sites. Breeding season survival was a key limiting factor and was too low to sustain bobwhite populations at Kyker Bottoms and Wolf River.**

Nonbreeding season survival was greatest at Wolf River, intermediate at Bridgestone, and least at Kyker Bottoms, whereas breeding season survival was greatest at Bridgestone, intermediate at Wolf River, and least at Kyker Bottoms (Figure 7). Overall, nonbreeding season survival was greater than estimates from many other studies across the southeastern U.S. (Sandercock et al. 2008). However, breeding season survival was less than estimates from many other studies, suggesting that breeding season survival is a critical limiting factor in Tennessee. Breeding season survival was negatively related to the amount of young and mature forest as well as midstory stem density.

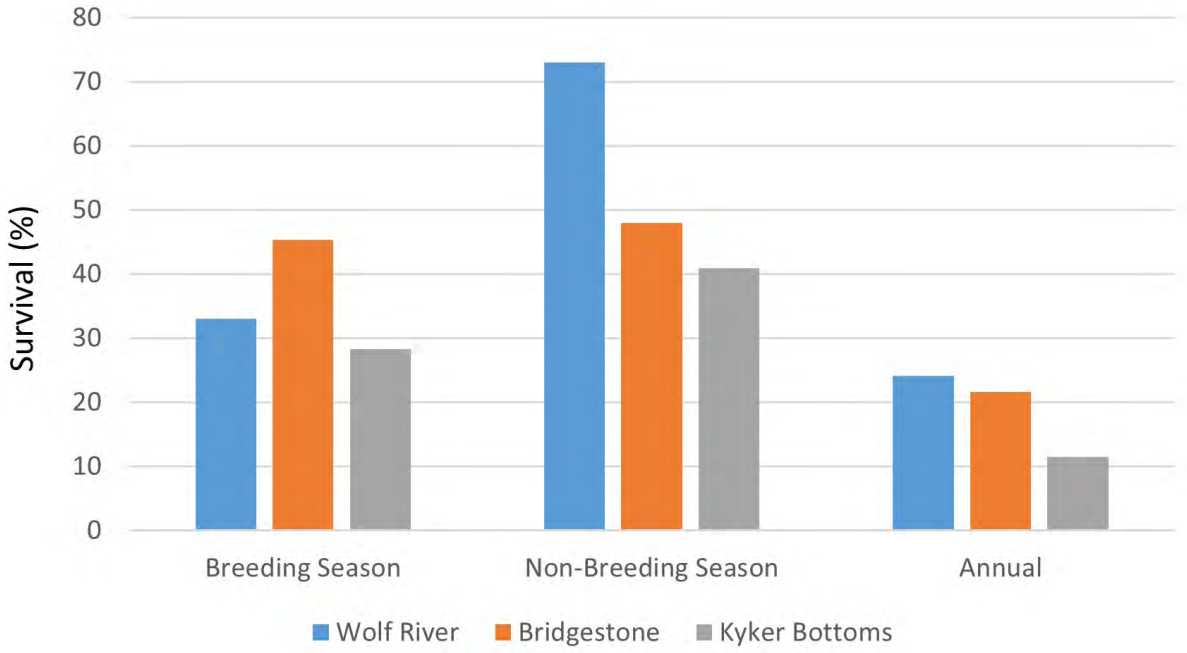
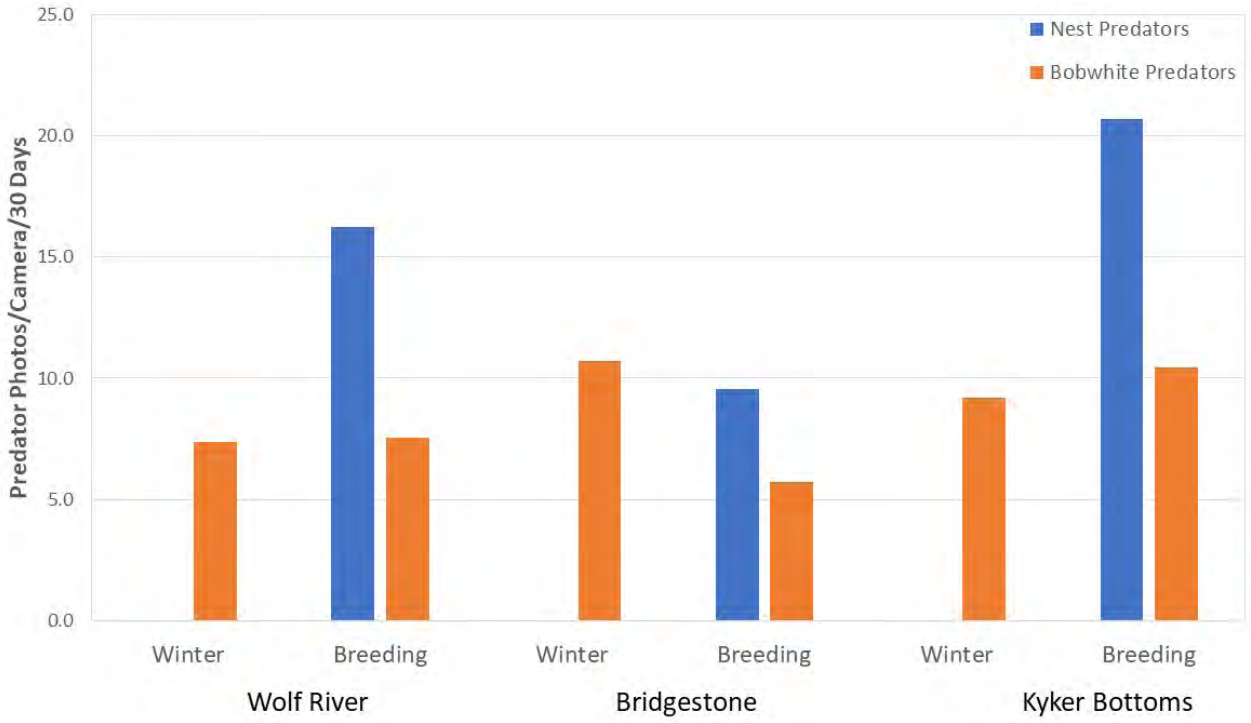


