

2000

The Status of Masked Bobwhite Recovery in the United States and Mexico

William P. Kuvlesky Jr.
U.S. Department of the Interior

Sally A. Gall
U.S. Department of the Interior

Steve J. Dobrott
U.S. Department of the Interior

Susan Tolley
U.S. Department of the Interior

Fred S. Guthery
Texas A&M University

See next page for additional authors

Follow this and additional works at: <https://trace.tennessee.edu/nqsp>

Recommended Citation

Kuvlesky, William P. Jr.; Gall, Sally A.; Dobrott, Steve J.; Tolley, Susan; Guthery, Fred S.; DeStefano, Stephen A.; and King, Nina (2000) "The Status of Masked Bobwhite Recovery in the United States and Mexico," *National Quail Symposium Proceedings*: Vol. 4 , Article 8.

Available at: <https://trace.tennessee.edu/nqsp/vol4/iss1/8>

This Quail Population Responses to Habitat Management and Change is brought to you for free and open access by Volunteer, Open Access, Library Journals (VOL Journals), published in partnership with The University of Tennessee (UT) University Libraries. This article has been accepted for inclusion in National Quail Symposium Proceedings by an authorized editor. For more information, please visit <https://trace.tennessee.edu/nqsp>.

The Status of Masked Bobwhite Recovery in the United States and Mexico

Authors

William P. Kuvlesky Jr., Sally A. Gall, Steve J. Dobrott, Susan Tolley, Fred S. Guthery, Stephen A. DeStefano, and Nina King

THE STATUS OF MASKED BOBWHITE RECOVERY IN THE UNITED STATES AND MEXICO

William P. Kuvlesky, Jr.¹

U.S. Department of the Interior, Fish and Wildlife Service, Buenos Aires National Wildlife Refuge, P.O. Box 109, Sasabe, AZ 85633

Sally A. Gall

U.S. Department of the Interior, Fish and Wildlife Service, Buenos Aires National Wildlife Refuge, P.O. Box 109, Sasabe, AZ 85633

Steve J. Dobrott²

U.S. Department of the Interior, Fish and Wildlife Service, Buenos Aires National Wildlife Refuge, P.O. Box 109, Sasabe, AZ 85633

Susan Tolley¹

U.S. Department of the Interior, Fish and Wildlife Service, Buenos Aires National Wildlife Refuge, P.O. Box 109, Sasabe, AZ 85633

Fred S. Guthery³

Caesar Kleberg Wildlife Research Institute and Department of Animal and Wildlife Sciences, Campus Box 218, Texas A&M University-Kingsville, Kingsville, TX 78363

Stephen A. DeStefano⁴

U.S. Geological Survey, Biological Research Division, Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, Tucson, AZ 85721

Nina King⁵

U.S. Geological Survey, Biological Research Division, Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, Tucson, AZ 85721

Kenneth R. Nolte⁶

Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX 77843-2258

Nova J. Silvy

Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX 77843-2258

James C. Lewis

U.S. Department of the Interior, Fish and Wildlife Service, P.O. Box 1306, Albuquerque, NM 87102

George Gee

U.S. Geological Survey, Biological Research Division, Patuxent Environmental Research Center, Laurel, MD 20708

Gustavo Camou Luders

San Dario Ranch, Sierra Murrieta 168, Hermosillo, Sonora, Mexico

Ron Engel-Wilson

Arizona Game and Fish Department, 2221 West Greenway Rd., Phoenix, AZ 85023-4312

ABSTRACT

The masked bobwhite (*Colinus virginianus ridgwayi*) is an endangered species currently numbering <1500 individuals and restricted to 2 locales in southeastern Arizona and northcentral Sonora, Mexico. The subspecies' endangered status is attributed to overgrazing

of Sonora savanna grassland that began during the late 1880's and continued well into the 20th century. This overgrazing resulted in the conversion of many native grass pastures to the exotic buffleggrass (*Cenchrus ciliaris*). The Arizona masked bobwhite population was extirpated around the turn of the century, and the Sonoran population was thought to have disappeared during the 1940's until a small remnant population was discovered on a ranch near Benjamin Hill, Sonora, in 1964. Masked bobwhite recovery efforts have a dynamic, long history of nearly six decades. Current masked bobwhite recovery efforts focus on reestablishing a self-sustaining population on the Buenos Aires National Wildlife Refuge (BANWR) in the United States, as well as 2 remnant wild populations located on privately owned ranches in northcentral Sonora.

Citation: Kuvlesky, W.P., Jr., S.A. Gall, S.J. Dobrott, S. Tolley, F.S. Guthery, S.A. DeStefano, N. King, K.R. Nolte, N.J. Silvy, J.C. Lewis, G. Gee, G. Camou Luders, and R. Engel-Wilson. 2000. The status of masked bobwhite recovery in the United States and Mexico. Pages 42–57 in L.A. Brennan, W.E. Palmer, L.W. Burger, Jr., and T.L. Pruden (eds.). Quail IV: Proceedings of the Fourth National Quail Symposium. Tall Timbers Research Station, Tallahassee, FL.

INTRODUCTION

The masked bobwhite is currently the only federally listed endangered quail in North America. The species was listed as endangered in 1968. It was among the fauna originally designated as endangered by the United States Government after the passage of the Endangered Species Conservation Act (Public Law 91-135; 83 Statute 275). The Endangered Species Conservation Act was superseded by the Endangered Species Act of 1973 (Public Law 93-205; 87 Statute 884) and the legal and biological status of the masked bobwhite remain "endangered".

Masked bobwhites remain endangered today throughout their current ranges in Arizona, U.S.A., and Sonora, Mexico. A recovery plan was first completed for the species in 1978 (U.S. Fish and Wildlife Service 1978), was revised in 1984 (U.S. Fish and Wildlife Service 1984), and underwent a second revision in 1995 (U.S. Fish and Wildlife Service 1995). Current masked bobwhite recovery goals, strategies, and efforts are outlined in detail in the second revision of the recovery plan and are being adhered to by the various Federal, State, and private organizations involved in the recovery process. The objectives of this paper are to provide: (1) a brief description of masked bobwhite distribution, taxonomy, and life history; and, (2) a history of past recovery efforts.

DESCRIPTION

Distribution

Historic accounts and scientific collections indicate that the masked bobwhite was restricted to level plains and river valleys in Sonora and extreme south-

central Arizona, between 150 and 1,200 m elevation (Brown 1885, 1900, Van Rossem 1945, Ligon 1952, Tomlinson 1972a) (Figure 1). Consequently, masked bobwhites inhabited the grassy savanna habitats (Ilanos) within Shreve's (1942, 1951) Plains of Sonora, which are subdivisions of the Sonoran Desert. These biotic communities have a mean rainfall ranging from 250 to >500 mm, of which more than 70% occurs from July through September (Shreve 1951, Tomlinson 1972b).

The eastern and southern distribution of masked bobwhites is limited by the merging of Sonora savanna grassland with the more structurally dense Sinaloan thornscrub where bobwhites are replaced by elegant quail (*Lophortyx douglassi*). Masked bobwhite occurrence south or east of the Rio Yaqui has not been documented. To the west and northwest, a decrease in summer precipitation excludes masked bobwhites from the desert scrub communities of the Central Gulf Coast, Lower Colorado River, and Arizona Upland

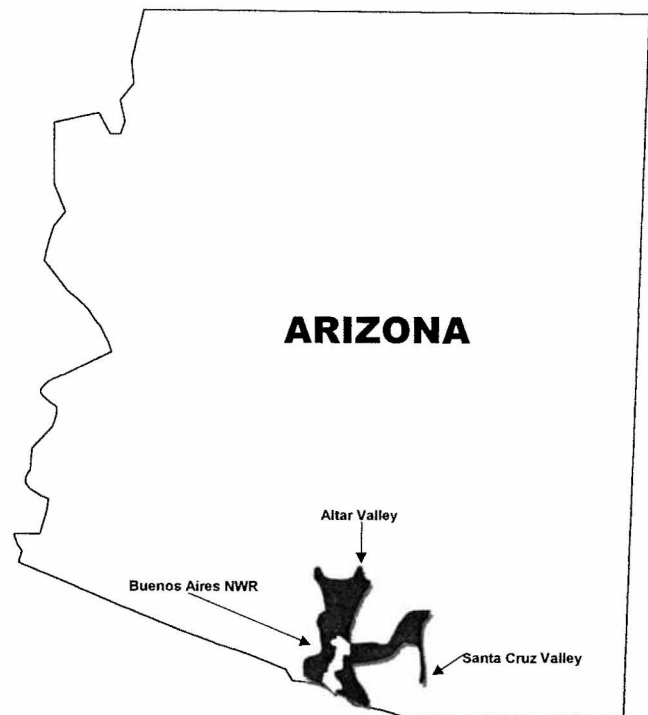


Fig. 1. Historic range of the masked bobwhite in Arizona including areas considered most suitable for masked bobwhite recovery activities.

¹ Present address: Caesar Kleberg Wildlife Research Institute, Texas A&M University, Campus Box 218, Kingsville, TX 78363.

² Present address: Ladder Ranch, HC Box 95-A, Caballo, NM 87931.

³ Present address: Department of Forestry, Agriculture Hall, Rm. 008C, Oklahoma State University, Stillwater, OK 74078-6013.

⁴ Present address: Massachusetts Fish and Wildlife Cooperative Research Unit, University of Massachusetts, Amherst, MA 01003-4210.

⁵ Present address: U. S. Department of the Interior, Fish and Wildlife Service, San Bernardino National Wildlife Refuge, 1408 10th St., Douglas, AZ 85607.

⁶ Present address: 961 E. Parlier Ave., Reedley, CA 93654.

subdivisions of the Sonora Desert. Northward and above 1,200 m in elevation, the subtropical scrub and grass understories of Sonora savanna grassland give way to sod-forming perennial grasses and shrubs, and leaf succulents characteristic of warm temperate desert grassland. At the northern limits of masked bobwhite range in the Altar and Santa Cruz valleys of Arizona, semidesert grassland replaces Sonoran savanna grassland and the masked bobwhite is supplanted by scaled quail (*Callipepla squamata*). Reports of masked bobwhites outside this range are unsubstantiated by specimens or other corroborating evidence.

