

## RESEARCH ARTICLES

# Captive Breeding and Reintroduction of the Endangered Masked Bobwhite

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Efforts to restore the endangered masked bobwhite (*Colinus virginianus ridgwayi*) to its former range have required 1) habitat acquisition, restoration, and preservation; 2) captive propagation; and 3) reintroduction of captive-bred stock. In its role to recover the masked bobwhite, the Patuxent Wildlife Research Center (U.S. Fish and Wildlife Service) has refined captive breeding techniques; provided captive-produced stock for release; conducted field research on the distribution, limiting factors, and habitat characteristics of this species; and developed release methods. Techniques for the husbandry and captive management, breeding, artificial incubation and hatching of eggs, and rearing of young of the masked bobwhite have been developed. Successful reintroduction techniques for the masked bobwhite have included prerelease conditioning and/or cross-fostering of captive-reared masked bobwhite chicks to a wild-caught, related, vasectomized bobwhite species and their release to the wild as family units. In addition, the establishment by the U.S. Fish and Wildlife Service of the Buenos Aires National Wildlife Refuge in 1985 has further enhanced the potential for establishing a self-sustaining population of the masked bobwhite in the U.S. Through continued releases and active management of habitat, therefore, it is believed that the masked bobwhite can become permanently established at the refuge to ensure its continued survival in the wild.

**Key words:** *Colinus virginianus ridgwayi*, propagation, release, artificial incubation

## INTRODUCTION

The masked bobwhite (*Colinus virginianus ridgwayi*), one of 21 subspecies of bobwhite in North America, formerly ranged in several areas of Sonora, Mexico, and southern Arizona. Because of the destruction of grassland habitat through overgrazing

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and a series of droughts, the masked bobwhite became extirpated in Arizona by 1900 [Tomlinson, 1972].

Attempts have been made to restore the masked bobwhite in its former U.S. range since 1937 [Ellis and Serafin, 1977]. The updated Masked Bobwhite Recovery Plan [U.S. Fish and Wildlife Service, 1983] has three key objectives: 1) habitat acquisition, restoration, and preservation; 2) captive propagation; and 3) reintroduction of captive-bred stock. The Recovery Plan calls for the establishment of three or more self-sustaining masked bobwhite populations in Arizona, with at least one additional self-sustaining population to be preserved or reestablished in Sonora. (A self-sustaining population is defined as approximately 500 birds, as determined through call-count censusing techniques.) The role of the Patuxent Wildlife Research Center in this recovery effort has been to provide captive-produced stock for release and, from 1967–1978, to conduct field research on the distribution, limiting factors, and habitat characteristics of the masked bobwhite. Field station personnel also developed the release methods that are now in use [Ellis et al., 1977; Ellis and Serafin, 1977].

## **NATURAL HISTORY AND DISTRIBUTION**

Early settlers reported bobwhites living in southern Arizona and Sonora, Mexico, as early as 1864, but these birds were not identified as a separate taxon until 1884 [Allen, 1886; Brewster, 1885; Brown, 1884]. The uniquely colored males of this race have a brick-red breast with a black head and neck, hence the name masked bobwhite (Fig. 1). The females are mottled brown and generally resemble those of other subspecies.

The masked bobwhite is a covey-oriented bird normally found in groups of eight to 20. The covey travels, feeds, and roosts as a unit and will regroup quickly if flushed. Little is known of masked bobwhite food habits, but the species appears to adapt to seasonally abundant grasses, weeds, and insects. If the habitat is suitable, a covey may live within an area of less than 30 acres (J.G.G., Jr., unpublished data).

The breeding season of masked bobwhites corresponds to the summer rainy season in Arizona. Over one-half of the annual precipitation occurs from July to mid-September. The coveys separate into pairs in June and July, and the pairs nest in August and hatch broods of about a dozen chicks in early September. Winter coveys comprise family units and associated adults that were unsuccessful in breeding.

In Arizona, masked bobwhites were originally found in the mesquite-grassland community (Fig. 2) of the Altar and Santa Cruz Valleys and were reported to have been common in these areas up to 70–80 km north of the Mexican border [Brown, 1904]. In Sonora, the bird's range extended south to Guaymas, east to the foothills of the Sierra Madres, and west to within 50 km of the Gulf of California [Brown, 1885].

