

**Masked Bobwhite**  
**(*Colinus virginianus ridgwayi*)**

**5-Year Status Review:  
Summary and Evaluation**



**U.S. Fish and Wildlife Service**

**Arizona Ecological Services–Tucson Field Office  
Tucson, Arizona**

**Buenos Aires National Wildlife Refuge  
Sasabe, Arizona**

**August 2025**

# 5-YEAR REVIEW

Masked Bobwhite (*Colinus virginianus ridgwayi*)

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## 5-YEAR REVIEW

[Masked Bobwhite (*Colinus virginianus ridgwayi*) ]

### 1.0 GENERAL INFORMATION

#### 1.1 Reviewers:

##### **Lead Regional or Headquarters Office:**

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#### 1.2 Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service or USFWS) is required by section 4(c)(2) of the Endangered Species Act (ESA) to conduct a status review of each listed species once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing as endangered or threatened is based on the species' status considering the five threat factors described in section 4(a)(1) of the ESA. These same five factors are considered in any subsequent reclassification or delisting decisions. In the 5-year review, we consider the best available scientific and commercial data on the species and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process including public review and comment.

### 1.3 Methodology used to complete the review:

[This review was completed jointly by USFWS Ecological Services, including the Arizona Ecological Services–Tucson Field Office and Southwest Region Ecological Services, and the National Wildlife Refuge System, including Buenos Aires National Wildlife Refuge, Southwest Region Division of Biological Sciences, and the Wildlife Health Office. In addition to the general solicitation of public comments published in the Federal Register (89 FR 4966), comments were solicited from individuals and organizations familiar with or responsible for the species. This 5-Year Status Review was completed using the best available scientific and commercial information which has become available since the publication of the most recent Masked Bobwhite Recovery Plan (USFWS 1995) and 5-Year Status Review (USFWS 2014). Information used came from published literature, informal documents, unpublished data, verbal correspondence with subject experts, recovery team discussions, research results, and refuge files. ]

### 1.4 Background:

#### 1.4.1 FR Notice citation announcing initiation of this review:

[89 FR 4966, January 25, 2024 ]

#### 1.4.2 Listing history:

##### Original Listing

**FR notice:** [32 FR 4001]

**Date listed:** [March 11, 1967]

**Entity listed:** [Masked Bobwhite (*Colinus virginianus ridgwayi*)]

**Classification:** [Endangered]

##### Revised Listing, if applicable

**FR notice:** [A/L]

**Date listed:** [A/L]

**Entity listed:** [A/L]

**Classification:** [A/L]

#### 1.4.3 Associated Rulemakings:

[None ]

#### 1.4.4 Review History:

[A 5-Year Status Review was published March 2014. ]

#### 1.4.5 Species' Recovery Priority Number at start of 5-year review:

[For the 2014 5-Year Status Review, the Recovery Priority Number for the masked bobwhite was 6. This number indicates that: (1) the masked bobwhite was listed as a

subspecies; (2) populations face a high degree of threat; (3) recovery potential is low; and (4) recovery of the masked bobwhite is not likely to be in conflict with construction or other development projects. |

#### **1.4.6 Recovery Plan or Outline**

**Name of plan or outline:** [Masked Bobwhite Recovery Plan, Second Revision]

**Date issued:** [April 1995]

**Dates of previous plans/amendment or outline, if applicable:** [1978, 1984, amended December 2019. |

## **2.0 REVIEW ANALYSIS**

Section 4 of the ESA (16 U.S.C. 1533) and its implementing regulations (50 CFR part 424) set forth the procedures for determining whether a species meets the definition of “endangered species” or “threatened species.” The ESA defines an “endangered species” as a species that is “in danger of extinction throughout all or a significant portion of its range,” and a “threatened species” as a species that is “likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” The ESA requires that we determine whether a species meets the definition of "endangered species" or "threatened species" due to any of the five factors described below.

Section 4(a) of the ESA describes five factors that may lead to endangered or threatened status for a species. These include: A) the present or threatened destruction, modification, or curtailment of its habitat or range; B) overutilization for commercial, recreational, scientific, or educational purposes; C) disease or predation; D) the inadequacy of existing regulatory mechanisms; or E) other natural or manmade factors affecting its continued existence.

The identification of any threat(s) does not necessarily mean that the species meets the statutory definition of an “endangered species” or a “threatened species.” In assessing whether a species meets either definition, we must evaluate all identified threats by considering the expected response of the species, and the effects of the threats—in light of those actions and conditions that will ameliorate the threats—on an individual, population, and species level. We evaluate each threat and its expected effects on the species, then analyze the cumulative effect of all of the threats on the species as a whole. We also consider the cumulative effect of the threats in light of those actions and conditions that will have positive effects on the species—such as any existing regulatory mechanisms or conservation efforts. The USFWS recommends whether the species meets the definition of an “endangered species” or a “threatened species” only after conducting this cumulative analysis and describing the expected effect on the species now and in the foreseeable future.

### **2.1 Distinct Population Segment (DPS) policy (1996):**

[No |

### **2.2 Updated Information and Current Species Status**||

## 2.2.1 Biology and Habitat

### 2.2.1.1 New information on the species' biology and life history:

New information presented in this report speaks to diet, water use, thermal refugia, and nesting that inform multiple facets of the masked bobwhite recovery program located at the Buenos Aires National Wildlife Refuge (BANWR).

#### Diet and Water Use

The masked bobwhite recovery program relies on the reintroduction of masked bobwhite individuals into suitable habitat on BANWR in southeast Arizona. Successful reintroduction of any species requires that basic habitat needs are met in areas identified for releases. For masked bobwhite, a critical component of habitat is the availability of food resources, especially seeds, invertebrates (i.e., soft bodied as snails and caterpillars) and to a lesser degree vegetative matter. In the past, anecdotal observations had placed masked bobwhite individuals closely associated with the shrub *Acaciella angustissima*, prairie acacia. In DeRango (2019a), seed forage preferences of captive masked bobwhite were examined to better understand how masked bobwhites will select seed in the wild, post-release.

Despite experimental flaws, findings indicated that prairie acacia was seemingly the least preferred among all seed choices, perhaps due to its novelty. The preference for the other seed types (milo and red millet) which bear more similarity to the seed blend used as part of the diet fed to captive quail conveys the importance of a well-defined search image when seeking out forage. DeRango (2019a) further concluded that released adults may show preferences on the landscape for the supplemental seed offered, perhaps exacerbating a reliance on supplemental feeding and skewing the trajectory away from learning to utilize food found on the landscape. As birds become conditioned to foraging on supplemental seed in the wild, they may learn to prefer this forage over wild food sources.

It should be noted that prairie acacia is one of several acacia species on BANWR and is the least abundant on the landscape and least likely to be encountered by masked bobwhite. Two other acacia species, cat claw acacia (*Senegalia greggi*) and wait-a-minute bush (*Mimosa aculeaticarpa biuncifera*), are ubiquitous across the refuge and produce seeds of similar size to prairie acacia. Cat claw acacia is common in ephemeral drainages and provides dense cover for quail in areas often used by masked bobwhite, suggesting that it is likely a very important species for several reasons (i.e., cover, concealment, and foraging).

More recently, Byrne (2023a) assessed the importance of seasonal plant phenology as a pivotal component of deciphering overall food availability and abundance for masked bobwhite within the varied biotic communities of BANWR. Seed diversity, availability and abundance, as well as invertebrate diversity and abundance are highly tied to plant phenology. Since botanical communities differ on various parts of the refuge, assessing how food availability for masked bobwhites at all life stages changes seasonally is crucial for post-release survival. Byrne (2023a) communicates recent discoveries that capture specific winter and spring plant dietary behaviors in the field, which are described below

Byrne (2023a) documented masked bobwhite in late winter (March 3, 2023), consuming the leaves of Western tansymustard (*Descurainia pinnata*). The plant occurs under the canopy of mesquite trees but also thrives in open and marginal disturbed areas in full sun. This plant emerges as a seedling in early winter of each previous year, as most spring annual plants on the refuge do. In March, it often has no phenological characteristic other than ‘new growth’ (no flower buds, flowers or seed pods yet). It is by far one of the most common, abundant and widespread spring annuals on BANWR. Later in spring (May 2, 2023), a masked bobwhite was documented consuming the dried seed pods of a Western tansymustard plant, as the phenology of this plant in early May on the refuge is primarily only these dried seed pods. Each small seed pod is filled with many tiny seeds, and each individual plant may have dozens or even hundreds of seed pods, dependent on the size of the plant.

Further, Byrne (2023a) documents in spring (May 2, 2023) a masked bobwhite was removing and discarding the leaves of a mature large yellow desert primrose (*Oenothera primiveris*). This plant does not occur under a protective tree canopy but thrives in full sun throughout the refuge. The mature leaves observed during the plant interaction were not consumed, only removed, which had uncovered and exposed the immature flower buds and hidden seed pods at the base of this near-prostrate plant. Later, on May 9, 2023, a masked bobwhite was documented pecking at and feeding on the top, distal portion of distant scorpion weed (*Phacelia distans*). This plant almost exclusively occurs under the protective canopy of mesquite trees. The phenology of the attended plant, and others nearby, exhibited the distal presence of flower buds, flowers and seed pods.

These observations presented by Byrne (2023a) are uniquely important to the masked bobwhite recovery program because while food plant types for Texas bobwhites are fairly well documented, those observations have been specific to quail and habitat in Texas. Thus, the transferability to masked bobwhites in arid grasslands of Arizona and Sonora, Mexico is not fully understood, and many of the native plants that masked bobwhite will encounter on the refuge are not specifically documented. In addition, one of the challenges of introducing captive-bred birds to the landscape as habitat-naïve animals revolves around these birds being able to promptly identify and exploit food resources upon release. The abovementioned three species of plants and their associated observations could potentially benefit the masked bobwhite recovery program on BANWR by conditioning captive birds to recognize and use ‘proven’ native food plants within the flight pens prior to release. These three species of spring annuals collectively represent both food availability and food abundance for approximately six months of the year, from November to May, even as their phenology changes. Further, these three plant species represent three different plant families, with approximately 46 individual species of plants document on the refuge and many of these are also likely food sources.

The importance of plant phenology is also described by Creech et al. (2023), where plant phenology (combined with climate extremes) was found to be a better predictor of wildlife responses to future climatic conditions than climate means. Predictors related to the timing and amount of vegetation greenness were strong predictors for the focal species, two of which were scaled and Gambel’s quail (*Callipepla squamat* and *C. gambelii*), species inhabiting the same localities as released masked bobwhites. Given the precipitation patterns

in the southwest, a single event is capable of influencing vegetation phenology, and thus food resources, for masked bobwhite. Considering precipitation timing and amount in relation to changes in habitat suitability for masked bobwhite should be a foundation in choosing release sites each year.

It is well documented and widely accepted that bobwhite quail chicks have high protein growth needs that are met by consuming invertebrates. Although there is published documentation that focuses on the type of invertebrates consumed in the wild by northern bobwhite adults and chicks (Orthoptera, Araneae, Coleoptera, Hemiptera, Homoptera, Hymenoptera) (Utz et al. 2001; Harveson et al. 2004), there is little information in this regard for masked bobwhite within the Sonoran grassland biotic community. Byrne (2023b) reviews the diversity of invertebrates encountered on BANWR from November 2022 to November 2023 during Buenos Aires Quail Index (BAQI) habitat assessments, and documents field invertebrate predation and consumption of invertebrate species by masked bobwhite, which are described below.

Not all invertebrate species that could be consumed by masked bobwhite are readily available, even if these are abundant in the field. Examples of this plausible reduction in availability include some species of adult invertebrates within the orders of Odonata (dragonflies / damselflies), Diptera (flies), Lepidoptera (butterflies and moths) and other fast, flighted invertebrates. These invertebrate species that have limited availability to masked bobwhite as adult invertebrates passively offer a spectrum of availability during their immature phases due to form and structural limitations intrinsic to their developmental stages. For instance, immature forms of adult winged insects have no functional wings during their developmental stages, making escape from predators unlikely when they are discovered. The amount of time an invertebrate species spends at 'quail level' (ground to tree level) as dictated by its ecology and natural history also affects its potential availability to masked bobwhite, but some species demonstrate behaviors that make them inaccessible. For example, most butterfly and moth larvae spend weeks as caterpillars on trees, shrubs, subshrubs and annual plants. These are accessible and available to quail. However, there are butterfly and moth species that demonstrate natural history behaviors that make them less accessible to land predators. The larvae of some butterflies in the Family Lycaenidae are tended and protected by ants, and there are moth caterpillars in the Family Crambidae that are aquatic organisms.

Between August 23, 2022 and August 24, 2023, there were 22 incidental, documented observations of masked bobwhite pursuing, capturing and eating live invertebrates in the field (USFWS 2023a). These incidental observations occurred during telemetry tracking of radio-collared birds and were made by four individuals over that period. The field observations of masked bobwhite feeding upon grasshoppers included one chick observation and 21 adult masked bobwhite observations that included males and females, with 23% of the observations from November 22, 2022 to March 16, 2023 during cool weather. While many invertebrate species have short adult life spans of only a few days or weeks, there are some that can survive and even become intermittently active during the winter months.

All of the aforementioned field observations were of masked bobwhite and grasshoppers, and multiple observations were of large *Schistocerca*. While some grasshopper species, such as spur-throated, slant-faced and lubbers, are limited by their inability to overwinter as adults and their short lifespan, bird and band-winged grasshoppers on BANWR can overwinter as nymphs or adults. This allows them to survive year-round and remain active on warmer winter days. The relationship between masked bobwhite and grasshoppers on BANWR landscape is a vital piece of the ‘pre-release puzzle’ that should be considered and discussed when deciding when to, or even whether to release habitat-naïve birds at a given time. The use of grasshoppers as a component of habitat assessments for selecting sites for masked bobwhite release is crucial for four main reasons. First, grasshoppers are the ‘canary in the coal mine’ for BANWR habitat plant health and can therefore be used as a predictor. They require green plant material to thrive, often preferring new growth plant parts. If they are available and abundant, then the plants that quail need for food and protection are or soon will be in good condition. Second, the absence or near-absence of grasshoppers within a potential release site is commensurate with inactive plant phenology and should be a red flag for releasing birds. Third, wild grasshoppers and other invertebrates are available in the outdoor flight and display pens, so the habitat-naïve captive birds are already familiar with this food source upon release. Fourth, although it takes a keen eye to assess grasshoppers accurately, especially tiny, newly-hatched nymphs, which can be abundant, their hatching is tied to rainfall, so their presence can be a prelude to currently stressed habitat that may recover quickly if rainfall continues.

Given the importance of water across southwestern landscapes, understanding how captively bred, released masked bobwhite utilize water is needed to manage habitat across BANWR. Byrne (2023c) assessed usage of wildlife drinkers on BANWR by masked bobwhites. Bobwhites, in general, are believed to acquire water through their diet – specifically, seeds, green vegetation, and some types of invertebrates (i.e., soft bodied as snails and caterpillars). In addition, dew present on food sources may also contribute to water consumption by bobwhites. However, in arid environments, it is not well documented to what extent surface water or supplemental water is needed, and water attendance and use by masked bobwhite on the BANWR landscape is sparsely documented. Arid grasslands in Arizona and Sonora are typically very dry and hot during the months of May, June, and sometimes early to mid-July with ambient temperatures exceeding 100 degrees Fahrenheit (°F), often with very little to no rainfall. Early to mid-July through mid-September are typically the times of the summer rainy (monsoon) season, with anything from generous (1.75 in, 2023 maximum) rainfall at frequent intervals to sparse (0.01 in; 2023 minimum) rainfall at infrequent, prolonged intervals (NOAA 2025a). For May–August, while ambient temperatures commonly reach in excess of 100°F, surface temperatures approach 140°F (USFWS 2025a). Gullion and Gullion (1964) found that Gambel’s quail became dependent on external sources of moisture, as temperatures exceeded their thermal neutrality, which can be supplemented through diet or other water intake. Desert-adapted quail, such as Gamble’s and presumably masked bobwhite, show very little difference in water loss from respiration and excretion and water gained from primarily seed diets so long as temperatures remain below the upper levels of thermal neutrality (Gullion and Gullion 1964). Thus, depending on both long- and short-

term climatic conditions, supplemental water on the landscape has been observed to benefit masked bobwhite survival during the hottest and driest seasons.

On BANWR, intermediate bulk container (IBC) tanks, portable supplemental water tanks, were utilized for masked bobwhite on the landscape, and were manually filled with approximately 300 gallons of fresh water for each station. At the time (2023), each of the IBC tanks in use on BANWR was connected via a buried hose to a protected (via caging) shallow drinking dish that was volume-regulated by a protected float valve. The external caging structure not only afforded a measure of predator protection to birds while in the act of drinking, but it also excluded larger animals from accessing the water itself. The portability of these supplemental watering stations was an advantage that allowed for landscape placement and relocation as needed, such as the birds' current home ranges and seasonal landscape use in concert with pre-release field habitat assessments. Masked bobwhites were documented using these water resources in the summer of 2022 and 2023, when ambient temperatures ranged from 77–127°F (Byrne 2023c). From the aspect of recovering an endangered species at the northernmost extent of its historical range in chronic drought conditions on the modified landscape of BANWR, the provision and maintenance of portable, supplemental water stations throughout the year is a sensible tool to aid in the recovery of the species. Since 2023, the IBC tanks on BANWR have been removed from the landscape due to frequent vandalism. Future planned supplemental watering efforts include buried water tanks that feed several above-ground drinkers. These will be located at future release sites.