Figure 7: *Northern bobwhite survival estimates (%) by season and annually for Wolf River WMA, Bridgestone-Firestone WMA, and Kyker Bottoms Refuge, 2021–2023.*

4. **Predation was the leading cause of bobwhite mortality and nest failure. The mammalian Predator Index indicated predator abundance was negatively related to breeding-season survival and nest success.**

We investigated mortalities during daily tracking sessions, and we assigned mortalities to mammalian, avian or unknown causes based on evidence where we recovered the radio collar. Mammals were a consistent cause of predation on all quail focal areas, averaging 31% of mortalities, whereas avian predation varied from 28 percent at Bridgestone, to 30 percent at Kyker Bottoms, and 39 percent at Wolf River. We placed remote cameras without any bait or attractant on a grid pattern (1 camera per 62 acres) at each area to quantify mammalian predator relative abundance. We documented much greater predator abundance at Kyker Bottoms, especially during the breeding season, in terms of both bobwhite predators and nest predators than at Bridgestone and Wolf River. Predator abundance was strongly negatively correlated with breeding season survival and nest success across all three areas (Figure 8.1 and 8.2).



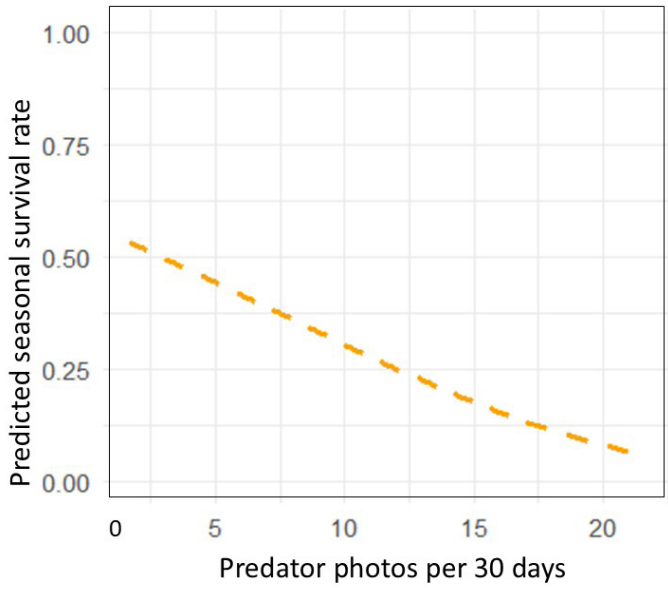


Figure 8.1 and 8.2: *Predator Index and relationship between predator relative abundance and northern bobwhite breeding season survival at Wolf River, Bridgestone-Firestone, and Kyker Bottoms, 2021–2023.*