Prior to about 1870 there were few livestock in the historic range of the masked bobwhite, and the fragile grasslands remained generally intact. However, from 1870 to 1890, cattle numbers in Arizona increased from about 5,000 to over one million. This overstocking, followed by severe droughts in the 1890s, denuded the rangeland and caused the masked bobwhite to disappear from Arizona by 1900. Grazing pressure was less severe in Sonora, and the birds persisted in several areas until about 1950 [Ligon, 1952]. Many ornithologists believed the bird was extinct after this date,

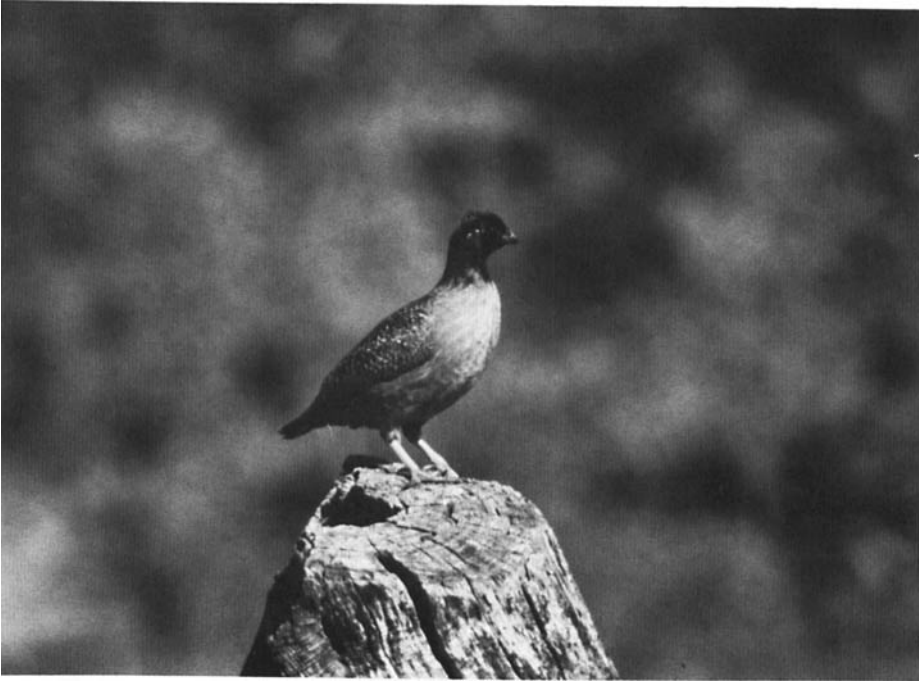


Fig. 1. An adult masked bobwhite male in the wild exhibiting the solid breast coloration and nearly all-black head.

but in 1964 a remnant population was found about 70 km north of Hermosillo [Gallizioli et al., 1967]. The Bureau of Sport Fisheries and Wildlife (now the U.S. Fish and Wildlife Service) began surveying this area in 1967 and found two small, relatively stable populations [Tomlinson, 1972]. In the mid- 1970s, these populations declined precipitously when heavy grazing and drought eliminated much of the grass and weed cover. Since then, they have survived in very low numbers.

### **CAPTIVE BREEDING**

The Patuxent Wildlife Research Center initiated a captive propagation and research program for the masked bobwhite in 1966 when four pairs of pen-reared birds were acquired. In 1968, 1970, and 1986, 75 additional birds were captured from the wild in Sonora and added to the Patuxent flock. In recent years, several hundred adult birds have been maintained in the captive flock to produce the number of chicks needed annually for release. Conservation of the masked bobwhite is enhanced by captive propagation because captive stock serve as 1) sources of animals for bolstering or reestablishing wild populations, 2) reservoirs for preserving and maintaining genetic diversity, and 3) a final redoubt in case the species cannot survive in the wild [Carpenter and Derrickson, 1982].

### **Care of Adult Masked Bobwhites**

The adult masked bobwhite facility consists of nonbreeding and breeding areas. The building is well ventilated, with both artificial and natural lighting. Concrete



Fig. 2. Masked bobwhite habitat in Mexico during the late summer breeding season.

floors facilitate regular cleaning and disinfection. Nonbreeding birds are housed in Petersime Broodunits (Petersime Incubator Co., Gettysburg, OH) consisting of six levels, each measuring  $183 \times 67 \times 20$  cm high. Twenty-eight birds are housed in each compartment. Although supplemental heat is not required in the summer,  $60^{\circ}\text{F}$  ( $16^{\circ}\text{C}$ ) is maintained automatically in each unit in cold weather. A valve-cup type automatic watering system (Edstrom Industries, Inc., Waterford, WI) provides fresh water ad libitum. Nonbreeders are provided a gamebird maintainer ration (2.4 mm pellet) containing 12% protein with amprolium added as a coccidiostat.