### Thermal Refugia

The role of local thermal environments in masked bobwhite conservation remains poorly understood. How landscapes influence thermal conditions, and how bobwhite utilize thermally buffered microhabitats, is likely to become increasingly important in the context of environmental change.

To begin addressing this knowledge gap, DeRango (2019b) assessed climate data from loggers deployed from 2015 to 2017 by the George Miksch Sutton Avian Research Center (SARC) at 45 locations across BANWR, representing a range of elevations, geographic positions, and vegetation types. Initial analysis assessed broad-scale thermal trends over the full monitoring period followed by a focused examination of peak warming during the 2016 nesting and brooding season to enhance ecological relevance.

Although limitations in sampling design constrained refuge-wide inference, and the absence of detailed site-level vegetative and abiotic data limited analytical understanding, this exploratory study provides an initial view into the thermal heterogeneity of the landscape. Among vegetative types in this data set no clear pattern emerged, though there were significant differences between different temperature variables during different months of the year. None were consistent enough to be conclusive.

For example, in the driest summer months (May, June) shrubs had a significantly higher minimum temperatures than grasses. Likewise, shrubs were occasionally significantly

warmer than the surface in cooler months. Trees had lower average temperatures than shrubs during summer months, and during those same months maximum temperature was higher in grasses than on the surface across all sites.

The most conclusive result for this monthly evaluation was that maximum temperature was significantly higher in grass than in trees across all sites for all but two months (Nov/Dec). These preliminary findings highlight spatial variation in microclimate conditions across vegetation types and may inform future habitat management strategies aimed at improving conservation outcomes for the masked bobwhite.

### Nesting

The masked bobwhite recovery plan requires self-sustaining populations, which in turn require reproduction, of which only anecdotal information exists (**USFWS 1995**).

A notable event in 2020 was the discovery and monitoring of two masked bobwhite nests through telemetry, an achievement not documented in decades. Unfortunately, after more than 35 days of incubation, neither nest successfully hatched. Only one egg showed any discernible development upon examination (**USFWS 2020a**).

In 2021, another two nesting attempts were documented, both in early June and both with unknown fates. One nest is described as occurring in open woody habitat, and the second nest, was recorded in grassy forb habitat (**USFWS 2021a**).

In 2022, one confirmed and two suspected nests were documented in woody open and grassy forb habitats. The single confirmed nest was documented on August 12, 2022 with a disclosed number of eggs. The remaining two observations were suspected as nesting attempts, given that the pairs associated with each remained at the location for multiple days (**USFWS 2022a**).

In 2023, two nesting attempts by masked bobwhite were discovered during radio telemetry tracking (**Byrne 2023d**). The first nest was discovered on August 25, 2023, and subsequent observations noted three eggs. The female was documented on the nest from August 25, 2023, to September 9, 2023 (15 days). No chicks were observed at any time, and on September 11, 2023, the female was tracked to Mormon Lake (approximately 0.5 miles away). After nest abandonment, a single intact egg was found with no evidence of the other two eggs (i.e., eggshell fragments). Short-leaf false willow (*Baccharis brachyphylla*) was the nest's primary vegetative cover. Surrounding vegetation included velvet mesquite (*Prosopis velutina*), the nonnative Lehmann's lovegrass (*Eragrostis lehmanniana*), cane bluestem (*Bothriochloa barbinodis*), short-leaf false willow (*Baccharis brachyphylla*), and snakeweed (*Gutierrezia microcephala*).

A second nest, discovered on September 19, 2023, was associated with a radio-marked female, containing seven eggs when observed. The date of nest abandonment is not known, but a follow-up visit on October 4, 2023, revealed that the nest was no longer occupied, and no intact eggs remained; however, many eggshell fragments were observed. The nest was

located within stands of the nonnative Lehmann's lovegrass with surrounding vegetation comprised of velvet mesquite, Lehmann's lovegrass, snakeweed, camphorweed (*Heterotheca subaxilaris*), ragweed (*Ambrosia confertiflora*), and Russian thistle (*Salsola tragus*).

Nonnative plant species, specifically Lehman's lovegrass and buffelgrass, are well documented in the Altar Valley and on BANWR. Although masked bobwhite have been documented using Lehman's lovegrass in the past (**Goodwin and Hungerford 1977; King 1998**) as well as above, it is generally considered unsuitable, given its tendency to create monoculture stands that do not provide the best structure for nesting and brooding. For both nonnative species, prescribed fire is not the single recommended treatment, rather an integrated approach is needed that focuses on removing adult plants and reseeding with native species for areas with Lehman's lovegrass and controlling established plants and propagule control for areas dominated by buffelgrass.

### Effects of Fire

New information regarding habitat for the masked bobwhite includes the effects of fire on habitat suitability and habitat modeling efforts in both the U.S. and Mexico.

Fire history of the semi-arid grasslands in southern Arizona, specifically the Altar Valley, suggests that naturally occurring (lightning ignition) fires had a frequency of 10 years or less and occurred during monsoon season (June–July) (**McPherson 1995**); but masked bobwhite habitat likely experienced longer return frequencies given the presence of woody shrubs and trees. The use of prescribed fire has occurred on BANWR since the establishment of the refuge in 1985. Yurcich (**2018**) looked at two components of fire in masked bobwhite habitat on BANWR. First, the relationship between site fire frequency was compared to masked bobwhite habitat components to understand potential interactions. Results showed that historical fire frequencies ranged from 0–31 years on BANWR across study plots, with 71% being prescribed burns. Burns occurred more often in areas with higher precipitation and locations consisting of higher Lehmann's lovegrass cover. Overall conclusions indicate that increased fire frequency on BANWR has nearly eliminated the shrub component of masked bobwhite habitat and facilitated the spread of Lehmann's lovegrass to the detriment of native perennial bunchgrasses.

Second, Yurcich (**2018**) quantified plant community composition differences along a resource and disturbance gradient to understand perennial and annual grass species composition related to prescribed fire. Higher precipitation and lower temperatures (located in the southern portions of BANWR) were highly correlated with nonnative grass cover. Given that increased grass biomass more effectively carries fire across a landscape, these areas were burned more frequently than drier areas, resulting in higher abundance of Lehmann's lovegrass. Further, locations of native perennial bunchgrasses were related to sandier soils located in drainages that had escaped burning, allowing these species to persist in the landscape. The presence of Lehmann's lovegrass negatively affected native grass species such that overall species diversity was lowered, thus diminishing the structural diversity of nesting habitat for masked bobwhite.

Building on this work, Sesnie and Dickson (2018) addressed four objectives related to fire and masked bobwhite habitat by developing methods to assess the long-term effects fire has on vegetation and fine-fuel loads essential for masked bobwhite survival, while also examining the effects that fire frequency and biophysical factors have in improving habitat conditions. Findings indicated that soil and climatic conditions were important factors in how fire affected masked bobwhite habitat. In the near-term (2–3 years), fire produced beneficial effects, most notably increased forb and herbaceous cover, but these benefits were mediated by increased Lehmann’s lovegrass growth. Further, fuel conditions on BANWR (as a result of nonnative vegetation), generally do not support the appropriate low-intensity fires that maintain sub-shrub and woody components within ideal ranges for masked bobwhite habitat. Lastly, dense stands of Lehmann’s lovegrass increase fire intensity and frequency that counteracts positive habitat management objectives for masked bobwhite. Sesnie and Dickson (2018) recommend considering appropriate recovery times across BANWR for differing vegetation communities and site conditions to improve habitat restoration outcomes.

#### Habitat Modeling–U.S.

Leveraging remotely sensed data, specifically LiDAR (light detection and ranging) and high-resolution multi-spectral satellite imagery, Sesnie et al. (2022) developed and evaluated multi-sensor machine learning models to estimate habitat suitability for masked bobwhite to inform reintroduction efforts and assess management efforts on BANWR. Given that the contemporary landscape is shaped by a legacy of intensive livestock grazing, periodic drought, and altered arid land hydrology, these changes, coupled with shifts in historical land use, have disrupted natural disturbance regimes, particularly fire cycles, that once sustained native grassland composition and structure. The use of multiple sensors (multispectral WorldView-3 satellite imagery and airborne LiDAR) and acquisition dates combined with field-based habitat assessments, enhanced habitat modeling by providing more detailed data, especially in distinguishing woody vegetation from herbaceous species. The application of regression and structural equation models across 239 vegetation plots stratified by topography and fire frequency was used to assess the influence of fire history, climate, and site biophysical factors on habitat suitability. In general, areas with less frequent fire return times tended to be more suitable for masked bobwhite whereas shorter fire return intervals tended to be less suitable due to increased abundance of nonnative grasses and decreased shrubby and woody cover. Sesnie et al. (2022) findings suggest that in desert grasslands with low primary productivity, more than 20 years of recovery may be necessary to reestablish the optimal mix of herbaceous and woody vegetation for masked bobwhite habitat, especially in areas subjected to two or more fires in the past three decades.

#### Habitat Modeling–Mexico

El Carrizo and San Dario ranches, collectively known as El Seri, cover approximately 39,537 acres (ac) in Sonora, Mexico. The area consists of subtropical grasslands and shrublands. Climate in the region has become warmer and drier since the 1970s. Average annual temperature and precipitation from 1991 to 2020 were 72.3°F and 14”, respectively, compared to 15.5” of precipitation recorded between 1961 and 1990. Precipitation records

from El Carrizo (1956–1994) averaged  $14.6 \pm 4.6''$  annually. These ranches are managed for rotational grazing, agriculture, quail habitat conservation, and recreational big-game hunting. Sesnie and Johnson (2023a, 2023b) examined habitat conditions for masked bobwhite on these ranches in Sonora, Mexico, where one of the few remaining wild populations had been documented (Camou et al. 1998). To support site selection for future masked bobwhite releases and habitat enhancement across management units, vegetation structure and composition were measured on El Carrizo and San Dario ranches, after which habitat conditions associated with masked bobwhite presence were planned based on data from autonomous recording units, but unfortunately no potential masked bobwhite calls were verified. Thus, using habitat information and map-based land cover vegetation data from El Carrizo and San Dario, these data were compared with vegetation plots from BANWR in southern Arizona to evaluate regional similarities and differences in habitat conditions.

Vegetation sampling was conducted at 44 systematically placed sites spaced  $7 \times 7$  miles apart, co-located with autonomous recording units (ARUs) to determine presence of masked bobwhite. Each plot measured  $66 \times 164'$  and included five 66-foot point-intercept transects, spaced evenly and aligned parallel to the slope. Plant species were recorded at 1.64' intervals across three vertical strata. Sampling occurred during an average rainfall year between September 20 and November 3, 2016. Vegetation composition and cover was analyzed by life form (e.g., tree, grass, shrub) to identify patterns associated with masked bobwhite detections.

Vegetation data were summarized descriptively and analyzed using species ordination and hierarchical clustering. These were compared to data collected from BANWR between 2014 and 2015. No conclusive detections of masked bobwhite calls were recorded on the Sonoran ranches using ARUs. Consequently, analyses focused on vegetation comparisons between Sonora and Arizona sites. Differences were observed in both life form composition and species assemblages. Notably, perennial nonnative grasses had greater cover on Arizona plots. In particular, Lehmann's lovegrass (Arizona) and buffleggrass (Sonora) were dominant in respective regions.

Sonoran plots had significantly greater cover of shrubs and native annual grasses, while Arizona plots had higher cover of native perennial grasses with key species associated with native-dominated plots in Sonora including *Bouteloua barbata*, *Panicum hallii*, *Aristida purpurea*, *Bouteloua aristidoides*, *Trianthema portulacastrum*, *Allionia incarnata*, and *Chamaecrista nictitans*. Common and ecologically significant species in Sonora included *Acacia angustissima* and *Ambrosia confertiflora*, along with *C. nictitans*, all of which are also present in Arizona and serve as important winter food sources for masked bobwhite.

The Sonoran and Arizona sites are separated by approximately 106 miles, which likely contributes to observed differences in species composition. Climatic differences, warmer and wetter summers in Sonora, and greater diurnal temperature variation in Arizona also influence vegetation structure. Additionally, land use practices vary markedly: Sonoran ranches are grazed rotationally, while BANWR has seen minimal grazing and frequent fires since 1985. Habitats with a mosaic of trees, grasses, shrubs, and native forbs appear most

suitable for masked bobwhite reintroduction. Ongoing work is focused on mapping such habitats to guide conservation efforts and restoration planning. |

**2.2.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, birth rate, seed set, germination rate, age at mortality, mortality rate, etc.), or demographic trends:**

Wild and Release Populations—U.S.

In the U.S., the masked bobwhite was extirpated from the wild before 1900, and all individuals that occur within the Altar Valley landscape are products of a captive breed and release program sited at BANWR. By 2012, approximately 31,000 captive-reared bobwhites had been released into the Altar Valley region, with 21,000 of these birds released directly on BANWR (Cohan et al. 2012; Brown and Clark 2017). Between 2014 and 2016, there were no significant documented releases of masked bobwhite on BANWR or in the broader Altar Valley.

Thus, 2017 provided an opportunity for reassessment of recovery methods and the planning of more targeted strategies (USFWS 2021b). As part of this new structure, management of the program was shifted from BANWR to the Division of Biological Sciences, a regional Refuges program. The release program began operating under an IACUC for the first time in the program's history, and pilot releases marked a shift in methods. A modified foster-parent approach was tested using 10 vasectomized male Texas northern bobwhites and 10 broods of masked bobwhite chicks (13–14 chicks per brood), totaling 132 chicks. These initial releases occurred in September. Simultaneously, a series of 11 call-box releases were conducted between October 2017 and February 2018. The call-box technique involved conditioning birds in semi-natural enclosures placed in suitable habitat, primarily in the eastern portion of the refuge. A total of 259 older birds (over three years of age) were conditioned, of which 149 survived the three-week acclimation period prior to release. The primary goal of this method was to reduce the aging captive population while evaluating the feasibility of establishing older birds in the wild. The longest post-release survival was one month.

In 2018, 29 broods averaging 15 masked bobwhite chicks each were released between July and September, totaling 447 chicks. Twelve of these broods were cross fostered with Texas northern bobwhite males and released in the Secundino area, while 17 broods were raised by captive masked bobwhite adults in the southeastern portion of BANWR. These two groups were spatially separated to enable comparative analysis. The use of masked bobwhite foster parents allowed for a higher number of chicks to be released and facilitated data collection on the survival of both the adult foster parents and their chicks. Habitat selection was guided by suitability assessments using a modified Texas Quail Index. At the end of the season, an estimated 60 chicks and two masked bobwhite adults survived to covey breakup. The overall survival was 13%, but survival varied by foster parent type—28% for chicks raised by Texas northern bobwhite and 4% raised by masked bobwhite adults.

In 2019, a total of 63 broods were released between July and October, averaging 10 chicks each and totaling 623 chicks. Of these, 29 broods were cross fostered with Texas northern bobwhite and 34 with captive masked bobwhite. Broods were released across three regions of the refuge: Secundino, Southeast, and Southwest. These regions were selected to allow for a comparison of survival outcomes across varying habitat compositions, while ensuring that all sites met the suitability criteria. Despite a higher number of releases, overall survival was lower than in 2018. An estimated 38 chicks and one masked bobwhite adult entered the 2020 breeding season, resulting in a 6% survival rate. Once again, chicks raised by Texas northern bobwhite exhibited better survival (11%) than those raised by captive masked bobwhite (3%). Chick detection challenges likely contributed to underestimation of survival of chicks for both parent types. It is believed that releasing younger, two-week-old chicks may have contributed to the reduced survival rate, prompting plans to return to using three-week-old chicks in antecedent releases. Importantly, in August 2019, reproduction by masked bobwhite in the wild (an adult with chicks) was captured on a wildlife camera, the first documentation in over three decades, marking a significant milestone in the recovery effort.

In 2020, 43 family units were released, totaling approximately 581 three-week-old chicks. Thirty-four of these units included Texas northern bobwhite males with 479 chicks (averaging 14 chicks per brood), and nine units involved masked bobwhite males with 102 chicks (averaging 11 chicks per brood). In addition, 82 adult masked bobwhite (33 males and 49 females) were released throughout the year for covey supplementation and to extend the duration of telemetry tracking. A small group of fewer than 25 adult masked bobwhite was also released near headquarters in the spring, with the goal of establishing a permanent population.

Released family units were tracked until either a mortality signal was detected, the transmitter failed, or the marked parent could no longer be located. Among the radio-marked foster parents, average post-release survival ranged from 17–25 days across four batches, with a maximum observed survival of 65 days. Seven family units were confirmed with chicks at the one-week post-release check, and one family unit was observed with chicks at four weeks. Survival rates for tracked adults and chicks in 2020 were lower than in previous years, likely due to extreme drought and heat conditions in southern Arizona. However, at 4–6 weeks of age, bobwhite can thermoregulate independently and may survive even after the loss of a foster parent. By the spring of 2020, a minimum of 50 birds from 2019 remained on the landscape, with additional individuals likely present but undetected. Observations continued throughout the summer and into the winter, including sightings of birds from both the 2020 releases and wild reproduction.

Between 2017 and 2020, as outlined in USFWS (2021b) masked bobwhite recovery efforts on BANWR evolved significantly through adaptive management. Strategies such as cross-fostering with Texas northern bobwhite and careful habitat selection have shown promise, with foster-parenting by wild birds yielding notably higher survival rates than those involving captive masked bobwhite adults. Environmental stressors, including extreme weather and predation, remain major challenges to long-term success. Nevertheless, key milestones; such as the first recorded wild reproduction in over 30 years and the discovery of

nesting attempts, offer encouragement and direction for future efforts. Ongoing refinement of release strategies, including optimal chick age, habitat assessment, refinements to conditioning, and foster-parent selection, will be critical to restoring a self-sustaining population of masked bobwhite.

