**Habitat Suitability Index Model: Mary Hunnicutt**

The following habitat suitability index model was created from the opinion of one species expert. We developed this model following the U.S. Fish and Wildlife Service guide to the development of habitat suitability index (HSI) models 103-ESM (USFWS 1981). However, unlike typical HSI models this model is intended to be used in conjunction with alternative HSI models developed from additional experts and existing literature. This model represents the best estimates of a single species expert.

**Section 1.Model Applicability:**

1.1 Geographic area. This model was developed based on knowledge of masked bobwhite habitat in Buenos Aires National Wildlife Refuge (BANWR), AZ, U.S. and nearby areas as well as the Rancho el Carrizo area south of Benjamin Hill, Sonora, MX.

1.2 Season. This model covers both breeding/nesting season (July-September) and post breeding (September-June).

**Section 2. Model Description**:

2.1 Overview. This model considers the ability of assessed habitat to meet the food, reproductive, and cover requirements of masked bobwhite as an indicator of overall habitat suitability. All components of the model are assessed by vegetative conditions. The relationship between habitat variables and critical life history requirements of masked bobwhite is illustrated in Figure 1.

2.2 Written Documentation.

The following sections provide a written documentation of the logic and assumptions used to interpret the habitat information for masked bobwhite in order to explain the variables and equations that are used in the HSI model. We present each critical habitat requirement and describe the variables which contribute to it.

1. **Cover**

This component provides both hiding cover and thermal cover for masked bobwhites. Overall canopy requirements are important, but species diversity and canopy structure may be even more important in providing what the bird needs.

Canopy cover requirements as determined by the HMP are:

* 15%-30% of woody vegetation cover (mid-story shrubs and trees 3 to 10 feet tall) (Johnson and Hoffman n.d.)
* ≥15% forb cover (Simms 1989)
* ≥15% native grass cover (Reichenbacher and Mills 1984)
* 0%-25% unobstructed bare ground (Goodwin and Hungerford 1977)

The tree component is not separated out from the shrub component because on BANWR there is very little shrub component available. Instead, small trees fulfill the habitat requirements otherwise satisfied by shrubs and are optimal at <10%-15% cover. However, leguminous shrubs are far more important to masked bobwhite than trees since leguminous shrubs provide a source of food as well as cover. Desert broom is not utilized by quail.

Cover should be composed of adequate species diversity. Diverse stands of native vegetation consisting of a minimum of 8-12 native perennial grass species; a minimum of 12-16 perennial forb species; and a minimum of 3-6 mid story shrub/tree species.

The structure of vegetative cover is also important for its efficacy. This structure is not well quantified, although Guthery (2001) described some portions using the vulnerability measures developed by Kopp et al. (1998). Good quality masked bobwhite habitat is multilayered and “clumpy” with a distinctive “lumpy” look. The term “lumpy” refers to the presence of multiple, overlapping, layers of vegetation. There should be tall components (typically trees), medium height components (typically shrubs), and a herbaceous component. The grass/forb (herbaceous) component sometimes stands alone, but it is often combined with interspersed areas of shrub mid-story and tree upper-story both with herbaceous understory. A substantial amount of bare ground is necessary, at least 25% and up to 50% in brood habitat. Bare ground should not be in blocks but, rather, should weave in and around clumps of vegetation to provide corridors for movement. Herbaceous cover should coalesce at the top while maintaining open space below to facilitate movement by masked bobwhites.

During the non-breeding season masked bobwhites are found almost exclusively in the edges between grasslands and woodlands. Even during the breeding season the birds may be nesting only a bit further away, indicating that edge habitat remains important during breeding. In Mexico, the drainangeges are very shallow and filled with whiteball acacia (*Acacia angustissima*) and bundleflower (*Desmanthus spp.*). In Arizona, the drainages were historically filled with sacaton grass which was likely used for both protection from predators and as a source of food (seeds). Unfortunately, most of the sacaton bottoms are gone, and very little protection from predators remains in drainages. Optimal drainages now contain *Mimosa* species, sometimes in combination with whiteball acacia, but also a wide variety of vines and forbs/grasses. Saltbush (*Atriplex spp.*) and whitethorn acacia (*Acacia constricta*) may also be beneficial.