Adult masked bobwhites are transferred to breeding pens (G.Q.F. Mfg. Co., Savannah, GA) prior to the onset of breeding. Each breeding compartment is approximately  $50 \times 30 \times 20$  cm high and holds one male and one or two females. Breeding birds are fed a gamebird breeder ration (2.4 mm pellets) containing 18% protein. They are provided 18 hr of light daily from mid-April to late August or September. Other management procedures used with masked bobwhites include: 1) cleaning droppings trays weekly; 2) lightly debeaking birds at least twice annually to control feather picking and cannibalism; 3) conducting routine fecal examinations to detect and control parasites; 4) maintaining accurate pedigree records for all birds; and 5) using a computerized mate selection program to minimize inbreeding and associated problems.

### Artificial Incubation and Hatching of Eggs

Eggs are collected daily, labeled with the date and pen number for subsequent pedigree identification, and sorted into cardboard quail egg trays for storage in a cool

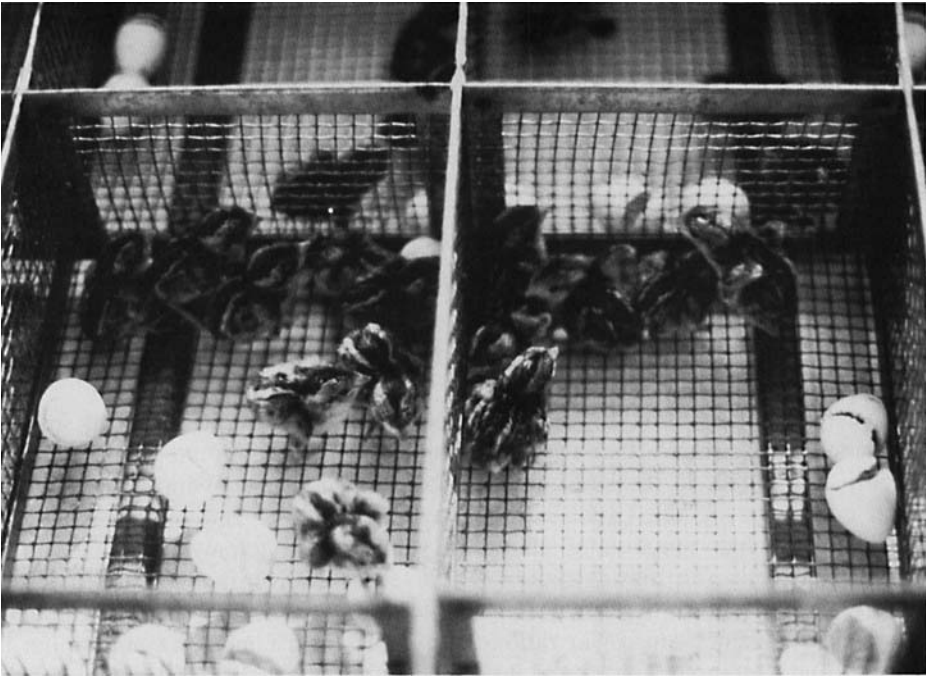


Fig. 3. Newly hatched masked bobwhite chicks in an incubator tray at the Patuxent Wildlife Research Center.

room (55°F, 13°C). Eggs are retained in the cool room for up to two weeks prior to setting to obtain groups of similar aged bobwhites for release. Eggs are set in a Petersime Model 4 forced-air incubator maintained at 99.25°F (37.4°C) dry bulb temperature and 85°F (29.4°C) wet bulb temperature (58% relative humidity) with automatic turning of 90° at 2-hr intervals. Prior to use, the incubator is cleaned and fumigated with 17.5 g potassium permanganate and 35 ml 40% formalin per 100 cubic feet for 20 min. The machine is then fumigated weekly and aired out afterward by leaving it open for 2 min. Because embryos under 3 days of age are susceptible to fumigant toxicity [Insko, 1949], fumigation only occurs when all eggs have been incubated at least 3 days.

Eggs are candled after seven days of incubation, and infertile eggs are removed. After 20 days, eggs are transferred to hatching trays in the lower part of the incubator for the final three days after hatching. Hatching trays are composed of 6-mm wire mesh and are subdivided to separate family groups (Fig. 3). Chicks remain in the hatcher for up to 12 hr after hatching before transfer to brooding units.