In 2021, management of the masked bobwhite recovery program was shifted back to BANWR leadership, as planned in 2017, to build upon knowledge gained from 2017–2020. Total birds released on BANWR in 2021 was 805 (105 adults and 688 chicks) (**USFWS 2021c**) with 105 individuals radio-marked for tracking and monitoring (**USFWS 2021d**). Of these 105 individuals, BANWR released 42 masked bobwhites, SARC and surplus BANWR individuals, as supplemental birds to augment known established coveys in March (Middle Tank and Headquarters), April (Middle Tank), June (Headquarters), November (Headquarters and Secundino), and December (Secundino). Groups released as new, established coveys contained 10 marked individuals and were released in November and December near the flight pens and Compartidero Flats. Four batches of foster males (northern and masked bobwhite, n=53) with chicks (11–15/brood) were released on BANWR. On July 29–30, 2021, 7 marked broods were released at Headquarters; August 18–19, 2021, 15 (7 masked and 8 northern bobwhites) marked broods were released at Middle Tank, Secundino, and near the Santa Margarita Ranch; September 13, 2021, 21 (masked bobwhite) marked broods released near Road 223 and in Secundino; October 4, 2021, 10 (masked bobwhite) marked broods released near Road 234. By October 22, 2021, of the 53 broods released, 43% (n=23) were still alive and being actively tracked, whereas 23 were confirmed dead and 7 broods considered missing (i.e., transmitter died so location and fate unknown).

In 2022, BANWR released batches of broods, of which 31 had radio transmitters and were monitored (**USFWS 2022b**). By October 26, 2022, 16 (51.6%) were considered mortalities. More detailed records could not be found in refuge files.

In 2023, BANWR released 517 birds, (41 adults and 476 chicks), primarily sourced from SARC. Final disposition of these birds is unknown, as detailed records could not be located in refuge files. In 2024, the refuge released 27 birds that were held in the display pen. The birds did not receive radio transmitters and thus were not monitored. The post-release fate of these birds remains unknown.

### Wild Populations–Mexico

No reintroduction programs are known to exist in Sonora, Mexico and the wild populations have been documented in decline for decades. A single, reduced population of masked bobwhite in Sonora was estimated to include 1,000 individuals between 1968-1972 (**Tomlinson 1972a**). A few individuals were detected in 2004 and 2006 (**Gómez-Limón 2007**) and by 2010 had disappeared (**CITES 2011**). In **García-Solórzano et al. (2017)**, the most recent status of the masked bobwhite in Mexico is presented. Surveys conducted between 2013–2015, informed by past information and new interviews with local residents, conducted by **García-Solórzano et al. (2017)** turned up anecdotal evidence of recent masked

bobwhite sightings, but no first-hand evidence was collected. Recommendations from García-Solórzano et al. (2017) included producing a sonogram for the masked bobwhite to increase detections using acoustic monitoring and increased survey efforts. The lack of evidence of wild individuals in Sonora is highly suggestive that the species may be functionally extirpated in the wild there.

### Captive Populations–U.S.

Given that few to no wild individuals occur in the U.S. and Mexico, several current and planned captive facilities are breeding masked bobwhite for release. The masked bobwhite recovery program at BANWR leverages captive breeding and releases of masked bobwhite, as described in the most recent recovery plan (USFWS 1995), in efforts to re-establish wild populations in the U.S.

#### *Buenos Aires National Wildlife Refuge*

In 1996, the captive population of masked bobwhite was transferred from the Patuxent Wildlife Research Center in Laurel Maryland to BANWR. The BANWR captive population continues to comprise approximately 325–450 individuals held at any one time (Table 1). The number of captive birds varies from year to year due to the variability in success hatching chicks and mortality rates across the population.

*Table 1. BANWR captive facility breeding metrics from 2015-2023.*

Year	Hatch #	Date Set	Date Hatched	No. of Eggs Incubated	No. of Eggs Fertile	No. of Chicks Hatched	Fertility Rate (%)	Hatch Rate (%)	Survival Rate (%)
2015	Hatch 1	7/1/2015	7/24/2015	168	98	68	58%	69%	91%
2015	Hatch 2	7/15/2015	8/7/2015	350	242	187	69%	77%	86%
2015	Hatch 3	7/29/2015	8/21/2015	479	343	283	72%	83%	93%
2015	Hatch 4	8/12/2015	9/4/2015	438	259	217	59%	84%	92%
2015	Hatch 5	8/24/2015	9/16/2015	231	111	89	48%	80%	82%
<b>2015 Summary</b>	Hatch 1–5	7/2015–8/2015	7/2015–9/2015	<b>1,666</b>	<b>1,053</b>	<b>844</b>	<b>63%</b>	<b>80%</b>	<b>91%</b>
<b>2016 Summary</b>	N/A	N/A	N/A	<b>N/A</b>	<b>N/A</b>	<b>N/A</b>	<b>N/A</b>	<b>N/A</b>	<b>N/A</b>
2017	Hatch 1	7/15/2017	8/7/2017	32	30	25	94%	83%	100%
2017	Hatch 2	7/22/2017	8/14/2017	148	136	126	92%	93%	97%
2017	Hatch 3	8/5/2017	8/28/2017	222	204	187	92%	92%	94%
2017	Hatch 4	8/19/2017	9/11/2017	79	65	63	82%	97%	100%
<b>2017 Summary</b>	Hatch 1–4	7/2017–8/2017	8/2017–9/2017	<b>481</b>	<b>435</b>	<b>401</b>	<b>90%</b>	<b>92%</b>	<b>96%</b>
2018	Hatch 1	6/30/2018	7/23/2018	68	58	56	85%	97%	89%

2018	Hatch 2	7/14/2018	8/6/2018	56	44	41	79%	93%	90%
2018	Hatch 2.5	7/21/2018	No Date	5	4	0	80%	0%	N/A
2018	Hatch 3	8/11/2018	9/3/2018	13	7	5	54%	71%	60%
<b>2018 Summary</b>	Hatch 1-3	6/2018-8/2018	7/2018-9/2018	<b>142</b>	<b>113</b>	<b>102</b>	<b>80%</b>	<b>90%</b>	<b>88%</b>
2019	Hatch 1	6/29/2019	7/21/2019	64	61	51	95%	84%	98%
2019	Hatch 2	7/13/2019	8/5/2019	143	128	116	90%	91%	-
2019	Hatch 3	7/27/2019	8/19/2019	32	30	23	94%	77%	90%
2019	Hatch 4	8/10/2019	9/2/2019	10	10	8	100%	80%	93%
2019	Hatch 5	8/24/2019	9/16/2019	7	6	6	86%	100%	83%
<b>2019 Summary</b>	Hatch 1-5	6/2019-8/2019	7/2019-9/2019	<b>288</b>	<b>259</b>	<b>224</b>	<b>90%</b>	<b>86%</b>	<b>91%</b>
2020	Hatch 1	6/27/2020	7/19/2020	131	109	92	83%	84%	91%
2020	Hatch 2	7/18/2020	8/10/2020	60	33	8	55%	24%	88%
2020	Hatch 3	8/1/2020	8/24/2020	63	33	17	52%	52%	100%
2020	Hatch 4	8/9/2020	9/2/2020	54	35	25	65%	71%	96%
2020	Hatch 5	8/26/2020	9/18/2020	54	14	8	26%	57%	100%
<b>2020 Summary</b>	Hatch 1-5	6/2020-8/2020	7/2020-9/2020	<b>362</b>	<b>224</b>	<b>150</b>	<b>62%</b>	<b>67%</b>	<b>93%</b>
2021	Hatch 1	9/4/2021	9/27/2021	83	51	32	61%	63%	94%
2021	Hatch 2	9/12/2021	10/5/2021	27	9	5	33%	56%	100%
<b>2021 Summary</b>	Hatch 1-2	9/2021	9/2021-10/2021	<b>110</b>	<b>60</b>	<b>45</b>	<b>55%</b>	<b>62%</b>	<b>95%</b>
2022	Hatch 1	6/18/2022	7/11/2022	104	75	53	72%	71%	92%
2022	Hatch 1.5	6/18/2022	7/11/2022	223	168	141	75%	84%	N/A
2022	Hatch 2	7/2/2022	8/25/2022	124	79	63	64%	80%	95%
2022	Hatch 3	7/17/2022	8/10/2022	85	60	49	71%	82%	96%
2022	Hatch 4	8/6/2022	8/29/2022	41	22	19	54%	86%	100%
<b>2022 Summary</b>	Hatch 1-4	6/2022-8/2022	7/2022-8/2022	<b>577</b>	<b>404</b>	<b>325</b>	<b>70%</b>	<b>80%</b>	<b>95%</b>
2023	Hatch 1	7/4/2023	7/27/2023	28	23	9	82%	39%	89%
2023	Hatch 2	7/8/2023	7/31/2023	68	55	37	81%	67%	86%
2023	Hatch 3	7/22/2023	8/14/2023	23	22	6	96%	27%	100%
2023	Hatch 4	7/30/2023	8/22/2023	43	35	25	81%	71%	96%
2023	Hatch 5	8/12/2023	9/4/2023	47	35	20	74%	57%	90%
2023	Hatch 6	8/19/2023	9/11/2023	17	15	4	88%	27%	75%
<b>2023 Summary</b>	Hatch 1-6	7/2023-8/2023	7/2023-9/2023	<b>226</b>	<b>185</b>	<b>101</b>	<b>82%</b>	<b>55%</b>	<b>90%</b>

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With the likely extirpation of masked bobwhite in wild habitats, and until recently a single U.S.-based captive breeding facility, there was increasing importance to maintain, improve, and increase the number of captive populations for reintroduction purposes. To address potential bottleneck effects and concerns over disease spread within the captive population at BANWR, efforts to establish a secondary population were initiated.

Thus, in 2009, SARC was contacted by the USFWS to explore the possibility of assisting with the captive breeding effort; equipped with a larger facility, they were better positioned to produce large quantities of chicks for the release effort. In 2017, the partnership between SARC and the USFWS fully materialized with the renovation of a building and first-year operating costs to expand captive breeding in the masked bobwhite program (Cooperative Recovery Initiative) (DOI 2017). In addition, this funding allowed for three years of post-release monitoring. In 2017, 343 eggs representing equal genetic lineages from BANWR were transferred to SARC to establish a secondary genetic assurance population. Once the captive population was established, SARC has bred and raised masked bobwhites for transport and subsequent release on BANWR (Tables 2 and 3).

*Table 2. Breeding statistics reported by SARC (SARC 2018, 2019, 2020, 2021, 2022).*

<b>Year</b>	<b>No. of Eggs Incubated</b>	<b>No. of Eggs Fertile</b>	<b>No. of Chicks Hatched</b>	<b>Fertility Rate</b>	<b>Hatch Rate</b>
<b>2018</b>	1,066	828	711	77.7%	85.9%
<b>2019</b>	2,010	1,544	1,246	76.8%	80.7%
<b>2020</b>	2,482	1,876	1,548	75.6%	82.5%
<b>2021</b>	2,599	1,949	1,504	75.0%	77.2%
<b>2022</b>	2,481	1,593	1,069	64.2%	67.1%
<b>2023</b>	N/A	N/A	N/A	N/A	N/A
<b>2024</b>	N/A	N/A	N/A	N/A	N/A

*Table 3. Number of masked bobwhite individuals transported to BANWR from SARC (SARC 2018, 2019, 2020, 2021, 2022).*

<b>Year</b>	<b>Adults</b>	<b>Chicks</b>
<b>2018</b>	16	524
<b>2019</b>	18	1023
<b>2020</b>	11	1022
<b>2021</b>	211	946
<b>2022</b>	146	653
<b>2023</b>	N/A	N/A
<b>2024</b>	N/A	N/A

## Captive Populations–Mexico

Similar to the U.S., there is a growing recognition that wild populations in Mexico are unlikely to persist without reintroduction efforts.

### *Africam Safari*

With this aim, between 2009–2016 the USFWS collaborated with Africam Safari in Puebla, Mexico to establish and enhance a captive breeding and release program for the masked bobwhite. Recognizing that Mexico likely contains the most viable remaining masked bobwhite habitat, Africam Safari was chosen as a strategic partner to streamline bird release efforts without navigating complex import/export regulations. In 2009, the USFWS committed technical assistance, masked bobwhite breeding stock, and \$118,453 funding, while Africam Safari agreed to construct facilities, breed and rear quail, and improve rearing and release techniques.

By 2012, the partnership evolved to focus on refining breeding practices and training Africam Safari staff in quail husbandry. The USFWS provided an additional \$10,000 for equipment and training, and both parties emphasized cooperative development of improved rearing strategies. Requirements included regular communication, progress reporting, and adherence to specified procedures, with any deviations requiring prior approval.

In 2016, the program expanded to include the development of a large flight and conditioning pen aimed at better preparing masked bobwhite for survival in the wild. The \$66,316 investment by USFWS supported construction of advanced enclosures designed to promote flight capability, predator avoidance, and natural foraging. This phase focused on creating stronger, more adaptable quail with measurable improvements in pre-release conditioning, while continuing the collaborative, performance-monitored approach between Africam Safari and the USFWS.

In 2015 and 2016 BANWR transferred 140 breeding birds to Africam Safari to help establish their captive breeding population. A full-fledged breeding program has yet to be successfully established at Africam Safari; however, new recovery program refinement and protocols developed at BANWR have been shared, with staff cross-training planned.

### *Ecological Center of Sonora Facility*

In 2005, the Camou family, owner of ranches northwest of Hermosillo, submitted a letter to the USFWS requesting repopulation of the masked bobwhite to ranches owned and managed in Sonora, Mexico. The Camou family originally provided birds to USFWS that allowed for the establishment of the captive population in the U.S. The USFWS recognized and acknowledged the debt owed to the Camou family.

In 2022, a partnership between the USFWS, Africam Safari, and the Comisión de Ecología y Desarrollo Sustentable del Estado de Sonora (CEDES), with funding from CEDES and Africam Safari, was established to implement a science-based program for captive breeding,

habitat restoration, and sustainable reintroduction of the species into its historical range in northern Mexico. The effort emphasizes collaboration, adherence to international best practices, and alignment with legal frameworks governing endangered species recovery.

The primary objectives include building and maintaining breeding infrastructure, ensuring animal welfare, facilitating inter-institutional exchanges to promote genetic diversity, and training technical staff across partner organizations. The project also focuses on habitat restoration, long-term monitoring of released birds, and fostering partnerships with local landowners to support reintroduction efforts. Together, the partners aim to recover a self-sustaining wild population of masked bobwhite while contributing to broader biodiversity conservation goals in the region. |

### **2.2.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):**

#### Genetic Assessment of a Hatchery Population of Masked Bobwhite Quail

In 2018, the USFWS conducted a genetic assessment of the captive population held at both BANWR and SARC to 1) quantify genetic diversity in the population, 2) evaluate the pedigree and relatedness of breeding individuals using genetic data, and compare these results to existing pedigree information, and lastly 3) assess the effective number of breeders for each year class (USFWS 2019a).

After collecting 651 samples, 18 microsatellite loci were used for genotyping. Results showed that most metrics used to measure diversity declined between 2010 and 2017, with 2015 birds showing the lowest heterozygosity and 2010 and 2011 birds demonstrating the highest. For the captive population at that time, the effective population size was 51.2. Models testing for evidence of bottlenecks produced conflicting results, with some age classes positive under some models and not others. However, under all models the 2011 age class did exhibit positive signs of bottlenecks. Of interest was that using a “mode shift” method to assess the shape of the distribution of allele frequency did not support any evidence of a genetic bottleneck. Genetic variation was highest within year classes for each location (BANWR or SARC) rather than across an age class or across locations. In addition, the genetic relatedness of birds within a year class increased, but not significantly, when mean relatedness among year classes was considered. These results suggested equal reproductive success of family lines. Discrepancies in documented parents compared genetically showed only 4.7% mismatch, of which all were attributed to the 2015 and 2017 age classes.

Overall, birds at the BANWR quail breeding facility experienced two major potential bottleneck events during the years encompassed by this study, 2010 and 2014. Year classes following these events (2011; 2015–2017) exhibited significant evidence of recent bottleneck events via deviations from expected heterozygosity; however, allele frequency distributions did not indicate that a bottleneck had occurred. In addition, among-year class comparisons exhibited little divergence and low relatedness, such that population structure did not correlate with year class, indicating that the captive population has not been dominated by

reproduction and survival of a small number of family lines, as would be indicated by an allele frequency shift causing patterns of population structure to correspond with year classes.

Recommendations originating from USFWS (2019a) included:

- 1) Selection of quail for breeding should continue to pair unrelated birds in an attempt to minimize the effects of inbreeding. Pedigree records were confirmed through genetic analysis; therefore, these records can inform pairings in years when genetic analysis is not conducted.
- 2) The long-term effects of genetic drift can impact the captive population. In the unlikely event that a wild breeding population is discovered that population should be assessed to determine if additional broodstock can be collected without causing a significant negative impact. If that determination can be made, then additional birds (or perhaps eggs from nests) should be captured to augment the captive population.
- 3) The significant impacts of disease on the effective size and genetic diversity of the population underscores the fact that biosecurity is paramount. Protocols that have been successful in treating or preventing spread of disease should be continued in order to protect the captive population.
- 4) It is recommended that exchange of eggs between BANWR and SARC occur annually. Selection of eggs for transfer should be random, with the exception of the first BANWR to SARC transfer, to ensure a complete representation of all identified family clusters at SARC (n=30 eggs, or approximately two representatives of each family group absent from SARC). Subsequent annual exchanges will require fewer eggs to maintain gene flow (n=15), with eggs being selected randomly for transfer.
- 5) Effective genetic management of the population, including periodic checks to ensure inbreeding is minimized and allele frequencies are maintained, will help ensure long-term population survival. By monitoring populations and taking a proactive approach to management, potential issues can be identified early and the need for drastic conservation measures can be alleviated. Genetic monitoring is recommended at a minimum interval of every three years.