Trees tend to be used for thermal cover and for males to call from during the breeding season. Coveys of masked bobwhites use the shade of trees for loafing habitat.

1. **Food** 
   1. Mexico – Food for masked bobwhites has been only rarely described. In Mexico there is a report of masked bobwhites feeding in a weedy garden with croton (*Croton spp.*), ragweed (*Ambrosia spp.*), and insects in their diet. Seeds of the appropriate size (generally considered to be the size of milo seed) are an important source of food. The availability of a variety of seeds species seems to be especially crucial, likely due to the progression of seed drop from the various species which provides continuous food throughout the year. In Mexico the main winter foods are white-ball acacia and bundleflower, of which there are at least two species. Both of these plants are abundant in the drainages. The bundleflower species appear to dehisce and drop seeds early in the fall while the white-ball acacia retains the pods on the plant for a longer into the winter. Almost all masked bobwhites sightings in Mexico outside of the breeding season are in association with drainages containing white-ball acacia and bundleflower indicating that the two plant species are important. There are many more leguminous shrubs in Mexico which are also likely to provide an important source of food.
   2. Arizona- Arizona lacks large stands of white-ball acacia and bundleflower. However, masked bobwhites have been observed in the vicinity of small patches of these plants, suggesting masked bobwhites do utilize these species in Arizona. Alternatively, *Mimosa biuncifera* and *Mimosa dysocarpa* do occur in large stands in Arizona and their seeds appear to be of the right size for utilization by masked bobwhites. Moreover, masked bobwhites have been trapped in *Mimosa* stands adding to the evidence that these plants are useful habitat for masked bobwhites. Masked bobwhites have also been observed consuming the seeds of partridge pea (*Chamaecritae nictitans*) and, possibly though unconfirmed, showy vetch (*Vicia pulchella*) and vine mesquite grass (*Panicum obtusum*). Seeds are an important source of food in the winter through the early summer until the monsoonal rains occur. In the spring flight-pen bobwhites have been observed eating a wide variety of spouted vegetation except coyote gourd (*Curccurbita digitata*).

Forbs become abundant during the summer monsoon. Masked bobwhites appear to key in on grasshoppers, and other insects, during this period. Local abundance of grasshoppers is correlated with the presence of masked bobwhites. Chicks in captivity and been seen pursuing and consuming flour beetles within the commercial feed they are given at the day old stage. Crickets which are 2-weeks old, and approximately ¼ inch in (6mm) size, appeared to be the right size for 2-3 week old chicks. The timing of masked bobwhite breeding may be synchronized to the period when grasshoppers of this size are abundant. It is possible that climate change is altering the timing of grasshopper emergence and reducing the availability of this important source of food.

1. **Reproduction** (Courtship, nesting, and brood rearing)

Optimal habitat for masked bobwhites changes slightly during the monsoon reproduction season, expanding into the uplands. Abundance of masked bobwhites during the breeding season is associated with high species diversity of both herbaceous plants and leguminous shrubs. Males use shrubs (3-5 feet or .9-1.5 meters tall) and trees (20-30 feet or 6-9 meters tall) as calling sites. Males call from the tops of shrubs but will call from midway up trees (10-15 feet or 3-4.5 meters up).

Nests are typically located in a 9 inch (23cm) round clump of grass but can be located at the base of a shrub or under other similarly dense vegetation. In flight pens, masked bobwhites will even use artificial structures for nesting cover. Appropriate nest sites should be available at the rate of approximately 300-600 per acre.

Bare ground is also important for reproduction. A very high amount of bare ground in needed for broods to be able to navigate and find food. The forb/grass cover can coalesce at the top, providing protection from predators, while being open underneath to allow chicks to move around and locate insects, sprouts, or seeds.

Mid-story shrub cover is essential in breeding areas to provide cover from predators and calling sites for males. As described above, these shrubs should be leguminous so that they can also serve as important sources of food later in the year.