### Rearing of Young

Chicks are reared in a building separate from the breeding flock to reduce potential disease exposure of younger birds. Hatchlings are removed from the hatching trays when completely dry and transferred to a recently disinfected, electrically heated, and thermostatically controlled Petersime Broodunits. Each brooder contains six levels

subdivided into two compartments per level, each measuring  $92 \times 67 \times 20$  cm high with a 6-mm wire mesh floor. Up to 40 chicks are placed in a compartment. Subdued lighting, from red fluorescent lights inside the brooding units, reduces intraspecific aggression among the birds. The brooder temperature is maintained at 95°F (35°C) during the first week of age, then decreased 5°F (2.5°C) weekly. Chicks are lightly debeaked following hatching to prevent cannibalism; when properly debeaked (blunted only), the beak regrows normally by three weeks of age.

Plastic canary leg bands are placed on newly hatched chicks for identifying future breeding stock. At 2.5 weeks of age, these temporary bands are replaced with permanent metal leg bands (4.76 mm inside diameter), and chicks raised for release into the wild are shipped to Arizona. Masked bobwhites that will be retained at Patuxent are transferred at about 3 or 4 months of age to the nonbreeding room in the adult facility.

Young quail are provided a finely ground gamebird starter ration in shallow disposable trays (covered with 13-mm mesh) and water ad libitum. Because chick mortality was higher in masked bobwhites than in eastern bobwhites raised under similar conditions, studies were undertaken at Patuxent to find ways to increase chick survival. Incorporation of chlortetracycline or oxytetracycline HCl, broad spectrum antibiotics, in starting rations at a level of 45 mg/kg was found to reduce mortality significantly [Serafin, 1982]. After one week, the diet is gradually converted to a gamebird grower ration in crumble form containing amprolium as a coccidiostat. At about 2 weeks of age, feeders are attached to the outside of the pens for ease in feeding and to keep birds out of their feed. Within a week, the chicks are accustomed to the new feeders and feed trays inside the pens are removed. When the birds are 5–6 weeks of age, the grower ration is fed in pelleted form (2.4 mm).

During the first 2–3 weeks of age, water is provided in 1-qt fountain type chick waterers. A 13-mm mesh screen is placed just below the water surface to prevent drowning. After three weeks, chicks begin using water trays attached to the outside of the brooding compartment. All waterers are changed daily. Through the use of good husbandry practices, the masked bobwhite breeding program generally experiences very low levels of mortality while producing large numbers of birds for release.

During 1980–1988, masked bobwhite production at the Patuxent Wildlife Research Center met or exceeded needs for birds for release and for captive breeding stock (Table 1). Many eggs were not set, especially from those genetic lines that were well-represented. Egg production generally began in May, peaked in late June or early July, and ended in early to mid-September. Fertility also was lower at the beginning of the season than later; fertility ranged from 39% to 70% during 1980–1988. This is a minimum fertility level because it includes eggs from pens that contained females only (due to death or removal of males) and newly established pairs. Actual fertility of pairs in full production, therefore, was higher. Hatchability of fertile eggs was consistently very good and exceeded 80% (Table 1).

Chick mortality ranged from 8% to 25%, except in 1982 when mortality was unusually high. Typical causes of mortality were cannibalism (due to regrowth of beaks on chicks approaching 3 weeks of age) and enteritis from coccidia or bacteria. Total chick production, both for release and for use as breeding stock, was nearly 19,000 for the nine-year period (Table 1).

TABLE 1. Summary of captive masked bobwhite production at the Patuxent Wildlife Research Center, 1980–1988\*

Year	Number in captive population <sup>a</sup>	Number of eggs			Number of chicks	
		Laid	Set	Fertile	Hatched	Reared
1980	974	6,996	7,330	4,646 (63)	3,102 (67)	2,321 (75)
1981	1,710	13,326	8,507	5,889 (69)	4,883 (83)	3,731 (76)
1982	1,500	9,332	6,353	3,621 (57)	3,158 (87)	1,860 (50) <sup>b</sup>
1983	1,300	3,544	1,944	876 (45)	803 (90)	623 (78)
1984	1,300	2,755	1,054	696 (66)	334 (80)	300 (90)
1985	800	6,735	5,413	2,104 (39)	1,712 (81)	1,319 (77)
1986	941	7,063	6,777	3,580 (53)	3,052 (85)	2,646 (87)
1987	700	9,213	8,029	4,428 (55)	3,513 (93)	3,234 (92)
1988	686	7,798	5,990	4,180 (70)	3,715 (89)	2,917 (79)

\*Numbers in parentheses are percentages. Percent fertile is a percentage of eggs set, not total production. Percent hatched is a percentage of fertile eggs only. Discrepancies between number of chicks hatched and calculation of percent hatch of fertile eggs are due to disposal of some fertile eggs before hatching. Discrepancies between number of chicks reared and percent mortality of chicks are due to euthanasia of some chicks not included in mortality calculations.