As part of this analysis, Mussmann and Wilson (2024) developed 18 microsatellite loci for masked bobwhite, as only markers for northern bobwhite had been previously available. The identification of these markers was from the analysis of 78 individuals. The microsatellite loci were successful in accurately identifying 100% (test data) of parent-offspring relationships. The development of these markers provides a highly important tool for the genetic management of the captive population of masked bobwhite.

#### Masked Bobwhite Program Review

Starting in 2017, masked bobwhite studbook management was stewarded by SARC with the formalization of a cooperative agreement and partnership. Management of the studbook encompassed the genetic pedigree for both captive populations (BANWR and SARC). Since the last genetic analysis of the captive populations had been completed in 2019 (USFWS

**2019a**) and previously with the DeYoung et al. (**2007**) study, a 2024 analysis was conducted. While genetic assessments in the past have utilized wild masked bobwhite DNA, the lack of wild birds for comparison more recently has led to a focus on the current captive population and their relationships back to the founding members.

In 2024 the USFWS requested a review and audit of the masked bobwhite breeding program and associated studbook by an AZA accredited conservation geneticist (**Chaille 2024**). The audit considered multiple aspects of the breeding program: the studbook, the use of demographic and genetic management software (PMx), and genetic analyses (**Chaille 2024**).

#### *Masked Bobwhite Studbook*

The masked bobwhite studbook was established in the early 2000's using 160 masked bobwhite individuals which were part of an original 2007 assessment (likely **DeYoung et al. 2007**). Chaille (**2024**) indicates that the genetic data used to assess the relatedness of these original founders has not been incorporated into the studbook; including it would help with the accuracy of founder relatedness. However, assuming unrelatedness among the founders is the current strategy used to retain genetic diversity in the captive population.

Studbook management techniques employed at SARC listed birds that had produced offspring, but then subsequently released as “deceased” with the release date as the death date. Chaille (**2024**) recommends discontinuing this practice, and creating a “moves” file to more accurately account for releases, which will reduce the overestimation of mortality rates. Further, accurately noting the disposition of birds (i.e., death, release, transfer) will remove non-contributing birds from life tables, leading to better estimates of fecundity.

#### *Use of Demographic and Genetic Management Software (PMx)*

Chaille (**2024**) recommends particular settings in PMx (currently used software package [**Lacy et al. 2012**]) and, as stated above, suggests using a “moves” file to more accurately reflect demographic parameters of the captive population. In addition, the use of an empirical kinship (or relatedness) data should be incorporated into the studbook to better estimate how birds in the captive population are related based on pedigree.

Birds that will no longer be contributing to the breeding population (i.e., geriatric, health, or other reason) but are not released should not be incorporated into life history tables that are used to estimate population demographic metrics, as their inclusion skew these estimates. Chaille (**2024**) provided other recommendations for parameter refinement in PMx for managing the masked bobwhite captive population, for consideration by the USFWS.

#### Masked Bobwhite Demographic and Genetic Summary

In 2024, studbook management was transferred back to the USFWS, where the pedigree development continues from the original DNA-Based Pedigree established in 2006–2007. In 2025, an independent pedigree analyst hired by the USFWS assumed management of the masked bobwhite studbook to analyze the genetic lineages represented in the captive population to provide breeding pairs and egg transfer recommendations for the two facilities

(BANWR and SARC) for the 2025 season. A demographic and genetic summary of the masked bobwhite recovery program was prepared (Ivy 2025). The report highlights that the combined masked bobwhite captive population currently retains 98.00% of founding gene diversity, with the combined population capturing slightly more gene diversity than either BANWR or SARC alone. Gene diversity within the BANWR population was identified at 97.86% and the SARC population at 97.57%. The founding allele retention within the current population was evaluated for the length of time it is projected to retain 90% founding gene diversity. Deterministic projections of gene diversity retention suggested that the combined population (BANWR and SARC) could retain 90.00% founding gene diversity for 54 years, given the starting gene diversity of 98.00%, a generation length of 2.9 years, an  $N_e/N$  ratio of 0.1567, and a target population size of 702 birds. While the parameters used in these projections can be adjusted to extend the generation time and slow the loss of gene diversity, the short life span of masked bobwhite is a practical limit on how much the generation length can be increased. The report provided estimates on generation length and  $N_e/N$  ratio for both BANWR and SARC separately, using the same modeling as used for the combined population, 2.9 years as the generation length, with target sizes of 315 birds at BANWR and 387 birds at SARC. BANWR is projected to retain 90.00% founding gene diversity for 7 years and SARC is projected to retain 90.00% founding gene diversity for 43 years. The summary indicated that the metrics strongly influence gene diversity projections calculated in PMx, so it is recommended they be carefully considered when managing the pedigree. As of March 2025, the existing masked bobwhite pedigree contains records for 4,378 individuals. Egg transfers between SARC and BANWR are now planned to retain 90% founder gene diversity at BANWR for approximately 50 years. |

#### 2.2.1.4 Taxonomic classification or changes in nomenclature:

##### Bobwhite Molecular Genetics and Phylogeography

The discovery and early history of the masked bobwhite was summarized by Tomlinson (1972b). Masked bobwhite were reported from southern Arizona and Sonora as early as 1864 (Couse 1903). In 1884, Stephens (1885) collected a male masked bobwhite 18 miles south of the U.S.–Mexico border. This bird eventually became the type specimen and was named *Colinus ridgwayi* (Brewster 1885). The scientific name of masked bobwhite remained as *Colinus ridgwayi* until the supplement to the American Ornithologist’s Union checklist was published in 1944, when the name was then changed to *Colinus virginianus ridgwayi*, which is presently the accepted nomenclature as a subspecies.

Williford et al. (2016) examined mitochondrial DNA variation throughout the range of bobwhite in the genus *Colinus*. Their primary objective was to test if northern bobwhite (*C. virginianus*), which included masked bobwhite specimens, and black-throated (*C. nigrogularis*) and crested bobwhites (*C. cristatus*) represented distinct, recognizable species. Other objectives of this study included testing if the three species exhibit strong phylogeographic structure based on intraspecific taxonomy, and reconstructing the phylogenetic relationships among the three species of bobwhite. They concluded that only two historically disjunct populations of bobwhites are considered native: the masked bobwhite and those on Cuba; both are considered distinct subspecies (Brennan et al. 2020).

Authors stated that they expected the masked and Cuban bobwhites to form reciprocally monophyletic clades relative to contiguous populations. However, the Cuban bobwhite possessed no unique haplotypes; the masked bobwhite displayed two unique haplotypes, with three additional haplotypes shared with other populations. And based on similarity of plumages, they expected the masked bobwhite to be most closely related to bobwhites from Chiapas and Oaxaca; however, masked bobwhites from Sonora and Arizona were most closely related to bobwhite specimens from Texas.

Williford et al. (2014) used mitochondrial DNA to study the population structure and genetic diversity of the northern bobwhite (*Colinus virginianus*) west of the Mississippi River. They observed a lack of phylogeographic structure, high haplotype diversity, and low nucleotide diversity for northern bobwhites in this part of their geographic range. Despite the discordance between geographic patterns of mitochondrial DNA diversity and subspecies designations, they detected significant genetic differentiation among four subspecies, the plains (*C. v. taylori*), eastern (*C. v. virginianus*), Texas (*C. v. texanus*), and masked (*C. v. ridgwayi*) bobwhites. Neutrality tests, Bayesian skyline plots, and test of spatial expansion provided evidence of demographic and range expansion following the end of the last Pleistocene glaciation. Lack of phylogeographic structure indicates that morphological differences that are the basis of subspecies designations are of recent origin. Ecoregions may provide a better basis for management units than subspecies taxonomy for some northern bobwhites in the western part of their geographic range. Results reported by Williford et al. (2014) indicate that much of the northern bobwhite's geographic range in the U.S. is the result of relatively recent colonization, which was a response to climate and habitat changes at the close of the Pleistocene. The northern bobwhite may be as vulnerable to fluctuations in climate as it has been to habitat and landscape changes during the past century.

#### Conservation Genomic Analysis of the Endangered Masked Bobwhite

Masked bobwhite is a geographically isolated subspecies and morphologically distinct to other subspecies in the U.S. (Williford et al. 2014). Previous studies based on partial sequences of the mitochondrial DNA control region found *C. v. ridgwayi* to be more closely related to *C. v. texanus* than to other northern bobwhite populations (White et al. 2000; Williford et al. 2016). Genetic studies have also revealed low genetic variability and high genetic differentiation of *C. v. ridgwayi* relative to other northern bobwhite subspecies in the U. S. (DeYoung et al. 2007; Eo 2008; Williford et al. 2014, 2017).

Vargas (2022) analyzed thousands of single nucleotide polymorphisms to elucidate genetic diversity patterns and population structure among nine bobwhite subspecies from the U.S. and Mexico. Bobwhite subspecies analyzed included masked bobwhite (*C.v. ridgwayi*), Texas bobwhite (*C.v. texanus*) in the U.S. and Grayson's bobwhite (*C.v. graysoni*), Godman's bobwhite (*C.v. godmani*), Salvin's bobwhite (*C.v. salvini*), Guatemalan bobwhite (*C.v. insignis*), Coyoleos bobwhite (*C.v. coyolcos*), Puebla bobwhite (*C.v. nigripectus*), and Thayer's bobwhite (*C.v. thayeri*) in Mexico. In agreement with early morphological studies and phylogenetic work, analyses suggested that the closest extant relatives of masked bobwhite are *C.v. texanus* and *C.v. graysoni*. Their data support maintaining subspecies designation and structure among subspecies from southern Mexico.

Expected heterozygosity was higher than observed for *C.v. ridgwayi*, *C.v. coyolcos*, and *C.v. texanus* (Vargas 2022). Contrary to previous studies (e.g., [DeYoung et al. 2007; Eo 2008]), masked bobwhite did not exhibit the lowest genetic diversity when compared to other subspecies from Mexico and Texas bobwhite. Therefore, Vargas (2022) did not obtain low levels of genetic diversity for *C.v. ridgwayi*.

The nomenclature for the masked bobwhite remains the same as when the species was listed in 1967 (USFWS 1967); thus, the original status of endangered for the masked bobwhite as taxonomically defined is still relevant. |

#### **2.2.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, pollinator availability, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):**

| Climatic factors are known to be strong influencers of population dynamics to include movement patterns, availability of suitable habitat, and demographic vital rates (Jenouvrier 2013; Thompson 2017; Neumann et al. 2022). Several studies considered the effects of climate on aspects of quail distribution, including some data on masked bobwhite; although not independently modeled, with the exception of Vargas (2022).

In Tanner et al. (2017), climatic variables known to influence the local abundance of six species of temperate North American quail were found to not always scale up to inform the species distribution. The highest performing variables included annual mean temperature, precipitation seasonality, precipitation of the warmest quarter, and mean temperature of the wettest quarter. When compared to current climate normals, results indicated that northern bobwhite potentially faces smaller distributional shifts in range (as percentage gain/loss of ensemble model) compared to other North American quail (years 2050 and 2070 for RCPs 2.6, 4.5, 6.0 and 8.5). Specifically, areas with high and intermediate relative abundance showed the greatest loss and generally occurred at the edge of the species range (Tanner et al. 2017).

In models compiled by Salas et al. (2017) for 9 species of concern, including northern/masked bobwhite, all traditional bioclimatic variables (Booth 2018) were used in modeling, with the most important variable contributing to model output (i.e., predicted climatic suitability) being maximum temperature of the warmest month. This finding aligns to some degree with findings by Tanner et al. (2017), in which three of the top four performing variables were temperature-related. For future scenarios (2050 and 2070), under RCPs 2.6 and 8.5, northern/masked bobwhite showed high loss in overall distribution of climatic suitability across the range of the species, diverging from Tanner et al.'s (2017) findings, although specific habitat in Arizona appeared stable (Salas et al. 2017), suggesting alignment with Tanner et al (2017) in this region.

In Vargas (2022), individual range-wide distribution models for 9 subspecies of northern bobwhite (from the southwestern U.S., south central U.S., and southern and central Mexico) utilizing the best performing bobwhite variables from Tanner et al. (2017), annual mean

temperature, precipitation seasonality, precipitation of the warmest quarter, and mean temperature of the wettest quarter, indicated that precipitation seasonality was the highest contributing variable explaining current distribution patterns. This finding was unique from Tanner et al. (2017) and Salas et al. (2017), which grouped masked bobwhite with all subspecies of northern bobwhite and found that temperature variables were also highly performing. Given the aridity of the landscape encompassing large swaths of the masked bobwhite's range, the importance of precipitation is consequential. Further, model projections for 2050 and 2070 showed precipitation seasonality remaining the highest contributing variable for 2050 but changing to precipitation of the warmest quarter for 2070 (Vargas 2022).

Suitable climatic conditions, as modeled using the four variables identified above for current and future conditions, show potential increases in climatically suitable areas in Arizona and Sonora under both Global Circulation Models BCC-CSM1.1 and CCSM4 for 2050 and 2070 and under RCP 4.5. These results show more expansion than results presented in both Tanner et al. (2017) and Salas et al. (2017).

Neumann et al. (2022) scaled down the influence of climate by assessing how climatic conditions influenced the movement of bobwhite in Oklahoma. They found that solar radiation and air temperature were strong predictors of the probability of movement as well as the hourly distance moved, such that when solar radiation was low, increasing air temperature increased the probability of movements, but when solar radiation was higher, increased temperatures resulted in farther distances traveled (Neumann et al. 2022). Implications of these findings for masked bobwhite suggest that microclimatic conditions are highly influential on many aspects of daily activities such as foraging, loafing, and traveling. Of interest is whether or how captively bred, habitat naïve, released masked bobwhite individuals are able to quickly learn appropriate survival skills while navigating these climatic limitations. Considerations that lowering the learning threshold in the hot, arid environments on BANWR may contribute to higher survival of individuals. |

#### **2.2.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):**

##### Habitat Suitability Index

The use of habitat suitability index (HSI) models in the USFWS dates back to around 1981, when the Ecological Services program incorporated their use into species conservation planning and recovery (Schamberger and Krohn 1982). LaRoche and Conway (2013) constructed HSI models for the masked bobwhite with three objectives; 1) summarize important habitat features for masked bobwhite, 2) quantify the explicit relationship between these important habitat features and habitat suitability for the masked bobwhite, and 3) translate the various bivariate relationships between habitat features and habitat suitability into a suite of mathematical HSI models.

Using a panel of nine experts (Masked Bobwhite Recovery Team experts), LaRoche and Conway (2013) compiled 22 habitat variables believed to be crucial to masked bobwhite

recovery. These variables included water, forb cover, tree cover, grass cover, brush and shrub cover, bare ground, herbaceous species diversity, vegetation structural diversity, vegetation height, leguminous shrubs, woodland/grassland edge, invasive plant species, winter food, arthropod diversity and abundance, climate, thermal refugia, and mammalian and avian predators. Variable weights were calculated based on expert responses and used to construct HSI models that accounted for uncertainty.

Each expert provided recommendations from the models produced for four important components of masked bobwhite life history: food, cover, reproduction, and thermal refugia. The interviews with the panel of experts helped identify key habitat characteristics and led to the development of a total of nine HSI models based on expert opinion and literature. However, these models produced different habitat suitability predictions when projected to the same geographic area using three different simulations.

While the models highlight critical features such as climate, leguminous shrubs, thermal refugia, and winter food, it is important to note that they differ significantly in content and are primarily based on expert opinion or limited data collected during periods of population decline. Calculating each model's ability to differentiate between high and low suitability is a useful way to evaluate model performance, with the lower confidence estimate serving as a conservative consensus estimate of habitat suitability.

Although these models lay a foundation for understanding habitat requirements and can guide future research, each model represents a competing hypothesis that requires validation through empirical data on actual masked bobwhite habitat quality. The current lack of standardized responses and comprehensive data highlights the need for further research to enhance the reliability of these models.

While some habitat suitability functions showed relatively low uncertainty, such as the proportion of bare ground, tree and forb cover, and shrub height, the overall findings indicate that more work is necessary to refine these models. Without additional stable populations to study, testing these hypotheses may prove challenging. Therefore, while the models serve as a starting point for habitat evaluation and management efforts, they should not be solely relied upon until further validation and refinement are conducted.

### BANWR Habitat Implementation Plan

In 2021, the USFWS developed a masked bobwhite Habitat Implementation Plan (HIP [USFWS 2021e]), which serves as a field-level guide that translates the broader goals of BANWR Comprehensive Conservation Plan (CCP [USFWS 2003]) and Habitat Management Plan (HMP [USFWS 2010]) into specific, actionable habitat management practices. These plans are focused on supporting the recovery of the masked bobwhite by identifying key habitat components, recognizing current deficiencies on the refuge, outlining effective restoration techniques, and designating priority areas for targeted work.