The current distribution of masked bobwhites is limited to 2 sites. One population of <500 birds occurs on the Buenos Aires National Wildlife Refuge (BANWR) in southeastern Arizona, while 2 populations exist in northcentral Sonora on privately-owned ranches. One of the Sonoran populations is located on Rancho El Carrizo approximately 120 km south of the BANWR, and numbers <1000 individuals. The existence of the second Sonoran population, located on Rancho Grande 20 km south of Rancho El Carrizo, was reestablished in 1995; population estimates were not made. Despite recent surveys (Dobrott 1990), no other wild population of masked bobwhite is known to occur in Sonora, Mexico. Considering the widespread deterioration of subtropical grasslands throughout Sonora, existence of any heretofore unrecorded population is unlikely. However, because large segments of the historic range have not been searched, and given the secretive habits of the bird as well as the difficulty of locating small, isolated populations, it is possible that additional masked bobwhite populations persist in remote areas of Sonora. For example, two masked bobwhites were reported to have been live-trapped on a ranch approximately 400 km southwest of the Rancho El Carrizo area during the winter of 1992–1993, and several birds were killed by hunters in the same area the previous winter (R. Engel-Wilson, unpublished data).

Taxonomic Classification

Masked bobwhites are one of 4 quail species endemic to Arizona. The other 3 species include Gambel's quail (*Callipepla gambelii*), scaled quail, and Montezuma quail (*Cyrtonyx montezumae*). Masked bobwhite males are very distinctive in appearance and are characterized by a brick red breast and black head and throat. A varying amount of white is usually present on the head, particularly above the eye and occasionally on the throat (Banks 1975). Johnsgard (1973) speculated that a link existed between masked bobwhites and the black-headed bobwhite (*Ortyx graysoni*) of the Pacific slope of southwestern Mexico because the males closely resemble one another. Females, however, closely resemble other bobwhite subspecies; they are essentially indistinguishable from the Texas bobwhite (*C. v. texanus*) found in subtropical Texas and Tamaulipas, Mexico (Ridgway 1887).

Recent work tends to support the early conclusions of Ridgway (1887). For example, Banks (1975) ex-

amined a series of 60 specimens from most portions of the masked bobwhite's presumed range, and concluded that all populations were of a single, although highly variable subspecies. He found no evidence that masked bobwhite integrated with other races in historical times. The genetic analysis conducted by White et al. (*this volume*) supports Bank's conclusion regarding the subspecific status of masked bobwhites. However, their results also suggested that masked bobwhites and Texas bobwhites from southern portions of the state are more closely related to one another than either subspecies is related to eastern subspecies of northern bobwhite. This seems plausible as masked bobwhites and bobwhites from south Texas occupy similar habitats and it is possible that evolution of both subspecies was similar. White et al. (*this volume*) believed that Texas bobwhites might serve as valid research models for masked bobwhite recovery in Arizona and Mexico.

Life History

Little quantitative information has been collected regarding masked bobwhite life history. Most of what is known comes from the observations of field biologists. However, masked bobwhite life history seems to closely resemble that of Texas bobwhites. The limited evidence available from studies in Sonora (Brown 1989) indicate that the incubation period, as well as average clutch and brood sizes of masked bobwhites, are very similar to those of other races of bobwhites. Moreover, the food habits of masked bobwhites are thought to be very similar to those reported for south Texas bobwhites by Lehmann (1984), Guthery (1986), and Koerth et al. (1986). Forb seeds and leafy material and invertebrates, chiefly insects, are probably the most important dietary items, although grass seed such as Johnsongrass (*Sorghum halepense*) and vinemesquite (*Panicum obtusum*) are consumed on a seasonal basis as well. The contents of approximately 20 fresh crops of chicks killed by a raptor at a release site on the BANWR were examined in 1995. Insects and forb material were the dominant food items identified.

Annual mortality rates for the masked bobwhite, though little studied, are believed similar to the rates (about 70%) for other northern bobwhite subspecies (Rosene 1969). Raptors are the most important masked bobwhite predators (Goodwin 1982). The telemetry studies done by Gall et al. (*this volume*) on the BANWR clearly demonstrated that raptor predation is the primary source of mortality among radio-marked masked bobwhites. Red-tailed hawks (*Buteo jamaicensis*) and northern harriers (*Circus cyaneus*) accounted for most of this predation. Mammalian predation is another important mortality factor. Goodwin (1982) attributed 4 mortalities out of 18 recorded (22%) to mammals, and Simms (1989) likewise reported 5 mammal-induced mortalities (21%) compared to 21 caused by raptors. Undoubtedly coyotes (*Canis latrans*) and bobcats (*Felis rufus*) account for a few mortalities each year, and raccoons (*Procyon lotor*) and skunks (*Mephitis mephitis*, *M. macroura*, *Spiolgate*

gracilis, *Conepatus mesoleucus*) are probably responsible for some nest destruction.

Behavioral patterns exhibited by masked bobwhites are also similar to those of eastern races of northern bobwhites. The reports of biologists who have studied wild masked bobwhites indicate that pairing activity, breeding, nesting and brood-rearing behavior, as well as covey formation, follow patterns similar to those reported for northern bobwhite populations elsewhere in the U.S. (Stoddard 1931, Lehmann 1984, Roseberry and Klimstra 1984). Despite these general similarities, masked bobwhites also exhibit seasonal behavioral patterns that are unique to the subspecies and seem to be a manifestation of the environments they inhabit. The most striking behavioral feature that differentiates masked bobwhites from eastern subspecies involves the onset of breeding activity. Masked bobwhite breeding activity is closely associated with the onset of summer precipitation in both Arizona and Sonora. Humidity levels must exceed 90% in order for breeding activity to commence (G. Gee, unpublished data). The captive masked bobwhite population at BANWR will not begin breeding unless biologists artificially elevate relative humidity levels in the propagation building by wetting the floors several times daily. Therefore, because high humidity is required, masked bobwhites remain in coveys until late June (Tomlinson 1972b) and do not display breeding behavior until rainfall commences in mid-to-late July (Tomlinson 1972b, Brown 1989). Peak breeding activity generally occurs in August and then terminates as humidity levels decrease in September (Brown 1989, Camou et al. 1998).

Breeding activity may also occur during early spring during years of above average winter precipitation. Masked bobwhite chicks have been observed during late March and early April following wet winters. This indicates that chicks were produced during late February or early March. Though spring breeding activity probably does not occur every year, and recruitment rates are smaller than those of summer, its periodic occurrence is likely of demographic importance. Modeling work conducted by F. S. Guthery (unpublished data) demonstrated that 60 days of breeding activity, the average length of a summer masked bobwhite breeding season, is insufficient to sustain a masked bobwhite population. Though the majority of the chicks produced each year are produced during summer, additional recruitment is necessary, even on an intermittent basis. Such recruitment is probably critical to the continued persistence of a masked bobwhite population. Early breeding activity is also probably constrained by photoperiod, but it is unlikely to occur in the absence of a wet winter. Therefore, masked bobwhites seem to exhibit a bimodal breeding season initiated and maintained largely by precipitation.

Masked bobwhites are associated with grassy river bottoms, broad level valleys, and plains. Habitat in Sonora is relatively open, subtropical, savanna grassland within dry-tropic scrub. The scrub components are characteristic of Sinaloan thorn-scrub and Sonoran desert-scrub (Shreve 1942, 1951). On the Sonora savan-

na grassland of the BANWR, the extreme northern edge of the masked bobwhite range (Figure 1), scrub components include a mixture of Sonoran species and dry-subtropical species of warm temperate semidesert grassland (Shreve 1942). Abundant grass cover is seasonal, along with a variety of summer-active forb and weed species. Typical masked bobwhite habitat in both Sonora and Arizona is characterized by lush and diverse herbaceous species interspersed with semi-arid shrubs (U.S. Fish and Wildlife Service 1996). Habitat preference studies indicate that ample herbaceous cover and diversity, as well as a shrub overstory of 15–30% total cover, are essential to masked bobwhite survival (Goodwin 1982, Simms 1989). In fact, Goodwin (1982) reported that several coveys emigrated from home ranges when the grass-forb understory was reduced (by grazing) to 400 kg per ha and 12–15 cm height. Reducing herbaceous cover to 12–15 cm in occupied masked bobwhite habitat probably represents at least a 50% reduction in total cover.

Reasons for Listing as Endangered

The rangelands of southeastern Arizona were described by early visitors to the region as some of the most lush and beautiful in the southwestern U.S. (Arrington 1942). Destructive land use practices were introduced by Anglo colonialists when they first visited southeastern Arizona during the 15th and 16th centuries, when livestock were first introduced (Bahre 1995). The earliest Anglo visitors were Spanish explorers (Bahre 1995) and Catholic clergymen whose goal was the conversion of Native Americans to Christianity (Whetstone 1994). Many overgrazed areas probably recovered between the late 1700's and the early 1800's because most Spanish missions were abandoned due to Apache hostilities (Bahre 1995). More extensive damage to grasslands transpired when Mexican Land Grants were awarded during the 1830's, and vast ranches, supporting huge herds of cattle, were established in portions of southeastern Arizona (Officer 1987). Nonetheless, the damage to grassland ecosystems due to livestock mismanagement was thought to be minimal, restricted to certain locales and temporary in nature (Bahre 1995). It is probable that large areas of many grassland ecosystems remained relatively undisturbed until after the Civil War.

Serious grassland destruction began during the latter part of the 19th century as a result of the subjugation of the Apaches and the advent of the Arizona cattle industry (Whetstone 1994). It is estimated that southeastern Arizona's productive grasslands were severely damaged in only two decades (Bahre 1995). By the 1880's hundreds of thousands of cattle, and over a million head of livestock including sheep, inhabited southeastern Arizona (Hollon 1966). Hollon (1966) reports that there were approximately 5,000 cattle in Arizona in 1870; 135,757 in 1880; and by 1890, there were 927,880. Wilson (1976) estimated that over 1,500,000 cattle were on Arizona rangelands, primarily in southern Arizona, at the beginning of 1891. A serious drought during the early 1890's exacerbated

grassland deterioration and almost destroyed the cattle industry (Brown 1900). The Chairman of the Livestock Sanitary Commission, C. Cameron, said that if the drought of 1891 to 1893 had continued 60 days longer, all the cattle in southern Arizona would have perished (Wilson 1976).