<sup>a</sup>On or about January 1 of each year.

<sup>b</sup>Unusually high mortality due to coccidiosis outbreak.

## REINTRODUCTION PROGRAM

Several unsuccessful attempts to reintroduce small groups of masked bobwhites in Arizona were made in the 1940s and 1950s [Ligon, 1952; Campbell, 1968]. Following successful efforts to propagate masked bobwhites at the Patuxent Wildlife Research Center, releases of large numbers of birds into the historic range in Arizona began in 1970. During the next four years, quail were raised to maturity in pens at the Center, flown to Arizona, and released with little conditioning to the wild. Studies with eastern bobwhites (*C. virginianus*) had shown that pen-reared quail could be successfully established if released in good habitat [Baumgartner, 1944; Frye, 1942; Stoddard, 1931]. Unfortunately, the habitat in Arizona was in very poor condition, and few of the pen-reared masked bobwhites survived for more than a few months [Tomlinson, 1972].

In 1975, two events occurred which eventually led to successful reintroductions of masked bobwhites in Arizona. First, the Victorio Company purchased the Buenos Aires Ranch in the Altar Valley of Arizona and began an extensive range improvement program, including shrub control, reseeding of grass, and reduced livestock grazing. This program provided suitable habitat into which masked bobwhites could be released. Second, biologists began to develop prerelease conditioning programs for the masked bobwhite whereby pen-reared quail could be better prepared for survival in the wild. The most successful of these programs were the training of adult quail with the use of a call-box and the cross-fostering of captive-produced chicks [Ellis et al., 1977].

The call-box program was a modification of a technique used by dog trainers to work hunting dogs [Robinson, 1975]. For this technique, several birds from a captive covey are released, dogs point and harass the birds, and then, because of their covey bonds, the captive quail call the others back to the pen where they reenter the cage

through a one-way funnel. For training the masked bobwhite, a two-compartment box was designed so that quail could be released from one compartment and recaptured in the other, thus ensuring that all quail received the same training.

Beginning with 20 birds in the box, five to ten were released daily over a one-month period. As part of the conditioning process, the quail were first harassed by humans and later by dogs and a trained hawk to make them wary of predators. The quail responded quickly, learned to use cover to avoid predators, and, when eventually released, were much better prepared to survive in the wild. The primary problem with this technique was that relatively few birds could be trained during the year [Ellis et al., 1977].

A more efficient technique involves adopting captive-reared masked bobwhite chicks to wild foster parents and releasing them as a family unit [Stanford, 1952; Stoddard, 1931]. Since the populations of wild masked bobwhites in Mexico are too small to provide foster parents, Texas bobwhites (*C. v. texanus*) from Texas are captured for use in the adoptions. Most wild quail populations contain more males than females, and because both sexes make good parents, only surplus males are removed from the Texas population for our program. To avoid interbreeding between the Texas and masked bobwhites, the Texas quail are vasectomized [Ellis and Carpenter, 1981].

The adoption procedure involves placing 12–15 masked bobwhite chicks, 2–3 weeks old, in a heated brooder with a Texas bobwhite adult until the adult accepts the chicks and begins to brood and defend them, usually within a day or two. The family is then placed in a small pen in dense grass for several days to strengthen the family bond. When the chicks have learned to follow and stay close to the adult, the family is finally released in the best available habitat (Fig. 4). Using this technique, from 2,000 to 3,000 chicks can be released in a summer. Because quail populations generally experience 70–80% mortality annually, these releases result in a few hundred potential breeding adults for the next season.

Using these techniques, annual releases of masked bobwhites were conducted in Arizona from 1957 to 1979. These efforts established several populations that maintained themselves by natural reproduction through at least 1983, although in low numbers because of continued grazing pressure and alteration of masked bobwhite habitat (J.G.G., Jr., unpublished data). After an appropriate period of conditioning, 2,757 masked bobwhites also were provided to the Mexican government from 1980 to 1982 to help bolster its dwindling populations (Table 2). These populations also failed to thrive because of continued use of release areas for cattle grazing.