The HIP provides detailed guidance for habitat managers to attain desired conditions for masked bobwhite by improving nesting and woody cover, enhancing the diversity and

availability of food resources, increasing water accessibility, and ensuring appropriate spatial distribution of these critical habitat features. Management efforts are concentrated within four focal areas on BANWR considered essential to masked bobwhite recovery.

Past masked bobwhite-focused field studies and recent field observations have led to broad consensus that habitat requirements for masked bobwhite largely follow those for other subspecies of northern bobwhite. Reality in a semi-desert grassland environment, where late seral stages more closely resemble early seral stages in higher precipitation areas to the east, is likely less dense woody cover and more distant interspersions. However, the habitat enhancement goal should not aim for the minimum requirements. In fact, it could be argued that less cover provided by grasses and forbs in a semi-desert grassland (resulting in more bare ground) would increase the need for more frequently encountered woody escape cover than typically suggested for northern bobwhite populations.

Herein, a habitat management goal for masked bobwhite includes approximately equal proportions (30/30/30% cover) for each of the three vegetative forms (native grass, good woody cover and forb cover), with 10% bare ground when viewed from above. Good woody cover is preferably a reliably seed-producing native shrub species that has branches low to the ground, numerous and relatively dense on the outer perimeter with quail-sized access pathways at ground level leading to a more open center (i.e., open at the base). These habitat components should occur in a small-scale mosaic that is “usable” for masked bobwhite. Ideally, each habitat component, at an appropriate percentage, needs to be available within each acre of identified masked bobwhite habitat so that the small-scale structural mosaic limits necessary daily movements. Increased daily movements expose individuals to greater probability of predation. The goal for native plant diversity beneficial to masked bobwhite are, at the minimums: 8–12 perennial grass species, 12–16 forb species, and 3–6 mid-story shrub/tree species (**USFWS 2010**).

To support planning and implementation, the HIP includes a collection of maps and spatial data that illustrate priority areas, vegetation types, habitat suitability, habitat improvement efforts from 2017 to 2020, recent release locations, currently occupied sites, and other key features of the refuge. These maps serve as practical tools to help identify and refine target areas for habitat restoration activities. To strengthen the scientific basis of habitat management decisions, the HIP draws on a range of historical and contemporary research, expert insight, and field data. This information has been used to develop an HSI model (**USFWS 2023b**), which combines field assessments with spatial analysis to provide a quantified overview of current habitat conditions across BANWR. The HSI model helps prioritize locations for restoration based on suitability for masked bobwhite occupancy.

#### BANWR Habitat Restoration/Management Activities, 2017–2020

To meet objectives identified in the CCP, HMP, and HIP, the following masked bobwhite habitat management activities were conducted on BANWR.

Between 2017 and 2020, progress was made to restore and enhance habitat for the endangered masked bobwhite on BANWR. The work included a variety of habitat restoration techniques across thousands of acres, focused primarily on thinning woody plant density over 30% cover, erosion control, prescribed fire, water provisioning, and native plant establishment.

In 2017, initial efforts involved conducting a prescribed burn on 3,000 ac to improve masked bobwhite habitat. By 2018, work expanded to the Secundino area, treating roughly 200 ac through mesquite thinning, construction of erosion control features like rock dams, and seeding with native plants to enhance vegetative diversity and cover.

During 2019, approximately 180 ac of habitat were treated with the help of volunteers using similar methods. Additional test plots were established to study the efficacy of restoration techniques in both upland and lowland settings. Over 800 ac were burned in a mosaic pattern to promote spring forbs and invertebrate availability, critical food sources for masked bobwhite. Water provisioning infrastructure was also expanded with additional tank-style drinkers and wells. Supplemental feeding of milo grain was initiated for known coveys, and a Refuge Operations Specialist position was created to coordinate ongoing habitat work. A grant was pursued to host an AmeriCorps crew to support future restoration efforts.

In 2020, habitat restoration scaled up significantly. About 600 ac were treated using various vegetation management techniques, and over 200 erosion control structures were installed and seeded with native mixes. Five acres in Canoa Wash were also planted with natives alongside erosion control work. Prescribed burns were conducted across 1,673 ac in the South Border, Compartidero 3, and Triangle units, using low to moderate intensity techniques to preserve forage and cover for masked bobwhite. Additional support structures for water and feed were deployed, including four portable drinkers, six well-based waterers, and water lines to promote vegetation establishment and insect abundance, and various feeders (USFWS 2021b).

Parallel to these efforts, the Cumero Fire Burned Area Rehabilitation Project ran from 2019 to 2021. This strategic initiative focused on restoring fire-affected areas with native species and controlling erosion. The project used a “resource islands” approach, establishing patches of restored habitat using deep-potted plants and native seeds in high-potential areas. Treatments were adjusted over time based on monitoring data. Erosion was mitigated through rock structures and natural revegetation, particularly targeting arroyo degradation. Over 13,000 nursery-grown plants were installed across seven identified management units, and a diverse seed mix of native grasses, shrubs, and forbs was distributed through various sowing methods (USFWS 2021f).

A series of experimental habitat plots were also developed in multiple site types (upland, bottomland, and areas dominated by Lehmann’s lovegrass) to evaluate the effectiveness of restoration techniques such as hydroseeding, imprinting, straw capping, and supplemental feed grain seeding. These trials aim to increase the quality and connectivity of quail habitat

across BANWR and are designed to identify which methods best convert marginal or degraded sites into functional habitat for masked bobwhite (**USFWS 2019b**).

No habitat management activities targeting masked bobwhite recovery were completed on the refuge between 2021–2024.

#### BANWR Invasive Species and Treatment Activities, 2018–2024

In addition to masked bobwhite habitat management, BANWR conducted invasive species treatment activities, as identified in the CCP and HMP. Between 2018 and 2024, invasive species management at BANWR focused on early detection and rapid response to control several priority species, including buffelgrass (*Pennisetum ciliare*), tickgrass (*Eragrostis echinochloidea*), yellow bluestem (*Bothriochloa ischaemum*), and stinknet (*Oncosiphon pilulifer*). Initial efforts in 2018 were limited in scale, treating approximately 130 ac in the Garcia Unit. In 2019, attention shifted to a dense tickgrass infestation near tower TCA-TUS-299 and the retreatment of previously addressed buffelgrass patches. Aerial sketch mapping was also tested for buffelgrass detection but found to be ineffective for small infestations. In 2020, tickgrass treatment efforts showed an 86% reduction in infestation size, although some areas needed further work due to herbicide penetration issues.

From 2021 through 2023, efforts expanded to include yellow bluestem and more comprehensive surveys; in 2022, American Conservation Experience interns mapped 408 new infestations and inventoried over 1,000 ac. In 2023, 20 days were dedicated to treating yellow bluestem and tickgrass, along with habitat surveys. By 2024, rising concerns over stinknet led to extensive roadside and campground surveys, resulting in the detection and removal of over 79 small populations. Across all years, annual reports typically included future treatment recommendations to guide ongoing invasive species management (**USFWS 2025b**).

#### Pima County Invasive Species Treatment and Restoration Activities

In addition to activities that occur on BANWR, other entities conduct invasive species treatments within the Altar Valley.

The Altar Valley is a significant ecological region of high desert grassland, southwest of Tucson in Pima County, Arizona, where the masked bobwhite relies on the resources that this watershed provides for survival. Pima County entered into a Multi-Species Conservation Plan with the USFWS. Since 2016, Pima County also partnered with the Altar Valley Conservation Alliance (AVCA) to implement the Northern Altar Valley Watershed Area restoration project. The goals of this project are to restore native vegetation cover and subsequent minimization of soil erosion and fugitive dust on abandoned agricultural lands owned by Pima County that were once used to cultivate cotton. This has been accomplished through the increased retention and infiltration of water via a cascading flow pattern of contoured berms and strategic vegetation management (**Pima County 2018**).

Restoration activities in the Altar Valley during 2016 to 2018 included continued restoration of the fallowed agricultural field, through the use of dirt berms and revegetation with native species (**Pima County 2017, 2018, 2019**). In 2019, invasive species treatment activities were conducted on the Kings 98 Ranch, with removed species including Russian thistle, Johnson grass and buffelgrass that filled 426 bags. Restoration activities centered around erosion control by repairing dirt berms and rock structures (**Pima County 2020**). Invasive species management activities in 2020 focused on the treatment of Russian thistle (**Pima County 2021**). In 2021, areas treated in 2020 were generally free of Russian thistle, with only a few small areas needing treatment. Monitoring of restoration activities showed that water catchments held water and supported aquatic wildlife, and the dominant vegetative cover were native plants (**Pima County 2022**). In 2022, Pima County worked with the University of Arizona to spread native grass and tree trimmings from the Pima County Native Plant Nursery as a mulch treatment for an approximately 1,000 square-foot area of bare soil. Monitoring showed that multiple cane beardgrass (*Bothriochloa barbinodis*) plants had established at the site. Pima County removed buffelgrass and yellow bluestem plants from the area (**Pima County 2023**). In 2023, Pima County invasive species management efforts focused on removing Russian thistle seedlings with herbicide treatment for about 6.5 ac (**Pima County 2024**).

#### Altar Valley Conservation Alliance Invasive Species and Treatment Activities

A 2018 report on the 30-year brush management project on the Elkhorn Ranch highlights the objectives and lessons learned through the initiative (**Simpson 2018**). Starting in 1984, where baseline conditions of woody vegetation was over 50% mesquite cover across historical arid grasslands, ranch owners removed woody vegetation from these open grasslands, while retaining woody structure along drainages. This mosaic benefited herbaceous plants such as native grasses and forbs in open areas, while the structure and cover associated with the drainage provided wildlife corridors for wildlife movement and prevented erosion and arroyo cutting by slowing down water in these drainages (**Simpson 2018**).

Masked bobwhites are known to use drainage for traveling and often occupy these edge habitats, where woody lined drainages cut through arid grassland systems providing cover for the species (**USFWS 2021e**). Efforts like the initiative on Elkhorn Ranch are positive community-driven habitat restoration activities that likely benefit the masked bobwhite, among other species.

#### Altar Valley Conservation Alliance Watershed Restoration Activities

The hydrology of the Altar Valley is primarily driven by seasonal monsoon rains, which contribute to surface water flow that nourishes vegetation and food sources (summer annuals and the invertebrates associated with them) essential for the masked bobwhite. Groundwater plays a crucial role in sustaining woody vegetation cover, particularly during dry periods. Understanding the hydrological processes and conducting restoration activities in the Altar Valley are essential for effective management and preservation of water sources in this arid region.

The AVCA, in partnership with the Pima County Regional Flood Control District, USFWS, and other organizations, for over two decades has used grant funding towards improving groundwater infiltration and creating surface water habitat for wildlife, developing a watershed plan and working group that support wild masked bobwhite populations, restoring abandoned agricultural lands, erosion control for moisture retention, applied research and monitoring, public outreach, and the publication of a Geographic Information System database for partners to use (**AVCA 2011, AVCA 2017; AVCA 2022; DOI 2023; Pima County 2024**).

In 2022, AVCA completed an Altar Valley Watershed Plan for the region that provides a summary of the resources available for addressing complex issues across land jurisdictions, guidance for landowners and managers in focusing their efforts, as well as a path forward to continue collaborative work to identify and address current and future issues (**AVCA 2022**). The Watershed Plan addresses five core elements:

- 1) Watershed-wide issues and current conditions
- 2) Desired conditions and strategies
- 3) Concept plans for approximately 20 collaboratively prioritized projects
- 4) A virtual toolbox of resources and best management practices
- 5) A path for implementing and updating the Watershed Plan and applying principles of adaptive management

Projects implemented under the Watershed Plan that benefit masked bobwhite include the following:

South Legunita Grassland Restoration Project: Habitat restoration located on the Santa Margarita Ranch on 1,100 ac. Project objectives include expanding on BANWR's grassland restoration efforts by removing mesquite from upland grasslands. Removal of mesquite (via grubbing) would focus in upland areas with thinning tapering closer to drainages to maintain cover for these wildlife dispersal corridors. The initial phases of this project were initiated in 2018 and completed in 2021, with a second phase in preparation (**AVCA 2021a**).

Altar Valley Fire Operations Plan: A plan for coordinating fire management response to natural and human-caused ignitions. The AVCA and Fire Coordination Group have developed a contact list of fire managers and land owners/permittees in the Altar Valley and drafted a web application that shows values at risk, fire management resources such as waters and staging areas, and other key information (**AVCA 2021b**).

Well Improvements for Wildlife on the Buenos Aires National Wildlife Refuge: A project to update existing wells, functioning and nonfunctioning, with solar pumps, storage tanks, and polyethylene tubing or wildlife drinkers to provide water to wildlife. The BANWR has improved two wells to date through a cooperative agreement with the AVCA (**AVCA 2021b**).

Altar Valley Brush Treatment Corridor: Connection of brush treatments on BANWR, Santa Margarita Ranch, Elkhorn Ranch, and/or Anvil Ranch to enhance native grasslands and

create a corridor for wildlife. This will involve new and maintaining recent treatments (AVCA 2021b).

#### Other Habitat and Ecosystem Conditions–U.S.

Since the early 1900's, over 1,500 manmade structures have altered the natural landscape and hydrology of the watershed for the purpose of providing water for livestock grazing, crop irrigation, erosion control, and natural gas operations (Nichols and Degginger 2021). These include wells for accessing groundwater, and check dams and earthen berms for diverting surface streams. Many of these cultivated lands are abandoned today. Water control structures specifically alter the spatial heterogeneity of vegetation, as reported by Nichols et al. (2023). In the Altar Valley, earthen berms that effectively retain runoff and sediment create differences in vegetation structure up- and down-slope (Nichols et al. 2023). Bare ground is significantly higher downslope, regardless of soil texture for intact berms; whereas soil texture influenced the amount of grass and shrubby cover (Nichols et al. 2023). Cisneros Vazquez (2020) found that the effects of water structure influence on vegetation was stronger during wet seasons than dry seasons. Further, intact water control structures are highly influential on the condition of floodplain vegetation by effectively catching water and keeping the soil moisture higher in the surrounding area (Cisneros Vazquez 2020). Of significance was that vegetation connectivity was higher during the wet season, with drier seasons showing higher fragmentation (Cisneros Vazquez 2020).

Masked bobwhites are often found using the cover of drainages to disperse across the landscape. Berms that alter the spatial arrangement of bare ground, grass, and shrub cover indirectly influence movement patterns of masked bobwhite. Further, vegetation connectivity across the landscape is essential for masked bobwhite dispersal patterns across the refuge and perhaps the Altar Valley. Thus, appropriate maintenance of these structures is needed to ensure the suitability of movement corridors for masked bobwhite.

#### Habitat or Ecosystem Conditions–Mexico

We are uncertain of efforts to increase habitat suitability in historical locations of masked bobwhite occurrence in Sonora. However, other relevant literature may provide some insight. For example, Ortega-S et al. (2013) conducted a review to assesses the status of exotic, nonnative grasses in Mexico, to include large parts of Sonora. As with the Altar Valley, cattle management in Mexico facilitated the introduction and spread of exotic grasses as early as 1860 (Ortega-S et al. 2013). In Sonora, buffelgrass produces 3–10 times more forage than native grasses and is able to support more cattle than native grasses to the extent that Mexican beef producers will continue to facilitate the use of these areas. While monoculture of nonnative grasses such as buffelgrass are known to reduce vegetative species richness as well as invertebrate abundance, these areas are often all that is left for wildlife after cattle have consumed all native grasses available. In these cases, wildlife, like the masked bobwhite, will utilize these monocultures as described in the 1990's when individuals trapped in Sonora were found in buffelgrass (Kuvlesky Jr et al. 2002). Ortega-S et al. (2013) suggest that ecological damage from the introduction of these exotic grasses in Mexico is likely irreversible. |

### 2.2.1.7 Other:

In addition to updated information on the species itself, new information is presented here on the masked bobwhite recovery program. The recovery program consists of three main components, captive breeding and release, monitoring, and habitat assessment and management.

#### Standard Operating Procedures for Captive Masked Bobwhite

Standard Operating Procedures (SOPs) exist for 13 steps in the Masked Bobwhite Recovery Program, created in April 2021. At that time, the yearly schedule started in the winter with coordinating trapping, testing and transport of northern bobwhite captured in Texas and Oklahoma. After their arrival in Arizona in the spring, northern bobwhite care and vasectomies were performed before they were utilized as foster parents of masked bobwhite chicks that began to arrive in mid-summer. Once chicks arrived in batches from breeding partners, bonding was performed, followed by a week of conditioning and bond strengthening in following pens, after which brood releases were conducted that consisted of a radio-marked parent and unmarked chicks. These releases occurred in suitable habitat within focal areas at BANWR. Telemetry of the newly released birds began post release, while nest monitoring and continued tracking of previously released radiomarked birds occurred simultaneously. At periods throughout the year, supplemental releases and call-box releases of birds (if appropriate) both radio-marked/leg-banded and only leg-banded also occurred. To an increasing degree, providing supplemental food and water resources was accomplished essentially year-round in the focal quail areas. Habitat assessments using a modified Texas Quail Index were performed to determine habitat quality and inform where and what habitat work to perform for enhancing habitat specifically for masked bobwhite. At BANWR, the Texas Quail Index is renamed the BAQI and includes slight modifications to more accurately assess conditions present in the semi-desert grassland of southern Arizona. The SOPs developed in 2021 include the following:

- SOP 1 Coordination of Northern Bobwhite Trapping, Testing and Transport
- SOP 2 Wild Northern Bobwhite Care and Pen Maintenance at BANWR
- SOP 3 Northern Bobwhite Vasectomy Coordination and Surgery Room Preparation
- SOP 4 Masked Bobwhite Quail Chick Bonding
- SOP 5 Following Pen Care
- SOP 6 Masked Bobwhite Quail Brood Release
- SOP 7 Trapping for Supplemental Release and Outfitting with Radio Transmitters
- SOP 8 Call Box Conditioning and Release
- SOP 9 Masked Bobwhite Quail Nest Monitoring
- SOP 10 Quail Survival, Movement, Home Range and Habitat Use Monitoring
- SOP 11 BAQI Habitat Assessment

- SOP 12 Supplemental Food for Masked Bobwhite Quail
- SOP 13 Supplemental Water Resources for Masked Bobwhite Quail

Currently, the masked bobwhite recovery program does not fully operate under these SOPs; specifically northern bobwhite are no longer utilized in the program. Many of these SOPs are currently under review and revision with the new recovery program structure. See Conservation Measures section for more information on program re-structuring.