In 1901 D.A. Griffiths, an early University of Arizona agricultural scientist, noted that the rangelands of southern Arizona were the most degraded of any he had observed in the West. A few years later J.W. Toumey, another University of Arizona scientist, stated that suitable herbarium specimens of perennial grasses were almost impossible to locate (Bahre 1995). The extirpation of masked bobwhites from Arizona coincided with Mr. Griffith's observations of grassland conditions at the turn of the last century. The last masked bobwhite specimens from Arizona were those taken for Brown at Calabasas on 29 December 1897 (Phillips et al. 1964).

The arrival of Europeans and their livestock in Sonora predates colonization of Arizona. However, the settlement of Sonora was slow and areas away from river valleys remained uninhabited by Europeans until the late 1880's. With the elimination of nomadic Apache and Yaqui Indian populations (1850 to 1900), settlement of Sonora accelerated. Accompanying settlement was the expansion of the livestock industry and the concomitant destruction of Sonoran grasslands.

Masked bobwhites apparently persisted in Sonora through the late 1880's as Benson and Cahoon separately collected birds in and around Cumpas and Ba-coachi in 1886 and 1887 (Stephens 1885, Brewster 1887, Van Rossem 1945). Nevertheless, populations in Sonora were probably declining as habitat was lost. The subspecies was thought to have been extirpated from Sonora, and therefore extinct in the wild, by the early part of the 20th century (Tomlinson 1972b, Brown 1989). However, a small population was re-discovered on Rancho El Carrizo in 1964 (Gallizioli et al. 1967) thereby stimulating interest in saving the subspecies. It was obvious to those concerned that rigid protective measures were necessary to prevent extinction. The masked bobwhite was consequently listed as an endangered species in 1968.

RECOVERY OBJECTIVES AND CRITERIA

The primary objective of masked bobwhite recovery is to increase populations of the subspecies to the point where they can be removed from the endangered species list. Recovery criteria state that the masked bobwhite will be considered for reclassification from endangered to threatened status when 4 separate, viable populations are established (consisting of 2 populations in the U.S. and 2 more in Mexico) and have been maintained for 10 consecutive years. A viable population is considered to consist of 200 calling males (500 individuals) which, without supplementation, maintains these numbers for at least 5 years and

never falls below 50 calling males (U.S. Fish and Wildlife Service 1995).

RECOVERY EFFORTS

1930 to 1950

The rangeland abuse that occurred during the late 1800's in southeastern Arizona and Sonora continued unabated well into the 20th century. After the Mexican revolution (1911 to 1927), establishment of "ranchos" in Sonora was again accelerated through the development of permanent water. By the late 1920's and early 1930's, ornithologists were concerned that the masked bobwhite might be extinct (Bent 1932). However, Ligon (1952) reported that birds were "still fairly numerous locally as late as 1937 in central and southern Sonora, Mexico."

When Ligon returned to Sonora in 1949 and 1950, the situation had changed. As cattle ranching expanded as an industry throughout Sonora after 1930, masked bobwhite populations continued to decline. Ligon's (1952) report of trips in 1937 and 1950, and Wright's experiences between 1931 and 1950, indicate that the once luxuriant grassy plains were denuded within that time span (Tomlinson 1972a). Sonoran ranchers, who had formerly known of the presence of the birds, stated that masked bobwhites seemed to have vanished overnight (Ligon 1952). Competent observers familiar with masked bobwhites also reported seeing birds through the 1930's in the Altar Valley of Arizona, and Ligon (1942) stated that reports of masked bobwhite observations persisted around the town of Arivaca and on the Baboquivari range west of the Altar Valley in Arizona. However, these sightings were neither confirmed by other observers nor substantiated by specimens.

It was obvious to ornithologists that monitoring programs, and recommending habitat protection to disinterested ranchers, would not save the few remaining masked bobwhite populations that still existed in Sonora. Therefore, while monitoring programs continued, several early attempts were made to reintroduce masked bobwhite to Arizona and to restore or bolster populations in Sonora. Ligon initiated 3 expeditions to Sonora to obtain wild stock for reintroduction and propagation in 1937, 1949, and 1950 (Ligon 1942, Lawson 1951, Ligon 1952). In 1937, 132 bobwhites were captured and another 25 were obtained in 1950. Restocking efforts following the 1937 trip resulted in the initial release of about 200 birds (including wild and propagated stock) in 6 areas of Arizona and southwestern New Mexico.

Most of these releases were well outside the presumed historic range of the masked bobwhite (Figure 1). Evidently, little effort was devoted to acclimating birds to the new environmental conditions associated with the release site. Thus, each reintroduction attempt was unsuccessful as masked bobwhites rapidly disappeared from release sites. Areas within the bird's known range were not selected as release sites because Arrington and Ligon believed range conditions in historic habitat were totally unsuitable for masked bob-

whites (Arrington 1942). The most recent collections and reports of masked bobwhites in Arizona at that time (Ligon 1942, Phillips et al. 1964) were at the upper elevational limits of the bird's habitat, consequently Ligon (and others) may have erroneously concluded that the bird's historic range included higher elevation desert grasslands (>1200 m). Additionally, these early biologists did not have accurate information about critical components of masked bobwhite habitat. Consequently, their reintroduction attempts probably occurred in habitats that lacked essential components such as tall, dense herbaceous cover, which further doomed the reintroduction efforts to failure. Early attempts to reintroduce masked bobwhites to Arizona and Sonora effectively ceased after the 1950 translocation to the Gardner Canyon area of the Huachuca Mountains in Arizona.

1964 to 1985

After the 1950 reintroduction effort failed, no attempts were made to recover masked bobwhite populations until 1964 when Steve Gallizioli, an Arizona Game and Fish Department (AGFD) Biologist, and Naturalists Jim and Seymour Levy documented a population between Benjamin Hill-Carbo and Hermosillo, Sonora (Gallizioli et al. 1967). The rediscovery of this population again prompted interest in saving the masked bobwhite from extinction. The Levys, with assistance from the AGFD, attempted to convince a Sonoran landowner to designate a portion of his ranch a masked bobwhite management area. Despite some initial encouragement, their efforts failed as the rancher ultimately refused to manage the area properly. Clearly protective measures alone would not suffice.

Accordingly, in 1964 the Levy brothers and personnel at the Arizona Sonora Desert Museum in Tucson began separate studies of the masked bobwhite using breeding stock obtained from Ligon (Walker 1964, Gallizioli et al. 1967). The latter study was terminated when vandals entered the breeding pens and destroyed the remaining propagated birds. In 1966 the Levys donated 4 pairs of pen-reared masked bobwhite to the U.S. Department of the Interior, Fish and Wildlife Service (USDI, FWS). These birds, and 57 wild birds captured near Benjamin Hill-Carbo, Sonora, in 1968 and 1970, were the original breeding stock sent to the USDI, FWS's Patuxent Wildlife Research Center (PWRC) in Laurel, Maryland where a captive masked bobwhite population was soon developed. The descendants of these 61 birds, with occasional supplementation of wild birds from Sonora, were then used for propagation and release projects in Arizona and Mexico for the next 30 years. Another important event regarding masked bobwhite recovery that occurred during the 1960's was the passage of the Endangered Species Conservation Act in 1968. When this act became Federal Law the USDI, FWS received a legal mandate to implement recovery efforts for the masked bobwhite.

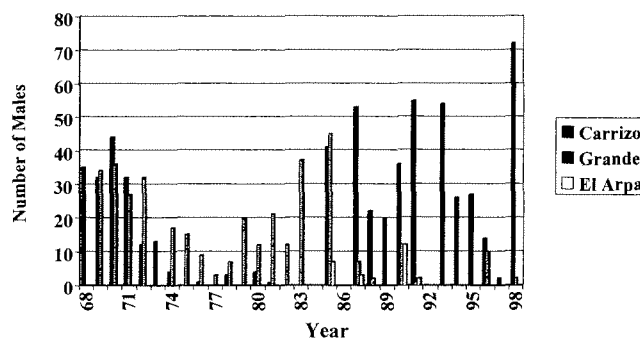


Fig. 2. Number of masked bobwhite males breeding on Rancho El Carrizo, Rancho Grande and Rancho El Arpa, Sonora, Mexico from 1968 to 1998.

Sonora

From 1967 through 1970, Tomlinson (1972b) conducted extensive surveys in Sonora to determine the distribution and status of masked bobwhites. He visited published localities and collection sites, and interviewed hundreds of Mexican citizens. During the fall and winter, areas thought to harbor masked bobwhites were searched on foot with a dog. Cactus wren (*Campylorhynchus brunneicapillus*) and verdin (*Parus* spp.) nests (which are frequently lined with feathers of other birds) were inspected for masked bobwhite feathers. The distinctive roosts of masked bobwhites were also sought. During the summer breeding season, Tomlinson listened for bobwhite calls, and used taped female calls to elicit male responses. His investigations concentrated on 8 general areas in Sonora. Masked bobwhites were located at 2 sites in the Benjamin Hill-Carbo area, Rancho Grande-El Arpa and Rancho El Carrizo, and a very limited region east of Mazatan (Tomlinson 1972b). Tomlinson therefore established call-count survey routes on both Rancho El Carrizo and Rancho Grande in 1968 (Figure 2).

Population trends were subsequently monitored on both ranches for the next several years. During the early 1970's it was apparent that both populations were declining and USDI, FWS biologists were unable to locate masked bobwhites on the Mazatan site when they revisited the area in 1974. By 1977, the trend in peak counts of calling males (Figure 2) suggested that the Rancho El Carrizo population was near extinction and that the Rancho Grande population, though still persisting, was in danger of disappearing as well (Ellis and Serafin 1977). These declines coincided not only with continued overgrazing by livestock, but dry weather as well. Fortunately, the drought ended during the summer of 1977. Despite continued overgrazing, both populations began to increase. The populations then experienced a combination of moderate declines and increases until 1983, when both populations contained more than 40 males (Figure 2). Like the increase in 1977, this increase again coincided with abundant summer precipitation in 1982. Habitat conditions improved as a function of increased moisture and the masked bobwhite populations responded accordingly. From 1980 to 1982, USDI, FWS biologists released approximately 2000 captive-reared masked

bobwhites on 3 additional areas in Sonora where extensive brush-clearing had occurred. These reintroduction attempts apparently failed due to excessive livestock grazing on cleared areas. Nevertheless, by 1985, masked bobwhite populations on Rancho El Carrizo and Rancho Grande appeared to be at the highest levels recorded since call-count surveys were instituted in 1967.