The outlook for future reintroductions of the masked bobwhite in Arizona is encouraging. The U.S. Fish and Wildlife Service purchased the Buenos Aires Ranch in 1985 and established the Buenos Aires National Wildlife Refuge. The establishment of this refuge allows appropriate habitat management to reestablish favorable conditions for the bobwhite's survival. With the removal of cattle in early summer, the vegetation had recovered enough by August 1985 to initiate releases of masked bobwhites produced at the Patuxent Wildlife Research Center. From early August and into September, 954 birds were released, primarily by the foster-parent method. Additional releases were conducted during 1986–1988, and by the end of 1988 a total of 6,664 masked bobwhites had been released on the Buenos Aires Refuge.

Although biologists at the Buenos Aires Refuge are optimistic about the success of the masked bobwhite releases, survival and reproduction of released birds on the





Fig. 4. Release of a Texas bobwhite male foster parent with a covey of 4-week-old masked bobwhite chicks.

**TABLE 2. Summary of masked bobwhite releases in Mexico and Arizona, 1980–1988**

Year	Release location	Number released
1980	Sonora, Mexico	743
1981	Sonora, Mexico	1,073
	Arizona	40 <sup>a</sup>
1982	Sonora, Mexico	941
1983	None	0
1984	None	0
1985	Arizona	853
1986	Arizona	1,699
1987	Arizona	2,171
1988	Arizona	1,841

<sup>a</sup>Accidental release of birds being conditioned for release in Mexico. It is believed that none survived.

refuge has been difficult to quantify. Furthermore, reproduction in the wild has been hampered by abnormal weather patterns in the years since releases were initiated. During November–March of 1988–1989, a minimum of 150 bobwhites in 15 coveys were located in winter surveys. Trapping efforts resulted in the capture of 30 birds, four of which were wild young of the year. Individual coveys consisted of from three to 16 birds (mean, 9.8), and trapped birds had ranged from 0 to 19 miles from their original release site (S.J. Dobrott, Buenos Aires National Wildlife Refuge, personal communication).

Refuge biologists believed that there was substantial breeding activity on the refuge during summer 1989. At the beginning of the breeding season, 64 calling males were located during call-count surveys. This exceeds the 50-bird minimum target number in the Recovery Plan objectives [U.S. Fish and Wildlife Service, 1983]. Surveys and trapping to assess 1989 wild production and survival of released birds was conducted in the winter of 1989–1990. From this survey, refuge personnel estimated that about 100–300 birds over-wintered on the refuge from releases in previous years. This represented an increase in over-wintering survival over past years in spite of a severe drought in 1989. Although some breeding of masked bobwhites has occurred on the refuge, it has not been quantified. The population is, therefore, not yet self-sustaining and no formal timetable has been established for discontinuing releases on the refuge.

Additional releases are planned, and refuge personnel will continue active management of masked bobwhite habitat through prescribed burns, discing, brush-piling, removal of dense overstory (especially mesquite), and planting of food crops. With these continued efforts, we believe that the masked bobwhite can become permanently established at the refuge to ensure their continued survival in the wild.

## **CONCLUSIONS**

1. Activities to recover the endangered masked bobwhite include: habitat acquisition, restoration, and preservation; captive propagation; and reintroduction of captive-produced stock to the wild.

2. Captive propagation is an important technique for recovering the masked bobwhite because captive stock serve as: sources of animals for bolstering or reestablishing wild populations; reservoirs for preserving and maintaining genetic diversity; and a final redoubt in case the species cannot survive in the wild.

3. A successful management program for a breeding flock of masked bobwhites includes: good nutrition; sanitary, uncrowded enclosures; disease and parasite control; and a sound genetic management scheme with accurate pedigree records.

4. Production of vigorous, healthy masked bobwhite chicks for release requires a well-managed incubation program and chick-rearing facilities separate from adult birds. Good sanitation and environmental control are key components of both artificial incubation and rearing regimes.

5. Successful reintroduction techniques for the masked bobwhite include pre-release conditioning and/or cross-fostering of captive-reared masked bobwhite chicks to a wild-caught, related bobwhite species and releasing them into the wild as family units.

6. The establishment of the Buenos Aires National Wildlife Refuge in 1985 has greatly improved the potential for reintroducing the masked bobwhite in the United States.

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