#### Captive Masked Bobwhite Program of Animal Care and Use

The most recent addition to the operation of the captive breeding component of the masked bobwhite recovery program is the development of the Captive Masked Bobwhite Program of Animal Care and Use (PACU).

The need for the PACU originated from reporting that indicated that animals with optimal welfare are more likely to exhibit increased reproductive success, maintain species-appropriate behaviors, experience reduced physiological indicators of stress, and be in good health, all of which are essential components of effective conservation breeding programs (**Greggor et al. 2018**).

The purpose of the Captive Masked Bobwhite PACU is to ensure that all entities involved in masked bobwhite conservation breeding are positioned to best meet the welfare needs of the masked bobwhite under their care and thus maximize production outcomes (**USFWS 2024a**).

The PACU achieves this by clearly outlining the professionally recognized standards of animal welfare, as applicable to conservation breeding populations, that must be met by all entities involved in masked bobwhite conservation breeding.

The PACU describes the health, husbandry, management, facility, personnel qualifications, and emergency preparedness standards that must be met to maintain acceptable levels of welfare for masked bobwhite held in captivity indefinitely as assurance, breeding, and/or surplus populations and for masked bobwhite held in temporary captivity if designated for release.

The components of the PACU work synergistically to meet the objectives of the masked bobwhite conservation breeding program, which is one part of the overall masked bobwhite recovery effort described in the second revision of the Masked Bobwhite Recovery Plan (**USFWS 1995**). Continuous program evaluation and an adaptive management strategy are cornerstones of all successful Galliforme conservation breeding restoration efforts. In keeping with an adaptive management strategy, the captive masked bobwhite PACU is reviewed, updated, and approved every three years.

The lack of a self-sustaining wild population of masked bobwhite in the U.S. and the concentration of masked bobwhite genetic variability into two captive assurance and/or breeding populations renders the species especially susceptible to potentially irreparable damage from a wildlife health or welfare incident.

It is imperative that all breeding and assurance populations establish a long-term partnership with a wildlife health professional to assist with general care of commonly diagnosed problems and to develop a response and treatment plan for a significant morbidity or mortality event.

The health and welfare needs of education and exhibit birds must also be adequately met by a wildlife health professional.

### Captive Health and Welfare Management

In 2022, the USFWS Wildlife Health Office began providing oversight for the captive population held at BANWR. As part of this oversight, the health and welfare histories of the various captive populations were compiled into a single document to inform current and future management (2025c).

Compromised health and welfare have been documented at various times in the assurance and breeding populations. Significant, acute morbidity and/or mortality events in breeding or assurance populations have been attributed to *Clostridium colinum* (i.e., ulcerative enteritis) or *Pseudomonas* spp. bacterial infection, hemosporidian (*Plasmodium juxtannucleare*-like or *Haemoproteus* sp.) parasitic infection, and infection with quail bronchitis virus (QBv). Chronic disease has been correlated with amyloidosis and neoplasia (e.g., fibrous meningioma, renal cystadenoma, liver carcinoma, renal cystadenocarcinoma, and disseminated lymphosarcoma), and pulmonary proteinosis. Documented poor quality diet and inadequate housing conditions have contributed to welfare concerns in the form of chick starvation, unacceptably high incidence of severe foot pathology, and inability to meet accepted minimum spacing requirements and subsequent overcrowding.

The 2016 occurrence of QBv in the assurance population resulted in significant morbidity but no mortalities. This is likely attributed to the fact that the virus was confined to one building. Biosecurity measures were enacted after the initial detection, and the virus was not introduced into the second building, which housed chicks. Chick populations infected with QBv may exhibit mortality as high as 100%, therefore the significance of this viral outbreak was likely greatly lessened due to the two-building design of the facility. QBv was confirmed again in the same building the following year. The risk of vertical transmission (i.e., viral transmission from dam to offspring in the egg) was investigated in 2018 by testing chicks hatched to QBv-positive parents. Results suggested that vertical transmission did not occur. A complete building evacuation, disinfection, and re-painting occurred in 2019. No birds showing clinical signs consistent with QBv have been reported since 2018.

### Masked Bobwhite Biobanking

Given the loss of “wild” genetics, and the inevitable genetic drift caused by captive breeding, the threat of additional genetic loss in the future is of concern. To help mitigate this threat, the Masked Bobwhite Action Team (described later) has now included biobanking as part of the recovery strategy for the masked bobwhite.

Biobanking can be a significant recovery asset that can be leveraged for future recovery efforts. Biobanking offers short- and long-term future applications that include genomic sequencing, stem cell development, recovery of lost diversity, genomic insight for managing, study of disease resistance, and other reproductive and genetic technologies that have yet to be fully developed.

Over the past two years, the USFWS has partnered with multiple external partners to begin a Service-wide biobanking program for threatened and endangered species. The scalable pipeline developed includes tissue collection, the creation of living cell lines, and a national repository for cryopreservation. The collection of samples is simple, straightforward, and convenient for the masked bobwhite recovery program to participate.

On March 17, 2025, eye and tracheal samples were collected from four deceased captive birds and shipped to Viagen Pets and Equine. On April 9, 2025, the USFWS received confirmation that four cell culture lines were successfully propagated at Viagen and shipped for long-term storage at the National Animal Germplasm Program, a USDA facility in Fort Collins, Colorado (**Rodriguez 2025**), see Table 4.

*Table 4. Information on the four masked bobwhite cell lines propagated and stored for future use in the recovery program.*

Cell line#	Name	Sex	Date Completed	Cell Count
V8640	17-116	female	3/24/2025	2.0 million cells in 8 vials
V8641	17-294	male	3/24/2025	1.68 million cells in 8 vials
V8642	17-324	female	4/2/2025	1.56 million cells in 8 vials
V8643	18-095	male	4/7/2025	1.452 million cells in 8 vials

### Wild Health and Welfare Developments

The masked bobwhite recovery program has intermittently used wild-caught Texas bobwhites as foster parents to masked bobwhite chicks since at least 1931, with sterilization explicitly incorporated into the program by at least 1978 (**Ellis et al. 1978**). Survival of sterilized Texas bobwhites post-surgery has not been documented for all years the subspecies was used in the program, but data from 2021 showed that 38% of individuals undergoing the procedure survived.

Lamb et al. (**2023**) researched four surgical approaches to vasectomies in northern and Texas bobwhites: external approach, internal approach with dissection, internal approach with cautery, and internal approach caudally. Of the four approaches investigated, the internal approach caudally was found to be an inappropriate technique for use on bobwhites, given that the species does not develop the required reproductive physiology to successfully conduct this surgery. Of the remaining three approaches, survival ranged from 0%–89.7%. The internal with dissection approach had 0% survival and was abandoned after attempting on 5 birds, although previous studies reported 92% survival (**Ellis and Carpenter 1981**). The lowest survival between the other tested approaches was seen using the internal with cautery procedure, which exhibited 33% survival. Of the 30 birds that died (out of 177

bobwhites used), the most common cause of death was hemorrhaging from the iliac vein (53.3%) followed by transection of one or both ureters (33.3%). Findings from this study, as expected, recommended the internal approach with cautery for field vasectomies of bobwhite quail. The continued use of sterilized Texas bobwhites for use as foster parents in the masked bobwhite recovery program is uncertain at this time, and other opportunities to use Texas bobwhite in the program are currently under consideration.

## Releases and Field Monitoring Developments

### *Foster Parent Survival*

As recovery efforts for the masked bobwhite largely depend on reintroducing birds raised in captivity, the recovery program has relied on using foster parents to release chicks. These foster parents brood and guide chicks as they mature post-release, and this strategy has so far been more effective than releasing older, pen-reared juveniles or adults. The survival of these foster parents likely affects the success of chicks that form the basis of new populations. Pre-release conditioning plays a role in how well foster parents survive after release. To guide management strategies, Chester et al. (2025) compared survival rates among foster parents with different backgrounds. These included (1) captive masked bobwhites from an indoor breeding flock, (2) captive masked bobwhites from an outdoor-conditioned flock, and (3) wild northern bobwhites (*C. v. taylori*). One hundred and twenty-nine foster parents were radio-tagged and paired with chicks before release into the wild. Findings showed that 120 days after release, wild foster parents had survival rates 1.6–1.9 times higher than outdoor-conditioned birds. Indoor-reared birds had the lowest survival rates, under 8%. Daily survival rates improved over time, suggesting birds acclimated to their environment. In 2020, survival rates dropped below 2% across all groups, likely due to extreme drought. Wild foster parents consistently outperformed the other groups, maintaining higher survival even during worsening drought and contributing more overwintering juveniles to coveys throughout the study. Enhancing reintroduction strategies, such as extending outdoor conditioning for captive birds or prioritizing the use of wild foster parents, could improve survival outcomes during more favorable environmental conditions.

### *Role of Extreme Temperature in Quail Mortality Post-Release*

Understanding conditions that contribute to post-release mortality is critical in moving the recovery program forward. Post release monitoring of individuals released during May and June 2023 provided a snapshot into acclimation and survival timelines in relation to excessive temperatures (Byrne 2023e). May and June are Arizona's driest and hottest months of the year, and the 2023 dry season manifested high ambient temperatures. Summer temperatures of  $\geq 100^{\circ}\text{F}$  often occur on BANWR, typically from June through early August and sometimes start as early as late May. In addition to excessive temperatures, the typical seasonal aridity occurring at this time was followed by a summer rainy season that was sporadic in rainfall interval and of lower-than-average volume for the season (NOAA 2025a). Data collected from individuals released into these conditions provide insight into how captive bred, habitat naïve birds survive under such extreme conditions.

Upon release, masked bobwhites must discover how to develop survival skills as quickly as possible. Such skills include seeking out and discovering vegetative micro-climate patches that support immediate, adequate cover and thermal protection; learning to identify unfamiliar plant types and structures and interface with their seasonal attributes as vital food and cover resources; interfacing with seasoned, experienced masked bobwhites in their new surroundings; learning how to engage in ground/ aerial predator avoidance and evasion techniques in new surroundings; developing home ranges by exploring and mentally mapping out a wider range of habitat for seasonal survival; and learning how to successfully utilize Sonoran arid grassland vegetation to reproduce within the home range. However, many of the above are new life skills to be learned or exercised upon release, since conditions within BANWR flight pens currently do not fully mimic the realities encountered on the landscape.

Of the masked bobwhite released and subsequently tracked daily, many were discovered dead in the field in the month of June, and these represent a fraction of the un-collared birds that were released onto the landscape. Of interest is a grouping of three masked bobwhites that died of non-predation on the same day, June 22, 2023. These individuals were recovered, and given the condition of the carcasses (very fresh and intact), these birds were collected and weighed. All three birds showed significant weight loss, (45.1%, 39.6%, and 30.3%) across varying times of survival post release (11, 36, and 9 days; respectively).

Since these healthy, radio-collared quail were being tracked daily and their bodies were recovered completely intact, it's plausible that the percent of bodyweight loss in the field reflects acute, systemic emaciation resulting from a lack of dietary intake, as well as moisture loss associated with temperatures that reached extreme levels. Air temperature forecasted during the week of these mortalities ranged from 99-107°F (**NOAA 2025b**), with corresponding land surface temperatures (as recorded by MODIS remote sensing data) averaging 121–138°F (**Wan 2013**).

Although the thermal tolerances of masked bobwhite are not fully known, research on northern bobwhites suggests that temperatures in excess of 102.2°F are dangerous (**Tanner 2020**). Thus, these extreme temperatures were not ideal for acclimation and survival of captive bred individuals and uncovers a potential source of significant post-release mortality (in addition to predation) not fully explored.

Carroll et al. (**2015**) reported that wild bobwhites are exposed to environments where temperatures range from 55.31–163.7°F (in Oklahoma as measured by black bulb), forcing quail to seek thermal refugia. Appropriate cover should provide thermal refugia for masked bobwhite; however, Palmer et al. (**2021**) found that not all woody cover provides thermal cover. Rather, temperatures in woody patches selected by northern bobwhites (in Texas) were often at the upper limits of their thermal tolerance, and these sites were occupied earlier in the day and for most of the day (**Palmer et al. 2021**). Increased time spent in thermal refugia reduces available time for foraging during diurnal periods and may have consequences for overall condition of individual bobwhites.

Extreme temperatures that increase heat loads have also been found to neutralize or eliminate the reproductive response to precipitation in bobwhites (**Robinson and Baker 1955**) and Gambel's quail (**Heffelfinger et al. 1999**). Guthrey et al. (**2001**) found that within non-coastal sites, increased temperature reduced calling activity; and further postulate, based on the thermal ecology of bobwhites, that extended extreme temperatures are expected to reduce the hatchability of eggs, cause premature incubation and staggered hatching, produce subnormal chicks, and reduce the length of the laying season.

Post-analysis of the outcomes of these birds suggests that releases of masked bobwhite likely need to more intentionally consider ambient and land surface temperatures as well as potential thermal refugia provided on the landscape. Given the increase in recent extreme temperatures and the potential for increased future temperature normals, careful consideration of how temperature affects post-release survival and even reproduction of masked bobwhite should be incorporated in the recovery program.

#### *Post Release Use of Autonomous Recording Units*

Post-release monitoring is a component of the masked bobwhite recovery program to assess survival and other outcomes needed for recovery of the species. While telemetry is the main technique employed on the landscape, other techniques such as “whistle” counts are sometimes conducted. Johnson et al. (**2024**) assessed how environmental conditions affect the detectability of the masked bobwhite's reproductive call, commonly referred to as the “whistle”, when using ARUs. First, the call intensity of the masked bobwhite reproductive call was measured, estimating a mean sound level of  $112 \pm 0.5$  decibels (mean  $\pm$  SE) at a distance of 4”. To evaluate ARU performance, 17 trials were conducted during which a total of 16,284 calls were broadcasted. These recordings were used to compare manual and automated detection methods. The probability of call detection was modeled, assuming the bird is present and vocalizing, as a function of distance and weather conditions. Generalized linear mixed models were employed, with trial included as a random effect. Across both detection methods, a single model structure emerged as the most competitive, indicating that detection probability was significantly influenced by distance, wind speed, and wind direction. Specifically, detectability declined with increasing distance and wind speed and was also affected by the direction of the wind relative to the recording device. Findings demonstrate how predictive modeling based on environmental variables can improve ARU-based monitoring of masked bobwhite populations. By accounting for the influence of environmental conditions on call detectability, survey designs and data interpretation can be refined, leading to more effective conservation monitoring strategies for this imperiled subspecies. A missing piece of detection within this paper is bird availability.

#### Habitat Assessment and Use Developments

Another aspect of the masked bobwhite recovery program is assessing habitat use by released masked bobwhite to understand the role that it plays in post-release survival and reproduction.

In 2017, the Texas Quail Index (**Reyna et al. 2012**) was modified to assess masked bobwhite habitat on BANWR, creating the BAQI (**USFWS 2021g**). The BAQI is conducted at points that each point represent a 1-acre circle of habitat. Entries for the following parameters: Nesting Cover SCORE, Woody Cover SCORE, Woody Cover Interspersion SCORE, Woody Species SCORE, Food Abundance SCORE, and Food Availability SCORE, are related to categories within habitat parameters. Individual scores combine to determine a total score for the point based on the original Texas Quail Index.

In the BAQI, categories and scores were modified slightly to better represent conditions at BANWR. Water availability (an original Texas Quail Index parameter) was not routinely scored in the field due to very limited occurrences of water sources (mainly stock tanks) that had unknown water conditions. Additional parameters of habitat (Mesquite Cover, Lehmann's Lovegrass Cover, and Bare ground Cover) were developed and recorded to better document, analyze, and understand habitat for masked bobwhite at BANWR. A scoring scale was developed for the new parameters as well for inclusion in the overall score for the site. Based on 400+ sites assessed 2017-2019, scores above .4 are higher-scoring areas on the refuge, with scores approaching .86 (maximum found during that timeframe) infrequently attained.

In 2023, the BAQI was updated to include information on plant phenology and updated measures of invertebrate abundance. By documenting phenology of the plants encountered during the assessment, availability of specific food plants and associated invertebrate types at a site could be tracked as well. In 2023, 206 assessments using this updated BAQI were conducted within known home ranges (buffered location points) of 5 telemetry-tracked individuals and as assessments prior to release of birds on the landscape. The maximum BAQI value was 0.724 and the minimum was 0.136, with an average of 0.424. Approximately 56% of the sites scored above 0.400 and were considered "high". BAQI habitat assessment points only associated with location of tracked birds showed a higher mean score of 0.467, with 73% of assessed points having a score higher than 0.400; higher than sites not explicitly associated with individual birds.