Other than establishing call-count surveys, monitoring populations, conducting several releases and establishing dialogues with the ranch owners, USDI, FWS biologists could do little to improve the masked bobwhite situation in Sonora. The population increases documented during the surveys indicated that the quail were responding to precipitation-induced habitat improvement. Livestock management practices were not altered significantly during the 1970's and 1980's. Goodwin (1981) was initially hopeful that the habitat situation would improve on Rancho Grande when owners implemented an extensive brush removal program and then planted thousands of acres to buffelgrass (*Cenchrus ciliaris*). Biologists believed that masked bobwhites would respond positively to the increased herbaceous cover. However, this did not occur because the buffelgrass formed extensive monocultures that replaced native grasses and such habitat was not suitable for masked bobwhite production. The future of masked bobwhites in Sonora therefore remained dependent on the management decisions of ranch owners, and their future remained tenuous at best in 1985.

Arizona

In 1969, the USDI, FWS, in cooperation with the AGFD, began surveying southern Arizona for suitable masked bobwhite reintroduction sites. Biologists conducting the surveys were unable to perform definitive habitat evaluations because Tomlinson's life history studies had just begun and little was known about specific masked bobwhite habitat requirements. Criteria used for selecting release areas were range condition, historic distribution, land status and availability, amount and composition of ground cover, recent land use practices, and elevation. Although little was known about masked bobwhite food habits, an effort was made to choose reintroduction areas believed to contain an adequate food supply.

Four areas in the Altar Valley were eventually selected as release sites in 1970, although none of these areas were comparable to occupied habitats in Sonora. The Altar Valley habitat was higher (730 to 1,300 m) than the Sonoran habitat (300 to 800 m), the soils were generally more shallow and the terrain more rugged, and subtropical vegetation of Sonora was less abundant. However, like the occupied habitat in Sonora, much of the land had been, and was currently being abused by livestock. Although the Altar Valley habitats were less than ideal, they were judged to represent the best available release sites in the U.S. Biologists released captive-reared birds on lands owned by cooperative ranchers; however, all releases failed.

Though cattle grazing rendered habitats unsuitable for masked bobwhite survival and contributed to the failure, poor physical conditions of the birds being released was also a contributing factor to reintroduction failure. These birds were fed, watered, and held for only 24 hours before being released. Many of the birds suffered deformities from excessive debeaking and confined rearing. Release protocols were thus altered after the 1971 releases and birds were held in Tucson for 3 months prior to release.

In an effort to alleviate concern about poor habitat on release sites the USDI, FWS leased 745.2 ha of the Las Delicias Ranch (Altar Valley) from the Arizona State Land Department in 1972 as a masked bobwhite management area. The pastures comprising this lease were within the historic range of the masked bobwhite, and would provide undisturbed nesting cover as cattle were removed from all pastures soon after the site was leased. Biologists immediately began releasing captive-reared stock on the leased pastures. Nevertheless, like the 1970 and 1971 releases, the early Las Delicias releases also failed. Most of the masked bobwhites that were released during this period received little wild conditioning and, as a result, most of them disappeared within 2 months of release. Abnormally high mortality rates due to coyote predation were documented immediately after most releases (Ellis and Tomlinson 1974, Goodwin and Hungerford 1977). A screening program was therefore initiated in 1974, and only those birds thought capable of surviving in the wild were released (Ellis and Serafin 1977). Two reintroduction techniques were developed which resulted in release-worthy stock (Ellis et al. 1978). One is a modification of the foster parent-adoption methods described by Hart (1933), Stoddard (1931), and Stanford (1952). The most promising foster parents were wild male Texas bobwhites sterilized by bilateral vasectomy (Ellis and Carpenter 1981). The second technique was a modification of the call-box or call-pen conditioning program originally proposed by Hardy and McConnell (1967).

These techniques were developed in 1974 and 1975, and tested with hundreds of birds between 1974 and 1977. This shift toward prerelease training produced captive-reared birds that were thought to be better prepared for survival in the wild (Ellis et al. 1978). Many of the birds released during the spring and summer of 1976 survived into winter, and by the onset of the 1977 summer rains, a population estimated at 30 birds was found near 1976 release sites in Altar Valley on the Buenos Aires Ranch. Several pastures of this ranch (465 ha) were included as release sites in 1975 because habitat conditions were deemed more suitable here than on the Las Delicias lease, which was terminated in 1976. The decision to move reintroduction efforts to the Buenos Aires Ranch was justified on 4 October 1977 when a USDI, FWS biologist observed a pair of wild masked bobwhites with at least three chicks. This observation was significant because it conclusively demonstrated that captive-reared birds could survive the winter and produce wild progeny.

Annual releases of masked bobwhites on the

Buenos Aires Ranch eventually produced a wild population by 1978. Natural productivity was documented, and winter survival was good. The number of calling males increased from 21 in 1977, to 54 in 1978, and eventually to a peak of 74 in 1979 (Goodwin 1982). Thereafter intensive grazing, combined with summer drought, sharply reduced the population (Goodwin 1981). Only 9 birds were detected in 1984 (Levy and Levy 1984, Ough and deVos 1984). It was evident that the reestablished population was again in danger of disappearing.

Much was learned from the reintroduction research conducted during the 1970's; previously unknown habitat requirements were identified, and new techniques were developed and applied that improved the postrelease survival of captive-reared birds. Most importantly research indicated it may be possible to reestablish masked bobwhites to historic habitats. Despite this increased knowledge, the masked bobwhite decline of the early 1980's demonstrated that the birds remained vulnerable to even moderate grazing pressure. Clearly, an area managed exclusively for masked bobwhite was needed to assure the future of the subspecies in the wild.

1985 to 1994

Sonora

The masked bobwhite populations on Rancho El Carrizo and Rancho Grande were not monitored between 1985 and 1987 because a USDI, FWS biologist was not assigned to the Recovery Project. However, 9 males were documented by an observer who conducted a call-count on Rancho El Arpa (a ranch adjacent to Rancho Grande) in 1985 (Figure 2). This small population was subsequently added to the monitoring program. After the BANWR was established in 1985, the USDI, FWS hired a biologist in 1986 to resume masked bobwhite recovery efforts in Arizona and Sonora. When call-count surveys resumed in 1987 the Rancho El Carrizo population appeared to have increased whereas the Rancho Grande and El Arpa populations had experienced a serious decline (Figure 2). Results of the 1988 and 1989 surveys indicated that not only were the Rancho Grande and El Arpa populations continuing to decline, but the Rancho El Carrizo population had suffered an alarming decline as well. In fact, it appeared that all 3 populations were in imminent danger of extinction. However, the 1990 survey revealed that the 3 populations had begun to increase, though the Rancho Grande and El Arpa populations again declined in 1991 while the Rancho El Carrizo population increased to the highest level recorded in almost 30 years (Figure 2). A bird dog survey conducted during the winter of 1991 yielded an estimate of 1000 birds (Carroll et al. 1994). The Rancho El Carrizo population appeared to occupy higher quality habitat than the other 2 populations. Habitat destruction caused by overgrazing and buffelgrass establishment were the norm on Rancho Grande and El Arpa because the owners were not interested in conserving masked

bobwhites. Conversely, the owners of Rancho El Carrizo were interested in masked bobwhite recovery and therefore expended efforts to protect important habitat. Nevertheless, the USDI, FWS felt that additional measures were necessary to protect the few masked bobwhites that remained in Sonora.

Therefore, a final effort to avert extirpation of the masked bobwhite in Sonora was initiated in 1991 when The Nature Conservancy, The Center for Ecology of Sonora (CES), the USDI, FWS, and private Sonoran landowners identified and protected approximately 20,000 ha of critical habitat. Management strategies were developed to enhance and expand masked bobwhite habitat, thereby providing additional areas for population expansion (Dobrott 1991). Members of the Camou family, the historical owners of Rancho El Carrizo, became more interested in masked bobwhite conservation and implemented habitat improvement measures on major portions of Rancho El Carrizo. Between 1992 and 1994, the Camous chained and rangedisked >20,000 ha of the ranch in an effort to improve masked bobwhite habitat (Kuvlesky 1993, 1994). During the winter of 1993, USDI, FWS biologists initiated line transect surveys and covey-call counts and obtained a population estimate of 1500–2000 birds (Carroll et al. 1994). Also, in 1994 the Camou family agreed to cooperate with the USDI, FWS, Texas A&M University, and CES to initiate a Ph.D. research project that would examine masked bobwhite habitat preferences on the ranch. This study represented the first intensive effort to quantify masked bobwhite habitat needs in Sonora. The cooperating parties also attempted to interest Sonoran cattlemen in masked bobwhite recovery in particular, and wildlife management in general, by cosponsoring an Educational Seminar in Hermosillo during the early fall of 1994.

Despite these efforts, the population declines continued due to habitat deterioration, overgrazing, and a severe drought that began during late spring of 1992. The Rancho Grande and El Arpa populations appeared extinct by summer 1993, while the Rancho El Carrizo population continued to decline (Figure 2). Line transect surveys conducted during the winter of 1994 indicated that the population had decreased by more than 50%. Habitat conditions remained poor and overgrazing continued. Therefore, USDI, FWS biologists were surprised the following summer when they conducted the call-count survey and discovered that the number of calling males had increased (Figure 2). The drought, however, progressed through the breeding season and few chicks were produced. Habitat conditions continued to deteriorate during fall and winter as the drought worsened. It began to appear that the Rancho El Carrizo masked bobwhite population would share the fate of the other 2 Sonoran populations.