5. Mature forest, young forest and woody midstory density were negatively related to breeding season survival.

In addition to the negative relationship between habitat use and the amount of forest in breeding season home ranges, there also was a negative relationship between breeding season survival and the amount of forest in the home range (Figure 9). Although low woody cover (about 3—8 feet tall) provides escape cover that may benefit non-breeding survival, there was a strong reduction in breeding-season survival with increased forest in the home range. Both young and mature forest harbor mammalian predators that are linked to bobwhite mortality.

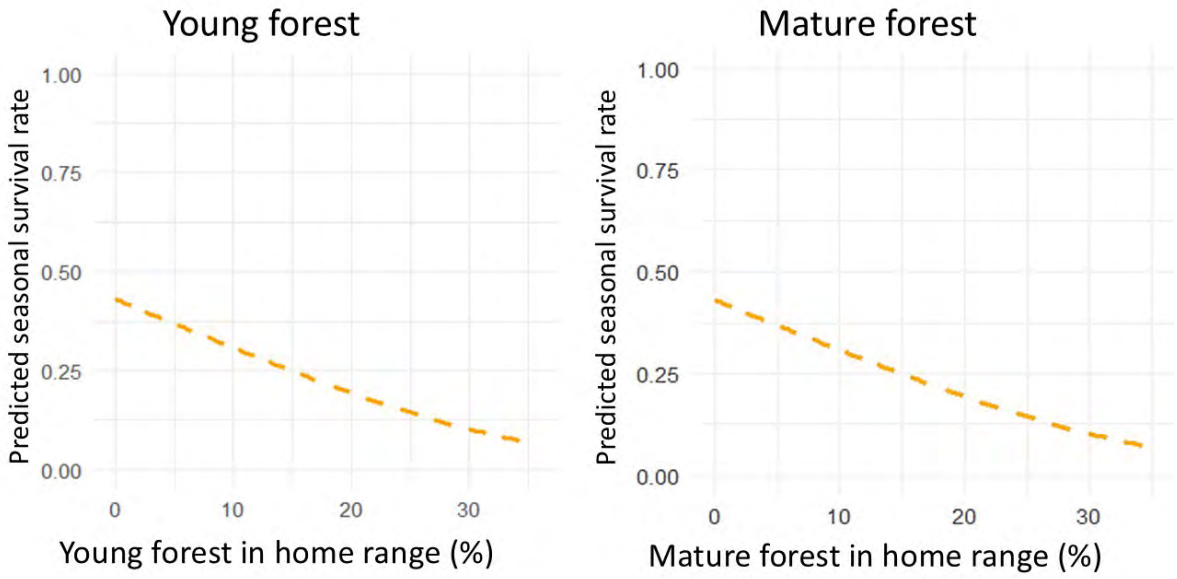


Figure 9: *Northern bobwhite breeding-season survival as related to the amount of young forest and mature forest within the home range. Young forest was represented by dense regenerating trees 3—10 years old.*

6. Bobwhite reproduction rates differed markedly among the three focal areas.

We monitored nesting activity at each focal area via radio-telemetry and documented the number of nesting attempts per female, clutch size, nest success, renest attempts and the number of nests incubated by males. In general, reproductive output was greatest at Bridgestone and less at Wolf River. We did not document successful nesting at Kyker Bottoms during three years of monitoring. These results are highly correlated with the Predator Index for each of the three focal areas, suggesting unsustainable predation was limiting reproduction at Wolf River and especially at Kyker Bottoms. Average nest success at Bridgestone was 46 percent, whereas nest success at Wolf River averaged 30 percent (Table 2).

7. Habitat management at the three focal areas had a positive effect on resource selection and survival.

Survival generally improved at each focal area with each successive year of the project, highlighting the benefits of continuous, intensive management for bobwhite. Management practices that were positively related to resource selection and survival included prescribed burning with 1- and 2-year fire-return intervals, spot-spraying nonnative plant species and woody species taller than 5 feet with selective herbicides and disking. In general, resource selection and survival increased when management units were less than 15 acres.