#### Inventory and Monitoring Plan– BANWR

An Inventory and Monitoring Plan which outlines the natural resource surveys to be conducted on the refuge over a 15-year period was finalized in 2020 (**USFWS 2020b**). The plan prioritizes surveys that are critical to advancing the refuge's mission, particularly those that support the conservation of ecosystems and the recovery of threatened and endangered species. The primary focus of this Inventory and Monitoring Plan is abundance monitoring of the masked bobwhite. The plan calls for the abundance of wild masked bobwhite to be assessed annually with sufficient precision to detect a 25% population change. This threshold enables the detection of meaningful population trends, whether stable, increasing, or declining, and guides adaptive management. If monitoring reveals a decline of 25% or more for two consecutive years, targeted management interventions will be initiated to support population recovery and ensure progress toward establishing a self-sustaining wild population.

### Partnerships with AZA Institutions

The masked bobwhite recovery program continues to provide birds to zoological institutions to educate the public about the species. There have been a number of zoological institutions accredited by the AZA that have maintained masked bobwhite on behalf of BANWR and the USFWS for display and educational purposes over the years. Institutions have included the Arizona-Sonora Desert Museum, Phoenix Zoo, Columbus Zoo, Saginaw Children's Zoo, National Aviary, and Los Angeles Zoo. Continued efforts to maintain and strengthen the partnership between the AZA affiliated zoological community and the USFWS have resulted in increased interest for involvement from new zoological institutions. In addition, several zoos already maintaining display masked bobwhite have initiated actions to participate as partners to the larger genetically managed captive population with goals to eventually produce birds for re-introduction. Between the years 2015-2019, 194 birds were transferred to different zoological institutions for display or breeding across the U.S. and Mexico.

### Masked Bobwhite Historical Data Entry and Archiving

Lastly, the masked bobwhite recovery program has a long history documented in records spread across BANWR, the regional office, and other USFWS programs. An effort to compile monitoring records (**USFWS 2015**) (e.g., masked bobwhite survey data from BANWR, focusing primarily on call counts, line transects, and field notes from Mexico) provided an overview of the work conducted thus far. Historical documents from both the U.S. and Mexico were scanned and digitized, and relevant information was compiled into Excel spreadsheets. Data sources included physical datasheets, GIS files, and various yearly summary reports. All observations were compared against GIS points to evaluate consistency and identify gaps.

Call count data were collected between 1989 and 2012, though not all years are complete. Notably, datasheets are missing for 1990, 1991, and 2008. Datasheets from 1998 and 1999 varied in format, and significant changes occurred in both U.S. and Mexico datasets in 2001 and again in 2006. While the later datasheets include more detailed information such as UTM coordinates and total bird call counts, the earlier datasheets, particularly from 1989 through the late 1990s, lack clarity.

Several examples reveal common issues: discrepancies between recorded totals and column sums, switching between reporting total birds versus total calls, and entirely missing or incomplete data entries. These inconsistencies compromise the reliability of the data and its use in robust analysis. However, the presence or absence of masked bobwhite at specific locations can still be confirmed based on the available information.

Line transect data, though more limited, is available primarily from 1994–1999. Overview sheets exist for these years but require further review, as the numbers they report do not always align with those in the datasheets. Field notes from Mexico collected in 2009 and 2010 provide maps and location data for transects, including initial and farthest points. These, too, have been integrated into the spatial dataset.

GIS maps were created to visualize all masked bobwhite detections, combining information from datasheets and GIS points. For both U.S. and Mexico, the maps can confirm that detections occurred at particular locations, but due to errors and inconsistencies in the data, they cannot reliably indicate the number of individuals observed at each site. Earlier records, especially those from 1989–2005, typically include only general location information and mileage, which limits their use for precise mapping.

Throughout this process, several key questions emerged. It remains unclear whether standardized protocols existed for every year, whether playback callers were used consistently, if the same routes were intended to be reused annually, and whether more detailed maps and missing datasheets or GIS files exist. These uncertainties highlight the need for greater consistency and documentation in future monitoring efforts.

#### **2.2.1.8 Conservation Measures:**

Other conservation measures implemented adjacent to the masked bobwhite recovery program are summarized below.

##### Masked Bobwhite Recovery Team

Section 4(f)(2) of the ESA authorizes the Secretary to appoint advisory groups, also known as recovery teams, as a tool to assist with recovery planning and/or implementation. The masked bobwhite recovery program has leveraged expert opinion to inform recovery. The most recent assembled Masked Bobwhite Recovery Team (Recovery Team), established in 2008, aimed to provide recommendations for urgent recovery actions to improve the critically endangered masked bobwhite populations through transnational cooperation. The Recovery Team consisted of representatives from U.S. Federal and state agencies, Mexican agencies, academia, and accredited facilities, along with quail experts and practitioners participating in masked bobwhite recovery activities.

The Recovery Team drafted a suite of recommendations for the USFWS after their first meeting that required immediate action (**USFWS 2009b**). The Recovery Team later wrote the Five-Year Interim Action Plan (**USFWS 2009a**) for the masked bobwhite which prioritized actions deemed essential by the Recovery Team for the continued survival of the species. This included shifting the focus from captive breeding efforts towards recovery efforts for masked bobwhite in the wild.

The staff at BANWR evaluated the effectiveness of conservation efforts to inform future priority shifts. Aiming to prevent species extinction, they developed a 10-year action plan to identify actions to reverse the decline of the masked bobwhite, with the intent to reintroduce them in Arizona and Mexico (**USFWS 2011**). Additionally, the document emphasized enhancing grassland restoration efforts that would also benefit other listed species within the refuge (**USFWS 2011**). This planning document was shared with the Recovery Team to generate a common vision for recovery and reducing duplicative efforts.

The Recovery Team worked on a rearing and release strategy to facilitate this priority. The recommendations emphasized producing more masked bobwhite *ex-situ*. This in combination with Recovery Plan recommendations and a need for increased production of masked bobwhites for release led to the creation of two new captive breeding programs, beyond the program established by BANWR since 1996. These programs were located at Africam Safari in Puebla, Mexico (established in 2015) and SARC (established in 2017).

In preparation for renewed efforts, including restarting the release of masked bobwhites after a 10-year break, BANWR and Division of Biological Sciences staff collaborated with the Recovery Team to create a 5-year management and conservation plan to establish masked bobwhites at the refuge (**USFWS 2021b**). This plan outlined activities, ideal partnerships, and requirements for yearly accomplishments.

BANWR staff, in conjunction with the Recovery Team, developed additional delisting criteria in 2019 subsequent to the 1995 revision of the Masked Bobwhite Recovery Plan. The modifications are documented as an addendum that supplements the recovery criteria in the existing Recovery Plan (**USFWS 2019c**).

Currently, the Masked Bobwhite Action Team (described in a sub-section below) is initiating a strategic restructuring of the masked bobwhite recovery program to better align with newly identified priorities and focal areas. As part of this re-envisioning process, the current Recovery Team is being adjourned in favor of establishing Recovery Working Groups. This transition aims to enhance collaboration with subject matter experts and strengthen relationships with external partners, allowing for a more focused and diverse approach to recovery efforts. The Recovery Working Groups will facilitate timely decision-making and incorporate a wider range of expertise, ultimately improving the effectiveness of the recovery program.

#### Masked Bobwhite Action Team

On July 11, 2024, the Southwest Regional Director instructed the Refuges and Ecological Services Assistant Regional Directors to reset the masked bobwhite recovery program. Guidance on this mandate was to establish a three-tiered decision-making process that values consensus at the lowest levels. The three-tiered teams include: the cross-programmatic Masked Bobwhite Action Team (MBAT or Action Team), Masked Bobwhite Greater Leadership Team (MBGLT or Leadership Team), and the Masked Bobwhite Regional Directorate Team (MBRDT or Directorate Team). Since multiple USFWS programs share responsibility for the masked bobwhite recovery program, representatives from each program have at least one seat on the Action Team. Five offices within the USFWS have members on the Action Team: from the Refuges program, this includes BANWR, Division of Biological Sciences, and the Wildlife Health Office; from Ecological Services, this includes the Arizona Ecological Services Field Office and Southwest Region Branch of Recovery and Restoration.

The purpose of the Masked Bobwhite Action Team is to create an environment of collaboration, inclusivity, and transparency that advances cross-divisional and multi-programmatic expertise to unify diverse viewpoints and knowledge sources though

leveraging both intra- and inter-Service partners to advance the masked bobwhite recovery program by ensuring both scientific integrity and ESA compliance.

Since its creation, the Masked Bobwhite Action Team has worked to develop needed guidance, processes, and frameworks within the masked bobwhite recovery program. Specifically, the Action Team moved forward the Masked Bobwhite PACU and a Geriatric Bird Management Plan, organized the transfer of the masked bobwhite studbook to an AZA population geneticist, successfully incorporated biobanking in the recovery program, developed a needed Memorandum of Understanding with SARC, initiated a new structure and paradigm surrounding the Masked Bobwhite Recovery Team, and accomplished multiple regulatory requirements under the ESA.

### 2019 Amendment to the Masked Bobwhite Recovery Plan

In 2019, the USFWS completed an amendment to the second revision of the Masked Bobwhite Recovery Plan (**USFWS 1995**). The amendment considered the adequacy of the existing recovery criteria, amended recovery criteria by adding delisting criteria, and provided the rationale supporting the recovery plan modification.

USFWS personnel associated with BANWR and Ecological Services, and in conjunction with the Masked Bobwhite Recovery Team, reviewed the best available information on the status and needs of the masked bobwhite. Information found in the current Recovery Plan (**USFWS 1995**), the Masked Bobwhite 5-Year Review (**USFWS 2014**), pertinent published literature, USFWS files, and recent efforts/experiments, and personal experiences of BANWR staff and Recovery Team members, were considered during this process. Following a review of the best available scientific and commercial information, BANWR personnel summarized the state of our knowledge and the need to develop delisting criteria for the Recovery Team. In discussions with the Recovery Team, the summarized information was assessed, possible metrics to develop criteria identified, and potential delisting criteria considered. Recovery Team members provided insights and recommendations on what conditions and population status were needed to determine when the species would be recovered. Following this discussion and input, BANWR and Ecological Services personnel collaboratively utilized that information to develop the delisting criteria.

### Masked Bobwhite Conservation Benefit Agreements

Section 10(a)(1)(A) of the ESA provides terms to create conservation agreements and their associated Enhancement of Survival Permits to cover potential take of covered species. A Conservation Benefit Agreement (CBA) is a voluntary agreement created with Federal and non-federal partners for listed and non-listed species to implement actions that contribute to the conservation or recovery of the agreement's covered species.

Recovery of masked bobwhite in the wild depends upon the cooperation of property owners that neighbor BANWR. CBAs can reduce barriers to masked bobwhite recovery by assuring that the presence of masked bobwhite on private property do not result in regulations or requirements beyond those agreed to in the CBA. Additionally, a variety of partners are

involved in ongoing conservation activities in the Altar Valley and as a result, a number of plans, agreements, and other guiding documents have been developed to facilitate conservation. CBAs reinforce these other plans and remove possible impediments that the presence of masked bobwhite may have on these watershed and plant community projects.

Masked bobwhite recovery efforts continue to be implemented on BANWR located in the Altar Valley in southern Arizona. As recovery efforts prove successful, CBAs with partners beyond BANWR boundaries are a logical next step. The finalization and enrollment of private landowners into a CBA will contribute to the recovery actions needed to either down- or de-list the masked bobwhite. The associated permit issued for the CBA is valid for 50 years and allow private landowners to return their properties to the baseline status before the end of the permit (or if they leave the CBA earlier).

### Conservation Measures–Mexico

Conservation efforts in Mexico include regulatory protection by listing the species as “en peligro de extinción” (endangered) in 1994 and prioritizing the masked bobwhite in the Endangered Species Conservation Program of the Natural Protected Areas Commission. |

#### **2.2.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms):**

##### **2.2.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:**

|Historically, overgrazing combined with severe drought was the largest contribution to loss of suitable habitat for the masked bobwhite. However, the status of grazing across the range of the masked bobwhite has drastically changed since the 1890s. The following information is provided on the recent and current status of grazing in the U.S. portion of the masked bobwhite historical range.

Since its creation in 1985, grazing has not occurred on BANWR, although trespass livestock occasionally stray onto the refuge. The remainder of the Altar Valley is dominated by private ranches as well as grazing allotments on both state and federal lands. While managed grazing is generally practiced by private landowners, grazing permits also set thresholds and restriction on the total number of head that can be permitted to graze public lands (**USFWS 2024b**). Within the Altar Valley there are approximately 18 Bureau of Land Management (BLM)–Gila District Office grazing allotments (**BLM 2024**) and multiple Arizona State Lands grazing pastures (**AZSLD 2025**). With respect to grazing utilization prescriptions and monitoring required to ensure compliance with those prescriptions, the BLM administers the guidelines described in the 1997 Arizona Standards for Rangeland Health (**BLM 1997**). Stocking rates on most allotments range from 2–9 head per section (approximately 640 ac) per year, depending on range potential, with the Gila District Office average being five head per section. Grazing restrictions on Arizona State Lands are outlined in the Arizona Administrative Code (A.A.C R12-5-705), which state that carrying capacity for a section of land (640 ac) will be determined by the AZSLD, and leases may not exceed 110% of

carrying capacity without permission from the State (**AZSLD 2016**). Thus, the direct threat from grazing to masked bobwhite habitat no longer exists the way it once did, although indirect effects from long-term livestock management still persist; most notably nonnative grass introduction, mesquite encroachment and arroyo cutting.

Lehmann's lovegrass was introduced in Arizona as cattle forage in the 1930's (**Cox et al. 1988**). The species outcompetes native perennial grasses due to high seed production, low palatability to livestock, shifts in phenology timing, and high resilience to fire. Recent research also suggests that the microbial community associated with Lehmann's lovegrass suppresses native seed germination and potentially alters decomposition of litter (**Bradley 2023**). The spread of exotic grasses, specifically Lehman's lovegrass, continues to alter the landscape away from appropriate heterogeneity in vegetative structure as provided by native perennial bunch grasses to a homogenous monoculture. In addition, the seeds produced by Lehmann's lovegrass are too small for masked bobwhite to utilize. Despite sub-optimal vegetative structure, released masked bobwhite continue to be documented using dense stands of Lehmann's lovegrass, given its abundance on the landscape (**King 1998; Byrne 2023d**).

Gori and Enquist (**2003**) estimated that 82% of the BANWR landscape was comprised of exotic dominated grasslands with 10–35% shrub cover, with only 10.5% consisting of native perennial grasses and shrubs. In 2010, the BANWR Habitat Management Plan proposed an objective to remove 500 ac of Lehmann's lovegrass in 10 years (**USFWS 2010**), but control of this species requires an integrated approach, such that long-term reductions are rarely achieved. Most recently, Wells et al. (**2023**) report that of the fine fuel load (herbaceous grass and forb species) in the Altar Valley, Lehmann's lovegrass accounted for as much cover as annual and perennial grasses combined. A more recent estimate of the spread of Lehmann's lovegrass on BANWR or in the Altar Valley is unknown, but the use of fire in areas dominated by Lehmann's lovegrass often facilitates its spread. Lehman's lovegrass is capable of producing more fine fuel for fire than do native species in the arid grasslands of Arizona, such that the intensity of fire may be more severe; although the change to the fire regime may not be at the expense of native grasses (i.e., outside historical conditions experienced), as described by McDonald and McPherson (**2011**). Lehmann's lovegrass itself likely does not increase fire frequency but likely benefits from increased fire frequency. Overuse of prescribed burning, as documented in Sesnie et al. (**2022**), likely contributes to the spread of the species while inhibiting natural succession to a later seral stage that would provide the appropriate woody cover for masked bobwhite.

At the other extreme, past historical overgrazing has facilitated the spread of mesquite from drainages and lowlands to encroach into the surrounding grasslands. After the overgrazing of the late 1890s, Parker and Martin (**1952**) estimated that half of the suitable land for mesquite in southern Arizona had already been colonized. Cattle are excellent at dispersing seed, selectively avoid grazing woody vegetation, and decrease soil moisture, which favors deep-rooted mesquite (**Bahre 1991**). With high densities of cattle previously maintained on the landscape, fire suppression also aided the spread of mesquite. Mesquite, in its tree form, does not provide the appropriate cover needed for masked bobwhite; although in its shrubby form or modified by half-cutting, it can offer some measure of cover. Efforts to remove mesquite

trees and/or half cut others occurs on BANWR and surrounding lands in the Altar Valley. Sustained efforts to manage mesquite for masked bobwhite require multiple tools—fire, mechanical treatments, and chemical treatments, which can be hard to sustain across large spatial extents. Woody cover, when structured appropriately, offers thermal refugia and protective cover from predators (especially aerial) for masked bobwhite. In appropriate woody cover, such as large mesquite trees, can support raptors and increase density in areas with masked bobwhite. In addition, high temperatures in the Altar Valley require that masked bobwhite have areas that do not exceed their thermal tolerances, which requires acceptable woody cover.