Arizona

Unlike Sonora, significantly more effort was directed at masked bobwhite recovery in the U.S. during the mid 1980's. In 1985, after nearly 2 years of controversy and public debate, the Buenos Aires Ranch

was acquired by the USDI, FWS in an effort to restore the Sonora savanna grassland and provide suitable habitat for a self-sustaining masked bobwhite population. The new refuge assumed the name of the former ranch and eventually consisted of almost 48,564 ha of grassland, riparian, and desert mountain habitats. Acquisition of the BANWR accomplished a major objective of the 1984 recovery plan. One of the first things accomplished after the BANWR was established was to remove all livestock and construct a perimeter fence around the entire property. The refuge manager also implemented a vegetation monitoring program to document vegetation dynamics in the absence of grazing. He hired a range conservationist in 1986 to install almost 40 permanent transects throughout the Refuge. Data from these transects have been recorded at approximately 3-year intervals. USDI, FWS officials believed that masked bobwhites reestablishment could be accomplished rather easily in the absence of grazing pressure. This assumption later proved naive.

Although reports of masked bobwhites in the Altar Valley persisted at the time of BANWR establishment, none could be verified (Brown 1989). It appeared that the birds introduced during the 1970's had disappeared despite moderate- and above-average summer precipitation between 1981 and 1984. Obviously, captive-reared stock produced by the captive population at the PWRC in Maryland would have to be released on the Refuge in order to restore a free-ranging wild population. Therefore, the techniques developed for the release work conducted during the 1970's were again applied on the BANWR. The standard protocol utilized involved the foster parent-adoption technique developed by Ellis et al. (1978). Between 1985 and 1996 an average of 2,500 2-week-old masked bobwhites were produced by PWRC and flown to the BANWR each summer for release to the wild. Of the almost 25,000 chicks delivered to the BANWR, >20,000 (80%) survived transport and prerelease conditioning and were ultimately released.

Propagation and release protocols utilized and developed between 1985 and 1994 are discussed in detail by Gall et al. (*this volume*). They evaluate the techniques utilized and discuss the presumed fate of chicks released during this period and the high postrelease mortality that seemed to be occurring each year. Though some survival and natural reproduction was documented each year (Dobrott 1990), the overall poor results became apparent to refuge officials by the late 1980's. The USDI, FWS provided financial support to the Arizona Cooperative Fish and Wildlife Research Unit (ACFWRU) to conduct research on the habitat requirements of captive-reared masked bobwhites on the BANWR in hopes of learning what habitats the quail prefer and applying this knowledge to the release program. The results of this research (Simms 1989) yielded previously unknown information regarding masked bobwhite habitat requirements and homerange sizes, and proved useful in selecting future release sites. However, postrelease survival among chicks did not improve. It was obvious that simply removing cattle and maintaining undisturbed grassland did not pro-

vide habitat conditions conducive to the postrelease survival rates necessary to establish a self-sustaining masked bobwhite population.

The BANWR manager therefore implemented a prescribed burning program in 1988. Numerous studies in the southeastern U.S. and Texas indicated that prescribed burning produced suitable habitat conditions for bobwhites and that populations performed well on burned areas (Stoddard 1931, Rosene 1969, Wilson and Crawford 1979, Koerth et al. 1986). A fire management officer, along with a fire crew, were subsequently hired and instructed to ignite prescribed burns on a 4-year rotational cycle. By 1992, 11,000 ha had been burned by prescription. Numerous prescribed burns were conducted, and a few wildfires occurred during the late 1980's; dry weather, however, caused a deterioration in habitat conditions. Insufficient brood habitat and a lack of winter food were thought to be critical limiting factors until summer rains in 1990 improved habitat conditions. In 1990, refuge biologists estimated a wild population of 300–500 birds using trained bird dogs. Similarly, winter and spring surveys in 1991 estimated an overwintering population of 31 coveys (333 bobwhites) within a 4,000 ha study area (Dobrott 1991). However, without supplementation from captive-reared chicks, this population began to disperse and decline in 1992 (Dobrott 1992). Winter food limitation was considered responsible for the decline.

Since scarcity of winter food was thought to be a limiting factor, botanists from the University of Arizona were invited to establish two plots of whiteball acacia (*Acacia angustissima*) on the BANWR. Whiteball acacia seeds are an important food item for masked bobwhites in Sonora. The plant is prolific on Rancho El Carrizo, particularly on areas where soil has been disturbed. The Levy brothers were unable to live-trap masked bobwhites on the ranch during the 1960's until they began using whiteball acacia seeds (S. Levy, personal communication.). USDI, FWS biologists suspected that the presence of whiteball acacia played an important role in maintaining masked bobwhite populations on areas where herbaceous food and cover were sparse on Rancho El Carrizo during drought. The BANWR lies within the historic range of whiteball acacia; however, it is presently rare. Refuge management believed that the poor winter food situation could be improved if whiteball acacia abundance could be improved on the BANWR. Generally, the plantings were successful and a seed source was established. However, seeds were not planted on any additional areas frequented by masked bobwhites so the presence of whiteball acacia on the BANWR did not really benefit masked bobwhites in any measurable way. Permanent vegetation transect monitoring conducted during 1993, however, indicated that the species appeared to be reestablishing itself on selected sites. Consequently, masked bobwhites may potentially benefit as whiteball acacia abundance increases on the BANWR.

There was little doubt that the elimination of grazing and the prescribed burning program were improving BANWR grasslands. Still, it was believed that ad-

ditional measures could be utilized to create better habitat conditions for masked bobwhites. Consequently, in 1992, arrangements were made for the refuge biologist, the manager, a CES biologist, and member of the Camou family to tour several south Texas ranches that were being actively managed for bobwhite production. During the tour they observed a number of management techniques employed to improve quail habitat, and discussed habitat management with numerous quail managers. Refuge officials returned from their visit determined to establish food plots and implement a range-disking program to improve masked bobwhite habitat on the BANWR. A limited amount of diskling was accomplished during the summer of 1992 on selected areas of the refuge. Mechanical habitat improvements, along with the prescribed burning program, were temporarily terminated due to the presence of an endangered plant, the Pima pineapple cactus (*Coryphantha scheeri* var. *robustispina*), which was discovered by the refuge biologist in 1991. Field personnel were required to search an entire potential habitat management site for cacti and protect individual cacti before habitat management could proceed. As a result of these limitations, only 800 ha were burned between 1992 and 1994, and no mechanical habitat management was performed. It was clear that a compromise was necessary to maximize protection of the cacti yet still apply habitat management on a scale that would benefit masked bobwhites. A biologist from the USDI, FWS Ecological Services Phoenix Field Office (PFO) visited the BANWR during late spring of 1994 and concluded a temporary agreement with the refuge manager that would permit prescribed burning until a formal agreement could be achieved. Formal intra-service consultation under Section 7 of The Endangered Species Act was scheduled with the PFO for winter of 1995.

Along with efforts to improve habitat conditions on the BANWR, refuge biologists attempted to improve postrelease survival of chicks by strengthening adoptive behavior of foster parents. In 1991, they participated in a study designed to determine if supplemental injections of testosterone and antiandrogens enhanced alloparental behavior of Texas males (Vleck and Dobrott 1993). Although initial results appeared promising, postrelease survival among chicks did not seem to improve. Another method attempted to increase the density of masked bobwhites on the BANWR involved releasing older captive-reared chicks during winter. Biologists thought that older chicks released during the covey season would perform better than younger chicks released during summer. The results of these releases were, however, inconclusive. A line-transect survey was initiated during late winter 1993 to determine how many masked bobwhites inhabited the BANWR. Surveys were conducted on most areas judged to be good habitat for masked bobwhites. Less than 10 observations were obtained, precluding precise estimation of population density.

In 1993 refuge biologists started using the flight-pens constructed in 1992, to better prepare chicks for the environmental conditions they would be confront-

ed with upon release to the wild (Gall et al. *this volume*). Native grass seed was planted in each pen and watered daily to promote vigorous growth and encourage insect utilization. Biologists also began utilizing radio telemetry to monitor the fate of released chicks. The telemetry results indicated that, despite the use of flight pen conditioning, postrelease survival remained poor. Biologists could generally locate a radio-marked foster parent and brood a day or 2 after a release. However, within 5–7 days very few chicks were observed with foster parents, and often foster parents were found alone. Biologists suspected that postrelease survival was $>2\%$. Nonetheless, the 1993–1994 winter line transect survey yielded a total population estimate of 1000 individuals. Refuge biologists believed that the abundant winter and fair summer rainfall of 1993 improved habitat conditions and resulted in a population increase. An increase in natural productivity seemed the most likely explanation, although some chicks released during the summer likely survived over winter. Live-trapping was conducted during the winter of 1993–1994, and though only 25 masked bobwhites were captured, 88% of the individuals captured were chicks released the previous summer, indicating that over winter survival did occur. Additionally, 2 adults released during 1992 and a chick produced in the wild were captured. Evidently, the long-term survival and natural reproduction that were documented several years earlier were still occurring in 1994.

In addition to the habitat research that was initiated on Rancho El Carrizo in 1994, refuge biologists succeeded in securing funding from the AGFD to conduct similar research on the BANWR. This project was administered by the ACFWRU at the University of Arizona, and involved hiring a Master of Science (M.S.) candidate to complete the research. The principal investigators involved in these 2 projects decided that data would be collected in an identical manner on both sites to compare habitat preferences between masked bobwhites on the BANWR and those on Rancho El Carrizo. The USDI, FWS had always assumed that habitat deficiencies existed on the BANWR because of its location at the extreme northern limit of the masked bobwhite's historic range. In contrast, the Rancho El Carrizo population exists near what is thought to be the core of the historic range, with therefore fewer potential habitat deficiencies. Biologists hoped that the 2 projects would illuminate habitat deficiencies on the BANWR if deficiencies exist.

1995 to 1997

Sonora

The status of the masked bobwhite population on Rancho El Carrizo remained perilous through the late winter, spring, and early summer of 1995. During a late winter bird dog survey, only 7 coveys were located on the ranch, and masked bobwhite observations were becoming more difficult to obtain as the Ph.D. research project progressed. The presence of masked bobwhites was, however, verified on a small pasture

on Rancho Grande during a call-count survey in August when 9 males were recorded (Figure 2). This population was believed to be much smaller than the 1 inhabiting Rancho El Carrizo, although the population had not been extirpated as USDI, FWS officials had feared. Another positive result of the rediscovery of the Rancho Grande population was that the ranch owner displayed remarkable enthusiasm relative to masked recovery when he was informed that 1 of the 2 last truly wild populations of this endangered species relied on his property for its continued survival. He expressed interest in managing important habitat if the USDI, FWS would contribute financial assistance.