Spring green-up of vegetation is essential to reproduction in masked bobwhite and in quail in general. Adequate winter rain must exist for forbs and grasses to sprout. Without suppression of phytoestrogens present in drying vegetation the birds do not come into breeding condition. Green plants available for food in the spring promote normal reproduction.

**Section 3. Graphical Representation**

**Figure 1.** The relationship between measured habitat variables, critical life history requirements, and habitat suitability for masked bobwhites.

Measured Habitat Variable Life Requisite Model Output

Tree Cover

Shrub Cover

Bare Ground Cover

Forb Cover

Food

Native Grass Cover

Number of Nest Sites

Suitability Index

Cover

Availability of Drainage/Upland Interface

Small sized Grasshopper Availability

Reproduction

Multi-Storied Vegetation

Native Grass Diversity

Forb Diversity

Shrub/ Tree Diversity

Spring Forb Green-up

**Section 4. Suitability Functions and Graphs**

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Description | Suitability Function | Suitability Graph |
| TC | Canopy Cover of trees as measured by a densitometer or aerial photo over each acre of ground. |  | X:\Masked Bobwhite\Graphs\Suitability Functions\Mary Hunnicutt\TC_Mary.emf |
| SC | Cover of woody shrubs as measured by aerial photo, or line intercept method, within each acre of ground. |  | X:\Masked Bobwhite\Graphs\Suitability Functions\Mary Hunnicutt\SC_Mary.emf |
| BG | Amount of bare ground, including that under vegetation. Must be capable of being traversed by a bobwhite. Measured as one would on Daubenmire transect. |  | X:\Masked Bobwhite\Graphs\Suitability Functions\Mary Hunnicutt\BG_Mary.emf |
| FC | Proportion of green forbs measured as one would in a Daubnenmire frame (per acre). |  | X:\Masked Bobwhite\Graphs\Suitability Functions\Mary Hunnicutt\FC_Mary.emf |
| GC | Proportion of native grass as measured by basal area by line intercept or Daubenmire Method (per acre). |  | X:\Masked Bobwhite\Graphs\Suitability Functions\Mary Hunnicutt\GC_Mary.emf |
| NC | The number of appropriate nest sites, as counted in a frame or intercept technique, per acre. |  | X:\Masked Bobwhite\Graphs\Suitability Functions\Mary Hunnicutt\Nest_Mary.emf |
| GD | The number of native grass species per acre as counted on a line intercept |  | X:\Masked Bobwhite\Graphs\Suitability Functions\Mary Hunnicutt\GD_Mary.emf |
| FD | The number of forb species per acre, as measured on a line intercept or frame method. |  | X:\Masked Bobwhite\Graphs\Suitability Functions\Mary Hunnicutt\FD_Mary.emf |
| SD | The number of shrub and tree species, per acre, as counted on a line transect or quadrant. |  | X:\Masked Bobwhite\Graphs\Suitability Functions\Mary Hunnicutt\STD_Mary.emf |
| EH | Presence or absence of an ecotone between drainage and upland grass habitat on each acre. |  | X:\Masked Bobwhite\Graphs\Suitability Functions\Mary Hunnicutt\Edge_Mary.emf |
| LV | The presence or absence of multi-layered vegetation on each acre. |  | X:\Masked Bobwhite\Graphs\Suitability Functions\Mary Hunnicutt\Layer_Mary.emf |
| GR | Grasshopper abundance during the breeding season on each acre. The exact relationship is unknown but more is better. The given function will assign suitability to an area relative to other measured areas. |  | X:\Masked Bobwhite\Graphs\Suitability Functions\Mary Hunnicutt\Hopper_Mary.emf |

**Equations.**

The final habitat suitability index score is a result of the combination of suitability scores from component variables. The equations which describe this combination are governed by the assumptions and relationships described in section 2.2. Additive equations imply each variable in the equation can compensate for other variables with low scores unless otherwise noted. Multiplication implies a score of zero for any variable results in a suitability score equal to zero (i.e. both variables must have non-zero scores for the habitat to be suitable).