The acceleration of the arroyo cutting process (**Dellenbaugh 1912**) in southeastern Arizona was attributed to the interaction of high cattle density, overgrazing, and climatic conditions (**Hastings 1959**). The trenching of stream channels often leads to loss of connectivity with their associated floodplains, which are essential for appropriate hydrological functioning since they divert water and spread out water energy (**Zeedyk and Clothier 2014**). These floodplains offer important habitat components such as thermal refugia as well increases in both habitat heterogeneity and resources (**Scamardo and Wohl 2024**). In addition, ephemeral stream floodplains are important for plant diversity and richness in these areas; as bare ground, more common in these floodplains, allows for increased annual plant species richness (**Stromberg et al. 2009**). Such areas within the arid grasslands of Arizona support the later successional stages that provide highly suitable masked bobwhite habitat. However, many of the streams and drainages within the Altar Valley have experienced some degree of cutting or other anthropogenic modification that has modified natural hydrological processes, likely severing the connection to the surrounding floodplain that provides the benefits mentioned above.

The causes and status of stressors described above are also likely relevant in Sonora, Mexico, to the best of our knowledge.

In 2008, Sonora, Mexico was the country's leader in livestock production with 83% of the state devoted to this purpose (**SEMARNAT 2008**). Agriculture and livestock production continue to expand, but slower than in the past; with land use changes to agriculture accounting for 81% of the change (**SEMARNAT 2016**). Further, increased demand for protein has shifted livestock production from mostly rangeland production to feedlot and more concentrated production systems (**Tello et al. 2020**). For grazing operations, Sonora has reportedly low overgrazing, and overall numbers of livestock have decreased (**SEMARNAT 2008**).

In the 1960s, Lehmann's lovegrass was introduced by the government into the state of Chihuahua, Mexico at the La Campana Experimental Station (**Sanchez Muñoz 2009; Ortega-S et al. 2013**) as well as in Coahuila and Sonora (**Cox et al. 1988**). In addition to Lehmann's lovegrass, buffelgrass, which was introduced in the 1950's (**Ortega-S et al. 2013**), is prevalent in Sonoran arid grasslands. Given the high forage production, ranchers in Mexico actively cultivate the species on grazing lands (**Brenner and Kanda 2013**). The full extent of nonnative species across the historical range of the masked bobwhite in Sonora is not known, but likely reflects the distribution in Arizona. Continued and renewed eradication

of buffelgrass on some ranches within the range of the masked bobwhite has resulted in improved conditions in habitat for the species. For areas dominated by buffelgrass, unsuitable habitat structure as well increased fuel loads leading to more severe fires likely remain as stressors in Mexico (**Burquez et al. 1996**). Shrubby encroachment into the arid grassland in Mexico, as in much of the southwestern United States, appears to primarily be caused by herbivory or grazing (**Auken 2000**). Although arroyo incision is not as well documented in Sonora as in Arizona, similar processes (high cattle density, overgrazing, and climatic conditions) have occurred regionally. |

#### **2.2.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:**

|The 2014 Five-Year Status Review of masked bobwhite stated that factors other than just habitat degradation may have contributed to the decline of the species. Historically, local overexploitation may have occurred, particularly in Mexico where, at least anecdotally, bobwhites were hunted. Bobwhites have been so rare in Arizona and Sonora in modern times that hunting of the species would be unproductive. Neither hunting nor collecting of masked bobwhite is currently known to be in practice in either the U.S. or Mexico.

Masked bobwhite individuals are used for scientific study, used as ambassador species at zoos for educational purposes, and are produced at one U.S.-based facility and planned for two Mexico-based facilities. Such collections do not negatively impact total wild population numbers because birds used to establish captive populations are sourced from BANWR, and no known self-sustaining wild populations currently exist in the U.S or Mexico. At present, this species is not recognized for its commercial worth, and there is no evidence of overexploitation, making overutilization insignificant as a threat. |

#### **2.2.2.3 Disease or predation:**

|Compromised health has been a continuing challenge in both captive and released populations. A full review of the health status of the captive populations of masked bobwhites can be found in USFWS (**2025c**). The expansion of the breeding component of the masked bobwhite recovery program will always be threatened by the potential introduction and spread of disease between individuals held in these facilities. Compromised animal welfare is likely to increase a captive population's vulnerability to disease and may also negatively affect productivity. The PACU describes minimum standards that must be met to reduce welfare costs to birds and minimize the risk of disease introduction and spread within the facilities. The PACU requires each captive facility to establish a veterinary-client-patient relationship to ensure that the health and welfare needs of the captive birds are properly addressed in real-time. In addition, mandatory submission of carcasses for diagnostic evaluation at a laboratory, as described in the PACU, will identify reoccurring diseases or pathologies and help to inform management and treatment decisions.

BANWR has a very high density of predators (**USFWS 2014**). Most deaths of adult radio-collared masked bobwhites continue to be attributed to raptors (**Goodwin 1982**). Increased occurrence of raptor perches due to the invasion of velvet mesquite, as describes earlier in

this section, may be responsible. In addition, although quantitative data are lacking, the potential for nest predation is high due to the large number of snakes, skunks, raccoons, bobcats, Gila monsters, road runners, ants, coyotes and foxes. |

#### **2.2.2.4 Inadequacy of existing regulatory mechanisms:**

|Regulatory mechanisms appear to be adequate to protect the masked bobwhite in both the U.S. and Mexico. The masked bobwhite has been on the Federal endangered species list in the U.S. since the passage of the Endangered Species Act of 1969 (Public Law 91-135, 83 Stat. 275). This Act was superseded by the ESA of 1973 (50 CFR 17.11; Public Law 93-205, 87 Stat. 22 884; 16 U.S.C. 1531-1540), as amended. The status is valid wherever masked bobwhites exist in the U.S. and Mexico. The masked bobwhite is also listed by the Government of Mexico as endangered in Mexico (**SEMARNAT 2010**). It is in Appendix I of the Convention on International Trade in Endangered Species (CITES) as a species in danger of extinction and is listed as near threatened by the International Union for Conservation of Nature and Natural Resources. As an endangered subspecies of a popular game bird, harvest is illegal.

Further protections under regulatory mechanisms include the initiation of a CBA with the AVCA that will provide net conservation benefits for the species under section 10 of the ESA. |

#### **2.2.2.5 Other natural or manmade factors affecting its continued existence:**

|Uncertainty in future temperature and precipitation regimes poses a substantial threat to the species and could undermine recovery efforts. Southern Arizona's ecosystems are sustained by the five seasons that occur: spring (late February to mid-May), dry summer (mid-May to mid-July), wet summer (mid-July to mid-September), fall (mid-September to late-November), and winter (December to late-February). Two rainy seasons (summer and winter) provide water availability and in arid regions is the limiting factor in plant growth (**Sabathier et al. 2021**) and therefore, phenology. Plants in arid environments are highly adapted to precipitation patterns (**Sabathier et al. 2021**), and the desert grasslands of the Altar Valley are no exception. Plant phenology cascades to seasonality in seed production and invertebrate diversity for masked bobwhite. In addition, humidity associated with wet summer monsoons is believed to partly trigger reproduction in masked bobwhite.

Altered temperature and precipitation regimes in the southwest are expected to increase temperatures, increase aridification, increase flood severity, decrease water availability, and increase fire frequencies (**Overpeck et al. 2013**). More recent data indicate increased prevalence of extreme temperatures (**Woodwell Climate Research Center 2023**), prolonged drought conditions (**AZDWR 2025**), and increased number of fire-weather days (**Boehm and Fitzpatrick 2025**), supporting many of the 2013 forecasts (**Overpeck et al. 2013**).

Changes to the temperature as well as amount, timing, and frequency of precipitation has altered vegetation phenology (**Sabathier et al. 2021**). These changes include earlier green-up

and flowering (**Lesica and Kittelson 2010**), shifts in growing season (**Reyes-Fox et al. 2016**), earlier senescence (**Reyes-Fox et al. 2016**), and other species-specific impacts (**Kopp and Cleland 2015**). Further, high surface temperatures are expected to limit plant growth (**Aminzadeh et al. 2023**). Changing phenology of masked bobwhite food plants likely alters the availability of vegetative and seed food opportunities for the species throughout the year. In addition, as plant phenology alters in response to changing temperature and precipitation trends, invertebrate diversity and abundance is also expected to decrease (**Barnett and Facey 2016**). In addition, invertebrates may directly be affected by increased temperatures: soft-bodied arthropods may disappear from areas due to desiccation, and hard-bodied arthropods may remain underground or in other refugia longer (**Barnett and Facey 2016**), such that they are less available to masked bobwhites. |

### 2.3 Synthesis

|Information generated since 2014 updates our understanding of the masked bobwhite, its threats, and recovery potential. BANWR continues to be the center of recovery efforts, and the establishment of the Masked Bobwhite Action Team has provided the framework for participation of additional personnel and entities inside and outside of USFWS. This new framework and cross-programmatic approach has facilitated the incorporation of the new information presented here, into the masked bobwhite recovery program. The results are a reorganization of the program, with a shift in recovery that focuses on the quality of masked bobwhites released rather than the quantity of individuals.

Within this new recovery focus and with essentially the entire population of the masked bobwhite being held in captivity, the success of the captive breeding program is critical to the species' survival and future recovery. Increased redundancy of the captive population held at BANWR has provided a degree of security against the threat of a catastrophic loss of a captive breeding population, and future planned facilities in Sonora increase that security. In addition, the establishment of health and welfare standards, as outlined in the PACU, ensures that healthy quail, exhibiting a higher level of fitness, both of which increase the chances of post-release survival, are produced. In addition, the creation of SOPs for each component of the masked bobwhite recovery program provides the foundation for long-term data collection and adaptive management that is needed to ensure that information learned is incorporated into the program.

New information on the diet, water use, thermal refugia, and nesting of captively-bred released masked bobwhites is beginning to inform release planning and post-release monitoring. New information on the effects of fire on masked bobwhite habitat has provided guidance on the best use of fire as a management tool to achieve desired results. Modeling efforts have shed light on potential areas of suitable habitat and climatic drivers that influence the distribution of suitability.

Habitat rehabilitation continues across the Altar Valley with partnerships, largely the AVCA. The establishment of the Masked Bobwhite CBA will solidify long-term beneficial conservation efforts across the Altar Valley. Habitat rehabilitation efforts in Mexico are not fully known.

Recent genetics work continues to support the subspecies status of masked bobwhite, as well as uncover relatedness to other bobwhite subspecies, particularly the Texas bobwhite. This important finding offers the recovery program new ways to think about incorporating the use of Texas bobwhites in the masked bobwhite recovery program. Just as important, genetics work on the captive population has confirmed the accuracy of the studbook and allowed for increased genetic management of the species that can incorporate long-term planning across multiple facilities.

Despite successes in the masked bobwhite recovery program, future environmental conditions may threaten the long-term recovery of the species in the U.S. Future temperature and precipitation patterns may threaten food and habitat structure for the masked bobwhite. Long-term planning to address these potential effects are needed in the recovery program. |

### **3.0 RESULTS**

#### **3.1 Recommended Classification:**

| **No change is needed** |

#### **3.2 New Recovery Priority Number (indicate if no change; see 48 FR 43098):**

| **No change needed; the recovery priority number should remain at 6.** |

#### **Brief Rationale:**

| This is a highly endangered subspecies with a poor chance of recovery. A Recovery Priority Number of 6 indicates that: (1) the masked bobwhite was listed as a subspecies; (2) populations face a high degree of threat; (3) recovery potential is low; and (4) recovery of the masked bobwhite is not likely to be in conflict with construction or other development projects. |

#### **3.3 Listing and Reclassification Priority Number, if reclassification is recommended (see 48 FR 43098):**

**Reclassification (from Threatened to Endangered) Priority Number:** | Not Applicable |

**Reclassification (from Endangered to Threatened) Priority Number:** | Not Applicable |

**Delisting (Removal from list regardless of current classification) Priority Number:** | Not Applicable |

#### **Brief Rationale:**

| Not Applicable |

### **4.0 RECOMMENDATIONS FOR FUTURE ACTIONS**

| Some recovery actions outlined in the latest version of the Recovery Plan (USFWS 1995) have not yet been implemented. Additionally, certain actions are no longer applicable due to

new information, and some actions have become unfeasible due to changes since 1995. In light of these factors, we present recommendations for future actions within various components of the masked bobwhite recovery program, including recovery activity planning, captive breeding, releases and monitoring, habitat assessment and management, research and data collection, and partnerships.

*Refine short-term recovery activity planning through development of a Recovery Implementation Strategy (RIS).* In the near-term, as priorities and staff time allow, new recovery activities should be identified in a RIS until the longer-term recommendation below can be accomplished. The RIS should identify new relevant recovery activities that would further masked bobwhite recovery in light of new information and new changes in the regulatory, economic, and societal environment.

*Improve long-term planning through the three-phase recovery planning process.* In the long-term, as priorities and staff time allows, the masked bobwhite recovery program would benefit from the development of a Species Status Assessment (SSA), updated Recovery Plan, and RIS. As living documents, the SSA and RIS are designed to be updated with new information periodically. The masked bobwhite has a remarkable depth of literature and information that has and continues to be added to. The speed with which adaptive management happens in the recovery program points to benefits that the three-phase recovery planning framework would provide.

*Develop thresholds for success within the masked bobwhite recovery program to assess the effectiveness of recovery actions.* To measure success within the masked bobwhite recovery program, success metrics related to recovery activities and their implementation should be developed. As multiple programs and their related staff share the responsibility of recovery, these thresholds of success can be leveraged across the USFWS.

*Continue recruitment of breeding facilities in the U.S. and Mexico.* With the believed extirpation of the masked bobwhite in the wild throughout its range, the captive population held in breeding facilities is paramount to the recovery of the species. Increased redundancy through the establishment of multiple breeding facilities protects the species from extinction in the case of a catastrophic event at any single facility.

*Continue revision of the PACU and application of adaptive management to breeding facilities.* The PACU has standardized health and welfare across non-AZA institutions breeding masked bobwhite for release. The adoption and implementation of the PACU at facilities should be monitored (via health assessments and other identified metrics) to assess its effectiveness and to revise the PACU, as needed.

*Develop pre-release educational processes for masked bobwhite to ensure the highest probability of post-release survival.* Preparing masked bobwhites for release on the landscape should ensure that individuals are at least able to learn the skills needed to survive (i.e., food recognition, predator avoidance, appropriate use of thermal refugia). It is preferred these skills be developed pre-release.

*Maintain genetic management of the species to ensure the highest genetic variation possible, with the fewest birds and resources to accomplish it.* Continue to use genetic management to select pairs for breeding, birds to transfer between institutions, identification of surplus birds, and overall genetic diversity. Meeting these objectives with the fewest birds held in facilities reduces the cost of captive breeding and should be pursued.

*Use past efforts to inform and develop comprehensive habitat assessments that address the multiple needs of released birds such as appropriate diversity and abundance of food, thermal refugia, and other habitat components.* Identify release sites that currently have and are expected to continue to have appropriate and abundant food, cover for thermoregulation and predator avoidance, as well as potential nesting and brooding habitat, which is essential to increase post-release survival and reproductive success.

*Use past efforts to advance understanding and identify release methods and variables that increase the survival of individuals.* Identify the most effective method to release captive masked bobwhite and associated strategies to ensure that individuals acclimate and survive in the wild.

*Assess whether captive birds can successfully recruit offspring at rates sufficient to support a self-sustaining population following release.* Previous observations indicate potential challenges related to hatch synchronization and chick survival to recruitment.

*Leverage post-release monitoring and establish structured program surveys to assess the 'wild' populations in the U.S. annually.* Develop methods to assess the status of the masked bobwhite population on BANWR and eventually the Altar Valley. The annual status of this population would inform recovery program efforts.

*Identify appropriate habitat management strategies in Arizona and Sonora.* Land management strategies, vegetation data collected on the ground, biophysical information expert knowledge, and prior research should be used to determine management approaches to achieving desired habitat conditions.

*Rehabilitate habitat at scales that resources can accomplish but are also meaningful and useful to masked bobwhites in the landscape.* Fully rehabilitate habitat such that all essential components exist within a management unit, and connect rehabilitated units to increase suitable habitat across the landscape.

*Finalize the Altar Valley Masked Bobwhite Conservation Benefit Agreement.* Complete the regulatory process to finalize the AVCA's conservation benefit agreement to ensure that landowners have protections from ESA section 9 prohibits from the beneficial actions they implement on the landscape.

*Continue to pursue partnerships with private, state, and other entities interested in the recovery of the masked bobwhite.* Leveraging a common goal of masked bobwhite recovery across organization and groups is needed to sustain interest in the species.

*Develop and implement a comprehensive strategy to actively pursue funding for research and recovery actions.* A focused effort is needed to re-engage both public and private partners in funding opportunities that can be strategically used to achieve recovery actions.

*Develop a method to incorporate anecdotal information on occurrences, food preferences, behaviors, and other useful information.* Given the low numbers of individuals on the landscape, any information observed that may be useful or inform any part of the masked bobwhite recovery program should be incorporated into the species record.

*Continue to promote research on the masked bobwhite.* Many aspects of the masked bobwhite life history, behaviors, and habitat preferences remain unknown. Research on these topics have provided valuable insights for the program in the past and will continue to do so, when supported.

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**U.S. FISH AND WILDLIFE SERVICE**

**5-YEAR REVIEW [of Masked Bobwhite (*Colinus virginianus ridgwayi*) ]**

**Current Classification:** [Endangered]

**Recommendation resulting from the 5-Year Review:**

[No change needed ]

**Appropriate Listing/Reclassification Priority Number, if applicable:** |

**FIELD OFFICE APPROVAL:**

**Lead Field Supervisor, Fish and Wildlife Service, [Arizona Ecological Services Office**

Approve \_\_\_\_\_

**REFUGE APPROVAL:**

**Project Leader, Fish and Wildlife Service, Buenos Aires National Wildlife Refuge**

Approve \_\_\_\_\_ |