The discovery that masked bobwhites continued to persist on Rancho Grande, together with improved summer rainfall on Rancho El Carrizo, resulted in increased optimism among recovery collaborators. Optimism increased further during July 1995 when the Turner Foundation, Inc. informed the Camou family and USDI, FWS biologists that they would fund a proposal to install short-duration grazing systems (SDG) on 4000 ha of critical habitat on Rancho El Carrizo. Mr. Beau Turner, a Foundation Trustee, toured the ranch in August and was impressed with what had been accomplished on behalf of masked bobwhites. As a result he pledged to support future recovery efforts. Biologists also discovered that the masked bobwhite population did not suffer the severe over-winter decline that they feared would occur. The August call-count survey revealed a slight decrease. The number of calling males was slightly lower (13) than the number recorded during the 1994 survey (19) (Figure 2).

Dry weather continued during the fall and winter on both Rancho El Carrizo and Rancho Grande. Habitat conditions over the winter of 1995–1996 deteriorated somewhat on Rancho El Carrizo while conditions on Rancho Grande deteriorated substantially. USDI, FWS biologists encountered difficulty in locating birds with dogs during a January visit to both ranches. One covey of 12 birds was found on Rancho El Carrizo while only a single hen was sighted on Rancho Grande. Despite the low numbers of birds observed, ranch vaqueros insisted that more birds remained on both ranches. The assurances of ranch personnel slightly assuaged the worries of biologists. Nevertheless, recovery collaborators remained concerned that installation of the SDGs had not yet begun by early spring 1996. Habitat conditions continued to deteriorate due to the combined effects of livestock grazing and drought. It was feared that all that had been accomplished during past years would be for naught.

Installation of one 1600 ha SDG was completed by the end of August 1996. The 5-year drought ended when the Rancho El Carrizo received over 50 cm of rainfall between July and September. Additionally, the 1996 call-count survey indicated that the number of males (10) remained similar to that of 1995 (13) (Figure 2). By fall, habitat conditions over much of the ranch were the best observed in almost 6 years. Moreover, the installation of at least 1 SDG would ensure that a sizable amount of critical habitat would be man-

aged properly for masked bobwhites in the future and improved livestock management would begin under high quality herbaceous vegetation conditions. Recovery collaborators received additional good news during the summer of 1996 when the National Fish and Wildlife Foundation awarded the Camous supplementary funding toward installation of a second grazing system. Alejandro Camou, the owner of the portion of Rancho El Carrizo where the second grazing system was to be located, indicated that instead of using the funds to install the grazing system, he would remove cattle from 2000 ha of critical habitat designated by BANWR officials. Completely resting critical habitat from grazing was deemed a better alternative than implementing a different grazing system. Therefore, the BANWR accepted Mr. Camou's offer and for perhaps the first time in a century, critical masked bobwhite habitat would not be disturbed by cattle.

Habitat conditions remained excellent on the functioning SDG through fall and winter 1996. Ranch personnel reported observing masked bobwhites on almost a daily basis, and documented several broods during summer 1997. The 1997 call-count survey results, however, initially alarmed BANWR biologists because only 2 males were recorded (Figure 2). Ranch vaqueros assured biologists that masked bobwhites were abundant despite the call-count results; surveys were simply being conducted too early. Camou et al. (1998) analyzed 30 years of call-count data, as well as 40 years of Rancho El Carrizo rainfall data, and found that peak breeding activity occurs during mid August.

By the late winter of 1997 it was estimated that at least 5 masked bobwhite coveys used the SDG. This is significant because few masked bobwhites, if any, were thought to occur on this area in 1995. SDG habitats had been recolonized and additional birds were thought to have moved into the grazing system from surrounding areas with poorer habitat conditions during the spring and summer. During the summer of 1997 BANWR biologists and scientists from Oklahoma State University secured funding to begin a research project aimed at evaluating the effects of the SDG on masked bobwhite habitat. The primary objective of this study was to determine grazing management strategies that best met masked bobwhite habitat needs. Data collection began in 1997 and screening cover was measured in each pasture of the grazing system. The study will terminate during winter 1999.

Unlike Rancho El Carrizo, the masked bobwhite situation on Rancho Grande remains tenuous at best. A low density population may still exist on the ranch. Mr. Fimbres remains interested in masked bobwhites and it is obvious that he enjoys the fact that they inhabit his property. He initiated a native shrub restoration program on his property during the summer of 1996 which may benefit the masked bobwhite population as the shrubs mature. The USDI, FWS pursued habitat improvement funding for the past 2 years but has been unsuccessful in obtaining the finances necessary for Mr. Fimbres to implement habitat improvement on his property.

Arizona

Like Sonora, the prospects for masked bobwhite recovery in Arizona also improved between 1995 and 1997. Formal intra-Service Section 7 consultation between BANWR staff and biologists representing PFO were convened on the Refuge in April 1995 to discuss the prescribed burning program and Pima pineapple cactus welfare. After lengthy discussions, an agreement was reached that permitted normal prescribed burning operations to resume. One aspect of the agreement was to expand the permanent vegetation monitoring program that has been ongoing since BANWR establishment in 1985. It was agreed that expansion of the current project and continued long-term monitoring of the BANWR grassland would provide insight about how prescribed burning influences the dynamics of grasslands not exposed to livestock disturbance. This information will undoubtedly benefit not only masked bobwhite recovery efforts, but Pima pineapple cactus recovery efforts as well. During the spring of 1996, refuge biologists and a fire ecologist at the University of Arizona received funding for a 4-year GIS-based study that should quantify the effects of recurring fires on BANWR grasslands, and by association, masked bobwhites and Pima pineapple cactus.

An event that threatened to impede masked bobwhite recovery on the BANWR occurred during the fall of 1995. The Southern Arizona Cattlemen's Protection Association (SACPA) mounted an assault on the "no grazing" policy of BANWR Management. The refuge manager hosted a meeting for members of the SACPA in October to explain and clarify refuge policy, and to answer any questions. Refuge biologists also explained that masked bobwhite recovery and traditional cattle grazing were not compatible because the quail require dense herbaceous cover to survive. Little was resolved during the meeting, and SACPA representatives soon launched a relentless public relations and political campaign to force the USDI, FWS to permit ranchers to graze cattle on the BANWR. Masked bobwhite recovery was attacked in the news media and in January 1996 the SACPA succeeded in convincing ABC News to air a segment about masked bobwhite recovery as part of its weekly "Fleecing of America" broadcast. The segment prompted outrage among citizens throughout the U.S. who support the National Wildlife Refuge System and conservation in general. Though the national publicity seemed to increase public awareness and galvanized support for recovery efforts, the SACPA continued a campaign to open the BANWR to livestock grazing. Nevertheless, they have not yet succeeded in opening the BANWR to livestock grazing.

During the spring of 1995, the BANWR hosted a Population-Habitat Viability Analysis Workshop along with a Recovery Committee Meeting to evaluate the recovery process. Participants included most of the Federal and State Agencies in the U.S. and Mexico that had been active participants during the past several years (U.S. Fish and Wildlife Service 1996). A Conservation Biologist from the Conservation Breed-

ing Specialists Group (CBSG), Species Survival Commission of International Union for the Conservation of Nature (ICUN) conducted the workshop. Participants developed goals to be achieved during the course of the workshop, fulfilled these goals at workshops end, and made several recommendations relative to enhancing recovery efforts (U.S. Fish and Wildlife Service 1996).

One important recommendation from this workshop was that habitat improvement continue in both Sonora and Arizona, with special emphasis on improving grazing management in Mexico. Translocation of wild masked bobwhites from Rancho El Carrizo to the BANWR as soon as sufficient numbers are present on the ranch was also endorsed. Additionally, workshop participants recommended that traditional captive propagation and release protocols be altered on the BANWR in an effort to improve postrelease survival of chicks. In this regard, termination of the use of the Texas bobwhites as foster parents was a major recommendation. Refuge biologists have known for years that sterilized Texas males pair with masked bobwhite hens during the breeding season. Hens that pair with Texas males cannot be fertilized and they are essentially lost from the masked bobwhite breeding population for that breeding season. Demographic modeling scenarios produced during the workshop demonstrated very clearly that the loss of as few as 25 hens from the breeding population could have serious negative impacts on masked bobwhite population dynamics. Therefore, for this and other reasons discussed in more detail in the workshop proceedings (U.S. Fish and Wildlife Service 1996), refuge officials terminated the Texas male foster parent program during summer 1995.

Refuge biologists immediately implemented protocol alterations discussed in detail by Gall et al. (*this volume*) during the 1995 release season. Follow-up monitoring via radio telemetry conducted after each release, as well as the field observations obtained by the M.S. candidate conducting habitat research, indicated that the protocol changes appeared to have improved postrelease survival rates (Gall et al. *this volume*). Survival among radio-marked birds averaged about 2.5 days in 1994 whereas survival increased to 12 days in 1995 (Gall et al. *this volume*). Moreover, in 1995 larger groups of masked bobwhites were observed for longer periods of time than in years past. Improved postrelease survival also occurred during a very dry winter (1995-1996), so habitat and environmental conditions were not conducive to good quail survival. BANWR biologists did not receive the funding necessary to purchase new radios in 1996. Nevertheless, though only 4 radios were available, postrelease survival of these radioed birds averaged 28 days (Gall et al. *this volume*). Recovery committee members were optimistic that the new propagation and release protocols would contribute significantly to achieving recovery goals on the BANWR.

Meanwhile, during the fall of 1995, U.S. Department of the Interior's policy makers decided that the PERC would no longer house and maintain the captive

masked bobwhite population. USDI, FWS, Region 2 officials subsequently initiated the process of assuming responsibility of caring for the captive population and housing it on the BANWR. With the assistance of PERC Scientists a "state of the art" captive propagation facility was designed and construction commenced on the BANWR during December 1995. The facility was completed by the end of March 1996 and the captive population was moved to the BANWR in April. Refuge officials believed that housing the captive population in Arizona would improve propagation and release efforts because BANWR biologists could now immediately implement alterations to chick production protocols to improve the release program.