Table 2. Reproductive parameters measured at Wolf River WMA, Bridgestone/Firestone WMA, and Kyker Bottoms Refuge, 2021–2023.

Number of Nests	25 - Bridgestone 13 - Wolf River 1 - Kyker
First incubation date Last incubation date	May 23 Sept. 29
Nesting rate (females) Incubated by males	67% 17%
Average clutch size	10.8 - BF 12.8 - WR
Hatchability	99%
Nest success	46% - BF 30% - WR

Management Recommendations

1. Reduce the amount of forest on properties managed for bobwhite.

The northern bobwhite requires relatively large open landscapes with few trees. Such landscapes should be at least 500 acres and dominated by forbs and grasses. Large agricultural areas also support bobwhite, but only if field borders, fence-rows, drainage ditches, and other non-cropped areas are managed to provide early successional plant cover. Bobwhite do not use mature closed-canopy forests. The more forest there is on a property, the less bobwhite habitat there is, and the less likely the birds will occur on the property. Ideally, a property managed specifically for bobwhite would have no forest, but may have oak/pine savanna or open woodland that has no more than about 30 percent tree cover and burned frequently to maintain herbaceous groundcover.

The northern bobwhite is considered a "shrubland obligate," meaning they require scattered, low, woody cover necessary for escaping predators and protection from weather. Shade is extremely important when the temperature gets above 90 F. If low woody cover that provides shade is not present, the birds are not likely to use the property. Woody cover for bobwhite needs to be relatively short (less than 10 feet tall) and in strips or relatively small patches (no more than about 0.10 acre) to allow a little sunlight to reach the ground and maintain some herbaceous groundcover. Bobwhite seldom venture far into woody cover. They are usually within 20 yards or so of the edge. Larger patches of woody cover harbor more predators, and when trees begin to grow tall and dense, herbaceous groundcover is eliminated because of shade, and the area becomes a pred-ator trap. We documented this situation on our sites, especially at Kyker Bottoms, where the birds used young forest cover with dense regenerating stems 15–20 feet tall. Although the birds selected dense woody cover, mortality from predation increased and quail density was relatively low.

So, what does all that mean? If you want to manage for quail, your property must be in an open landscape (surrounding 500+ acres), and you must reduce existing upland forest cover to no more than 10 percent of the area managed for bobwhite. Excessive upland forest should be cut and converted to early successional vegetation, not resprouting trees. It is important to spray tree stumps with the appropriate herbicide soon after cutting so they do not sprout. If you do not spray the stumps and you allow them to sprout, it will be much more difficult to maintain an early successional plant community without excessive woody stems.

Figure 10. *Bobwhite may use young forest (such as shown here at Kyker Bottoms Refuge) for protective cover, especially in winter. However, annual bobwhite survival goes down as young forest and mature forest increase in the home range. Early successional vegetation with encroaching shrubs and trees provides better cover with increased survival.*

Figure 11. *Quail habitat is increased by clearing trees and transitioning forest into an early successional plant community. Here, the forest was cleared, and two years later, regenerating tree stems were sprayed with an aerial herbicide application. The dead vegetation then was burned and two years later, an outstanding early successional plant community has developed naturally from the existing seedbank. Bobwhite began using the area in the first year post-burning.*

2. Frequent disturbance is required to maintain bobwhite habitat.

In the eastern U.S. where we receive more than 40 inches of rain per year, frequent disturbance is necessary to maintain early successional plant communities that bobwhite require. Prescribed fire or disking on a 1—2-year return interval will maintain early successional plant cover, promote an open structure at ground level that is necessary for quail mobility, limit advancement of woody species, and enhance bobwhite survival. Lengthening the disturbance interval to 3 years on small patches that are well-interspersed within the more frequently disturbed early successional cover will provide low woody cover required by bobwhite for escape and thermal cover. When using fire, there is no need to disk around patches of woody cover to protect them from burning. Top-killed woody stems will resprout. Fire intensity can be adjusted when burning around patches of desirable woody cover. By allowing fire to back into woody cover, relatively few woody stems may be top-killed and, depending on conditions and time of burn, the woody cover may not burn at all. Alternatively, if the woody cover needs to be set-back because it is getting too tall or dense, fire intensity can be increased by using heading fire or by burning when conditions allow more intensive fire. Spot-spray applications of selective herbicides in early successional areas are quite effective and should be carefully applied to control undesirable species without eliminating desirable low woody cover.