Moving the captive population, however, did create some difficulties relative to the 1996 release season. Since the captive birds did not arrive until April, and needed at least a month to acclimate to their new surroundings, the captive breeding season was delayed for almost 6 weeks. Breeding behavior was not stimulated until the third week of May, and although egg production was similar to what the PERC achieved each year, young chicks were released later than they had been in the past. Chicks were thus exposed to cooler temperatures and prerelease survival rates suffered significantly as a result. Consequently, substantially fewer chicks were released during the late summer and fall of 1996. Nevertheless, refuge biologists continued following the new protocols developed in 1995 and again, postrelease over-winter survival among chicks released appeared to be at least as good as what was achieved in 1995 (Gall et al. *this volume*).

Though results of the improved propagation and release protocols are preliminary, refuge biologists are now confident that these protocols improve postrelease survival. The focus of 1997, and the future, was to begin captive breeding earlier, by April 1, and to maximize chick production each year. Biologists will also consider initiating breeding activity in January during wet winters in order to release a group of chicks in late March. Wild masked bobwhites probably produce a limited number of chicks in late March or early April following a wet winter. If this does occur, supplementing natural chick production with captive-reared chicks may bolster the wild population on the BANWR. The new captive propagation and release protocols also might improve post-release survival among wild birds translocated from Rancho El Carrizo.

1998 to 1999

Sonora

Herbaceous habitat conditions continued to improve throughout Rancho El Carrizo due to a reduced grazing pressure and above average precipitation. During the summer of 1998, ranch vaqueros told BANWR biologists that many masked bobwhite breeding whistles could be heard every morning on a 800 ha pasture that was designated as critical habitat by Alejandro Camou in 1996. Call-counts were conducted during

the third week of August in 1998 (Camou et al. 1998), and a record number of males were recorded (72) (Figure 2). In fact, an additional 60 males were recorded on new survey routes installed that summer. The ranch vaqueros also said that they had observed more broods during the late summer and early fall of 1998 than the previous 5 years. It was clear that the Rancho El Carrizo masked bobwhite population had recovered from the drought of the mid 1990's.

Like Rancho El Carrizo, masked bobwhite habitat conditions improved on Rancho Grande during 1998. Mr. Fimbres constructed 4 SDGs on approximately 3500 ha of the ranch. He also asked BANWR biologists for guidance in managing grazing on each of the SDGs, and indicated that he wants to manage these grazing systems in a manner that benefits masked bobwhites. Mr. Fimbres also emerged as a strong proponent of wildlife conservation in general, and masked bobwhite recovery in particular, in Sonora. He is a prominent rancher in the state, and is considered a leader by his Sonoran cattlemen peers. During fall 1998, he and Gustavo Camou, convinced 2 fellow ranchers, who control thousands of acres of masked bobwhite habitat, to consider joining the masked bobwhite recovery effort. Mr. Fimbres arranged for BANWR officials to meet the prospective cooperators at a meeting on his ranch. BANWR biologists were invited to tour the 2 new ranches (during summer 1999) and conduct a masked bobwhite survey as a result of this meeting.

Since masked bobwhite recovery in Sonora was proceeding in such a positive direction in 1998, and record numbers of birds were recorded during the summer survey, recovery cooperators in the U.S. and Mexico decided it was appropriate to attempt a major recovery goal. During the fall of 1998 they began the permitting process necessary to translocate 40 masked bobwhites to Rancho Grande and 100 masked bobwhites to the BANWR. Permits were issued in March 1999. During the first week of April, 37 wild masked bobwhites were live trapped and transported to the BANWR. Some of these birds will be used to improve the genetic quality of the captive population. However, over half of the wild masked bobwhites from Sonora will be released on the refuge. This release will represent the first time wild masked bobwhites have inhabited the U.S. since they were extirpated in the late 1890's. Biologists will attempt to capture the additional 103 wild masked bobwhites during the summer and fall of 1999. However, habitat conditions have deteriorated due to a drought that began during the fall of 1998, and the Rancho El Carrizo masked bobwhite population is currently declining. If the drought persists through the summer of 1999, chick recruitment will likely be poor and the population will continue to decline. Removal of additional individuals from the masked bobwhite population will therefore have to be postponed until the population increases again.

Despite present concerns about the drought in Sonora, the prospect of masked bobwhite recovery has improved since 1995. Better grazing management, and increased interest in recovery among U.S. conserva-

tion foundations and prominent ranchers, should improve the probability of achieving additional recovery goals on both Rancho El Carrizo and Rancho El Grande in coming years.

Arizona

Masked bobwhite abundance on the BANWR continued to improve through 1998. Summer call-counts documented an increase in calling males as 32 birds were recorded whereas 19 males were recorded on the same routes during summer 1997. Precipitation between the summers of 1997 and 1998 was average-to-above average. Habitat conditions were therefore good, and it is likely that increased survival and chick recruitment contributed to the population increase observed. Additionally, biologists are confident that the modified propagation and release protocols adopted in 1995 also contributed to increased abundance. Nevertheless, prerelease chick survival remains a problem because only 15 % of the chicks that are produced by the captive population survive and are released (Gall et al. *this volume*). At least 80% of the mortality occurs among week old chicks. Refuge biologists have yet to resolve the problem(s) responsible for the high mortality rate, but continue to work on isolating the cause(s). They are confident, however, that the chicks that survive the rearing process are strong, healthy and well suited for life in the wild. When survival among very young chicks improves, harder juvenile masked bobwhites will be released each fall, and the refuge population should increase as a result.

In 1998, the two graduate students working on masked bobwhite habitat ecology finished their respective projects. Analyses of their data revealed aspects of masked bobwhite habitat ecology that were previously unknown. For example, earlier observations from biologists working on masked bobwhites indicated that masked bobwhites required relatively open grasslands (5–10% woody cover) consisting of predominantly native herbaceous species to survive and persist in a self-sustainable manner (Tomlinson 1972a, Goodwin 1982, Brown 1989, Simms 1989). In contrast, Guthery et al. (2000) found that woody cover was a much more important habitat variable than previously thought. Masked bobwhites on both Rancho El Carrizo and the BANWR, selected habitats with more woody cover than was randomly available because operative temperatures and exposure to aerial predators were lower in these habitats (Guthery *this volume*). Masked bobwhite habitat should consist of at least 20–25% woody cover, and ideal shrub height is about 1-m. Moreover, masked bobwhites on the BANWR did not display a preference for either native grass cover or exotic grass cover (King 1998). Both herbaceous habitat types were used indiscriminately. The results of these studies have already impacted BANWR management. The prescribed burning program had to be modified in deference to the importance of woody cover to masked bobwhites. The previous burning cycle of 4 years had to be modified on portions of the BANWR important to masked bobwhites,

to 6 years to ensure that sufficient woody cover is available to the birds.

During the summer of 1999, about 2 dozen of the wild masked bobwhites translocated to the BANWR in March, will be released on the refuge. Two groups, representing the original coveys trapped in Sonora, will be released during the summer shortly before the masked bobwhite breeding season begins in late July. USDI, FWS officials hope that these wild birds will survive to produce and raise chicks during the 1999 breeding season.

Like masked bobwhite recovery in Sonora, recovery in Arizona continued to progress during 1998 and 1999. Additional time will be needed to achieve all of the masked bobwhite recovery goals on the BANWR; however, recovery appears to be proceeding in a positive direction.

SUMMARY

Masked bobwhite recovery has a long history and it has been a dynamic process. Early efforts focused on identifying remnant populations in Sonora, live-trapping individuals from these populations, and releasing them in the U.S. Despite the failure of these attempts, sufficient interest remained among ornithologists to conduct periodic surveys for masked bobwhites in Sonora. These efforts yielded dividends when a small population was rediscovered in north-central Sonora in 1964. Interest in preventing extinction increased as a result of the rediscovery. Conservation prospects further improved when masked bobwhites were listed as endangered in 1968. Essential financial support was made available to pursue recovery and as a result, a captive population was established and aggressive reintroduction research was implemented during the 1970's and into the 1980's. Establishment of the BANWR in 1985 was viewed as the most important accomplishment of recovery efforts at the time. However, increased interest and cooperation among Sonoran ranchers and conservation officials, as well as innovative habitat and propagation and release research that occurred over the next decade, proved to be as important as refuge establishment to the eventual recovery of masked bobwhites. The recent interest and financial support of conservation funding organizations, and a general increase in public support for masked bobwhite recovery, have also furthered recovery efforts in both Arizona and Sonora.

The masked bobwhite recovery program has weathered numerous set-backs. The recovery objective and associated criteria have not yet been fulfilled. However, aspects of the program improved dramatically over the past 3 decades. The deep sense of commitment and cooperation that existed, and still exists, among the various Federal and State Agencies in the U.S. and Mexico, as well as among private citizens in both countries, has prevented the extinction of masked bobwhites. Maintaining this sense of commitment and spirit of cooperation is essential to the future of recovery. These qualities are particularly important in

Sonora where the continued welfare of the masked bobwhite depends largely on cooperation of the people who manage the land. Great progress has been made in developing positive management attitudes among Sonoran ranchers whose activities directly influence masked bobwhite survival. It remains important that these individuals feel they continue to be an important part of the decision-making process. Those interested in masked bobwhite recovery must also do a better job of educating the public about not only the plight of the masked bobwhite and quail in general, but about the threats special interest groups pose to ecosystem protection. Masked bobwhite recovery remains an attainable goal, and those involved in current recovery efforts are optimistic it can eventually be achieved. Nevertheless, continued commitment to innovative research and public education are essential to achieving masked bobwhite recovery in the U.S. and Mexico.

ACKNOWLEDGMENTS

Many individuals, agencies and organizations have devoted a great deal of time and effort toward masked bobwhite recovery. Those people who deserve special recognition include E. Lopez Saaveda, T. Herrera Solis, F. Garza Salazar, J. Levy, S. Levy, S. Gallizioli, W. Swank, K. Brown, K. O'Malley, D. Ellis, J. Goodwin, K. Simms, N. Smith, A. Jontz, M. Hawks, M. Morris, P. Landin, A. Hiraes, E. Hiraes, A. Witman, R. Olding, J. Heffelfinger, B. Palmer, L. Wada, P. Miller, D. McKown, and D. Smith, as well as W. Shifflett and the members of the BANWR staff. The Camou and Fimbres families in Sonora, Mexico deserve special thanks for their generous hospitality and for maintaining an active interest in masked bobwhite recovery. Various Sonoran biologists also made significant contributions. P. Krausman and E. Maughan reviewed this manuscript; we appreciate their time and constructive comments.

LITERATURE CITED

- Arrington, O.N. 1942. A survey of possible refuge areas for masked bobwhite in the Arivaca and Altar Valleys. Arizona Game and Fish Commission Special Report. Project. 11D.
- Bahre, C.J. 1995. Human impacts on the grasslands of southeastern Arizona. Pages 230–264 in M.P. McClaran and T.R. Van Devender (eds.). *The desert grassland*. University of Arizona Press, Tucson.
- Banks, R.C. 1975. Plumage variation in the masked bobwhite. *Condor* 77:486–487.
- Bent, A.C. 1932. Life histories of North American gallinaceous birds. U.S. National Museum Bulletin. Number 162.
- Brewster, W. 1887. Further notes on the masked bobwhite (*Colinus ridgwayi*). *Auk* 4: 159–160.
- Brown, D.E. 1989. Arizona Gamebirds. University of Arizona Press.
- Brown, H. 1885 Arizona quail notes. *Forest and Stream* 25:445.
- Brown, H. 1900. Conditions governing bird life in Arizona. *Auk* 17:31–34.
- Camou, G., W.P. Kuvlesky, Jr., and F.S. Guthery. 1998. The effect of rainfall on endangered masked bobwhite breeding activity in northcentral Sonora, Mexico. Pages 253–260 in Proceedings of the 8th Annual Border States Conference. Tucson, AZ.
- Carroll, J.P., W.P. Kuvlesky, Jr., S.A. Gall, and F. Garza-Salazar. 1994. Status of Mexican quails. Transactions of the North American Wildlife and Natural Resources Conference. 59: 231–239.
- Dobrott, S.J. 1990. Annual biological report. U.S. Fish and Wildlife Service, Buenos Aires National Wildlife Refuge, Sasabe, AZ.
- Dobrott, S.J. 1991. Annual biological report. U.S. Fish and Wildlife Service, Buenos Aires National Wildlife Refuge, Sasabe, AZ.
- Dobrott, S.J. 1992. Annual biological report. U.S. Fish and Wildlife Service, Buenos Aires National Wildlife Refuge, Sasabe, AZ.
- Ellis, D.H., and R. Tomlinson. 1974. Development of release techniques for masked bobwhites. Annual Research Progress Report, Patuxent Wildlife Research Center, Patuxent, MD.
- Ellis, D.H., and J.A. Serafin. 1977. A research program for the endangered masked bobwhite. *World Pheasant Association Journal* 2:16–33.
- Ellis, D.H., S.J. Dobrott, and J.G. Goodwin, Jr. 1978. Reintroduction techniques for masked bobwhite. Pages 345–354 in S. Temple (ed.). *Endangered birds: management techniques for preserving threatened species*. University of Wisconsin Press, Madison.
- Ellis, D.H., and J.W. Carpenter. 1981. A technique for vasectomizing birds. *Journal of Field Ornithology* 52:69–71.
- Gallizioli, S., S. Levy, and J. Levy. 1967. Can the masked bobwhite be saved from extinction? *Audubon Field Notes* 2: 571–575.
- Goodwin, J. G. 1981. Releases of masked bobwhites. University of Arizona Report to U. S. Fish and Wildlife Service, Albuquerque, NM.
- Goodwin, J.G. 1982. Habitat needs of masked bobwhite in Arizona. University of Arizona, contract report to U.S. Fish and Wildlife Service, Albuquerque, NM.
- Goodwin, J.G., and C.R. Hungerford. 1977. Habitat use by native Gambel's and scaled quail and released masked bobwhite quail in southern Arizona. Research Paper RM-197, U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.
- Guthery, F.S. 1986. Beef, brush and bobwhites: quail management in cattle country. Golden Banner Press, Corpus Christi, TX.
- Guthery, F.S., N.M. King, K.R. Nolte, W. P. Kuvlesky, Jr., S.A. DeStefano, S.A. Gall, and N.J. Silvy. 2000. Comparative habitat ecology of Texas and masked bobwhites. *Journal of Wildlife Management*. 64:407–420.
- Hardy, J.W., and C.A. McConnell. 1967. Bobwhite quail: propagation, conditioning and habitat management. Tennessee Game and Fish Commission, Nashville.
- Hart, D. 1933. Stocking with day-old quail. *Game Breeder and Sportsman* 37:271–275.
- Hollon, W.E. 1966. *The great American desert: then and now*. Oxford University Press, New York, NY.
- Johnsgard, P.A. 1973. Grouse and quails of North America. University of Nebraska Press, Lincoln, NE.
- King, N.M. 1998. Habitat use by endangered masked bobwhites and other quail on the Buenos Aires National Wildlife Refuge, Arizona. M.S. Thesis. University of Arizona, Tucson, AZ.
- Koerth, B.H., J.H. Mutz, and J.C. Segers. 1986. Availability of bobwhite foods after burning of Pan-American balsamscale. *Wildlife Society Bulletin* 14:146–150.
- Kuvlesky, W.P., Jr. 1993. Annual masked bobwhite report. U.S. Fish and Wildlife Service, Buenos Aires National Wildlife Refuge, Sasabe, AZ.
- Kuvlesky, W.P., Jr. 1994. Annual masked bobwhite report. U.S.

- Fish and Wildlife Service, Buenos Aires National Wildlife Refuge, Sasabe, AZ.
- Lawson, L.L. 1951. Masked bobwhite and Benson quail trapping in Sonora, Mexico. Federal Aid Job Completion Report. P-R Project W-40-R-2, Work Plan 2, Job 2. Arizona Game and Fish Department, Phoenix, AZ.
- Lehmann, V.W. 1984. Bobwhites in the Rio Grande Plains of Texas. Texas A&M University Press, College Station, TX.
- Levy, S.H., and J.J. Levy. 1984. Report of a brief reconnaissance of the Buenos Aires Ranch during August 1982 and 1983 in search of the masked bobwhite. Report to the U.S. Fish and Wildlife Service, Albuquerque, NM.
- Ligon, J.W. 1942. Masked bobwhite quail in southern Arizona and notes on efforts on restoration. Type-written memo of Information and Reference. Tucson Field Station files. Tucson, AZ.
- Ligon, J.W. 1952. The vanishing masked bobwhite. *Condor* 54: 48-50.
- Officer, J.E. 1987. Hispanic Arizona. University Arizona Press. Tucson, AZ.
- Ough, W.D., and J.C. deVos, Jr. 1984. Masked bobwhite investigations on the Buenos Aires Ranch in 1982. Report to the U.S. Fish and Wildlife Service, Albuquerque, NM.
- Phillips, A., J. Marshall, and G. Monson. 1964. The birds of Arizona. University of Arizona Press, Tucson, AZ.
- Ridgway, R. 1887. A manual of North American birds. J.P. Lippincott, Co., Philadelphia, PA.
- Roseberry, J. L., and W. D. Klimstra. 1984. Population ecology of the bobwhite. Southern Illinois University Press, Carbondale and Edwardsville, IL.
- Rosene, W. 1969. The bobwhite quail: its life and management. Rutgers University Press, New Brunswick, NJ.
- Shreve, F. 1942. The desert vegetation of North America. *Botanical Review* 8:195-246.
- Shreve, F. 1951. Vegetation and flora of the Sonoran Desert. Vol 1. Vegetation. Carnegie Institute Publication. 591:1-192.
- Simms, K. 1989. Home range, habitat use, and movement of reintroduced masked bobwhite. M.S. Thesis, University of Arizona, Tucson, AZ.
- Stanford, J.A. 1952. An evaluation of the adoption method of bobwhite quail propagation. Transactions of the North American Wildlife Conference 17:330-337.
- Stephens, F. 1885. Notes of an ornithological trip in Arizona and Sonora. *Auk* 2:225-231.
- Stoddard, H.L. 1931. The bobwhite quail: its habits, preservation and increase. Charles Scribner's Sons, NY.
- Tomlinson, R.E. 1972a. Review of literature on the endangered masked bobwhite. Research Publication 108:1-28, U.S. Fish and Wildlife Service, Albuquerque, NM.
- Tomlinson, R.E. 1972b. Current status of the endangered masked bobwhite quail. Transactions of the North American Wildlife and Natural Resources Conference 37:294-311.
- U.S. Fish and Wildlife Service. 1978. Masked bobwhite recovery plan. U.S. Fish and Wildlife Service, Albuquerque, NM.
- U.S. Fish and Wildlife Service. 1984. Masked bobwhite recovery plan (1st Revision). Albuquerque, NM.
- U.S. Fish and Wildlife Service. 1995. Masked bobwhite recovery plan (2nd Revision). Albuquerque, NM.
- U.S. Fish and Wildlife Service. 1996. Masked bobwhite (*Colinus virginianus ridwayi*) population and habitat viability assessment workshop. Albuquerque, NM.
- Van Rossem, A.J. 1945. A distributional survey of the birds of Sonora, Mexico. Occasional Papers Museum of Zoology 21:379, Louisiana State University, Baton Rouge, LA.
- Vleck, C.M., and S.J. Dobrott. 1993. Testosterone, antiandrogens, and alloparental behaviors in bobwhite quail foster fathers. *Hormones and Behavior* 27:92-107.
- Walker, L.W. 1964. Return of the masked bobwhite. *Zoonoos*. February:10-15.
- Whetstone, J. 1994. Riparian zones: neither mountain nor desert. Pages 338-343 in L. F. DeBano, P. F. Ffolliott, A. Ortegó-Rubio, G.J. Gottfried, R.H. Hamre, and C.B. Edminster, (technical coordinators). Biodiversity and management of the madrean archipelago: the sky islands of the southwestern United States and northwestern Mexico. General Technical Report RM-GTR-264, U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.
- Wilson, M.M., and J. A. Crawford. 1979. Response of bobwhites to controlled burning in south Texas. *Journal of Wildlife Management* 50:84-88.
- Wilson, R. 1976. Cattle died by the thousands. Arizona Days Section, Arizona Republic Newspaper. 10-17-76.