Choose the Right Site!

Managing bobwhite habitat requires frequent disturbance. Properties chosen for bobwhite management should be upland sites that allow frequent fire and disking. Bottomland sites are exceptionally difficult, if not impossible, to manage for quail because of excessive moisture that precludes frequent fire or soil disturbance when needed. Choosing an appropriate site for bobwhite management is critically important for success.

Figure 12. *Bottomland fields can be very challenging to manage for bobwhite. Trees grow fast in moist soils, and conditions that allow burning or disking are limited. Here, green ash and sweetgum have grown almost too tall to disk the field after burning the year prior.*

Figure 13. *Frequent disturbance, such as burning or disking every one to two years, is necessary to maintain bobwhite habitat, such as seen here at Kyker Bottoms Refuge. Less-frequent disturbance will lead to a woody-dominated plant community that becomes a predator trap for bobwhite.*

Figure 14. *Frequent disturbance is required to maintain open conditions near ground level that allow quail better mobility under a canopy of herbaceous cover. Mowing typically results in dense growth near ground level (left), whereas fire and disking promote more open conditions that quail select (right).*

3. Management units should be relatively small and well-dispersed throughout the management area.

Our study revealed that large management units were negatively related to both resource selection and survival. The negative relationship likely resulted from disturbing bobwhite core-use areas, which increased vulnerability to predation when the birds were forced to move into unfamiliar territory after relatively large-scale disturbance. Smaller management units (5–15 acres) were best-suited for bobwhite. A management goal of disturbing **40–60 percent** of a quail focal area annually is required to maintain the early successional vegetation communities requisite for bobwhite. Disturbed management units should be juxtaposed with undisturbed units to prevent large contiguous areas of disturbance. Disturbance should be conducted throughout the year, not just during one season. Fire may be implemented at any time of year and should be timed according to plant composition and structure. Although quail nesting peaks in June/July, small-scale burns in June promote excellent cover for broods in July–September. Chronic burning during the dormant season and the early portion of the growing season, especially on a 2-year fire-return interval, will promote native warm-season grasses, such as broomsedge and little bluestem. Bobwhite may nest at the base of native warm-season grasses, but they do not require grass for nesting. Cover of various forbs is more important as forbs provide seed, insects, and better brood cover than grasses. Grass cover should not exceed about 30% of a management unit. Disking should be conducted December—early March to stimulate desirable forbs from the seedbank and reduce warm-season grass density where needed. Spot-spraying should be conducted in late spring/early summer to control undesirable plant species and control woody encroachment.

Figure 15. *Management units less than 15 acres promoted greater survival of bobwhite. Here, brooding cover and nesting cover are juxtaposed. The area on the right side of the picture was disked in mid-winter to stimulate common ragweed and partridge pea for brooding cover. The area on the left side of the picture was burned the previous year and the remaining dead vegetation provides nesting cover.*

4. Control mammalian predator populations to increase bobwhite survival and nest success.

Predators can suppress bobwhite populations, particularly if cover and food resources are not plentiful and well-interspersed. We detected a negative relationship between predator abundance and bobwhite survival across all three study sites. Kyker Bottoms had the greatest predator index and the lowest survival during both the breeding and nonbreeding seasons. The predator index was least at Bridgestone-Firestone, which suggested fewer predators at this site was directly linked to greater bobwhite survival rates and a much greater bobwhite population level at Bridgestone. An abundance of mammalian predators, such as raccoon, bobcat, striped skunk, opossum, and armadillo, will lead to reduced survival of bobwhite and nests. The negative impacts of predators were especially pronounced in forested areas (young and mature). Typically, managers employ a grid of dog-proof traps and cage traps to keep mammalian nest predators under control. It is important to understand that these animals are rarely trapped today as they were 30+ years ago. Some form of predator control along with contemporary habitat management strategies as outlined above are necessary today to maintain bobwhite populations large enough to support hunting like those prior to 1980.

Figure 16. *Some level of predator management along with contemporary habitat management may be necessary to reach population objectives for bobwhite.*

For More Information

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