**Habitat Suitability Index Model: Dr. David Ellis**

The following habitat suitability index model is the result of information obtained from a single 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.

1.Model Applicability:

1.1 Geographic area. This model was developed based on knowledge of masked bobwhite habitat in Arizona, specifically Buenos Aires National Wildlife Refuge.

1.2 Season. This model was developed to evaluate habitat needs of masked bobwhites over the entire year.

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 quail 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. Reproduction. Reproductive requirements are assumed to be met if all the other critical habitat requirements are adequately addressed.
2. Food. Structural diversity is important and is a function of the species diversity of grasses, forbs, and shrubs. Adequate diversity is important for providing food year round and can be measured via Shannon Diversity Index or similar method. Forb diversity is important for captive bred “uncultured’ masked bobwhites. Released birds don’t know how to utilize available food so it is important to have high diversity of forbs. This will increase the diversity of seed, vegetative, and arthropod food sources available to masked bobwhites over a greater period of the year. Masked bobwhites require a minimum of approximately 15 forb species before habitat becomes suitable. Habitat suitability generally increases with increasing forb diversity up to a saturation point at which increased diversity has no effect on suitability. Likewise, grass diversity is also an important food source and follows the same habitat suitability curve as forb diversity. Both perennial and annual grass species are important for food and the optimal ratio is likely 1:1. More information is needed about the role of grass diversity as a food resource for masked bobwhites. Shrub diversity is not essential but may provide an additional source of food.
3. Predator Protection. There are two important components of predator protection; 1) concealment, and 2) physical barrier. Concealment is primarily a function of forbs and grasses. Forb height is important for concealment from predators. Optimal height of forbs is between 0.33 and 1 meter. Suitability diminishes both above and below this range. Likewise, forb cover is important as escape cover year round. Forb cover is assumed to be adequate if both total cover and forb diversity are adequate. Grass cover, primarily perennial grasses, is important for concealment. Suitable levels of grass cover can create safe corridors for birds to move on the landscape. Grass cover should be measured both as stem density and as percent ground cover from above since these two metrics will indicate the suitability of grass cover to provide the appropriate cover matrix. Additionally, grass cover should be measured from the side through the use of a cover board (or similar device) to ensure adequate concealment from terrestrial predators while allowing adequate mobility and visibility.

Brush piles provide both concealment and a physical barrier and can be a replacement for natural cover if properly maintained. Brush piles should be placed approximately 45 meters apart and maintained to prevent collapse. Frames are recommended to prevent collapse of brush piles and maintain open space within the pile. Appropriate levels of shrub cover provide both concealment and physical barrier are preferable to brush piles and do not require regular maintenance. Moreover, shrub cover may provide additional benefits beyond that of predator protection (see Food). Shrubs should be between 0.33 and 2m in height to provide optimal protection from predators. As shrubs grow larger, and lose limbs which are close to the ground, they become less suitable habitat. Shrub cover is important year round but is most important during winter months. Total cover is a more important measure than any single cover metric. Total cover can be measured directly or can be computed from component parts as in Figure 1. Structural diversity creates both concealment and physical protection for masked bobwhites during the entire year while still providing adequate space for movement and visibility. Tree cover is counterproductive for masked bobwhite habitat as it provides perch sites for raptors.

**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

Forb Diversity

Structural Diversity

Grass Diversity

Food

Tree Cover

Shrub Diversity

Forb Height

Predator Protection

Suitability Index

Grass Canopy Cover

Shrub Height

Grass Height

Grass Stem Density

Grass Cover

Forb Cover

Shrub Cover

Total Cover

Grass Horizontal Cover

Brush Piles

**3. Suitability Functions and Graphs**

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Description | Suitability Function | Suitability Graph |
| FD | Forb Diversity measured as the total number of forb species on a given home range throughout the year | (Gamma CDF with α=23.5, β=1) | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dave Ellis\FD Ellis.emf |
| GD | Grass Diversity measured as the total number of both annual and perennial grass species on a given home range throughout the year | (Gamma CDF with α=23.5, β=1) | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dave Ellis\GD Ellis.emf |
| ShD | Shrub diversity measured as the total number of shrub species on a given home range throughout the year | (Gamma CDF with α=11, β=1) | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dave Ellis\ShDEllis.emf |
| FH | Forb Height measured as the average height of Forbs on a given home range |  | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dave Ellis\FH.emf |
| GH | Grass Height measured as the average height of grass on a given home range |  | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dave Ellis\GH Ellis.emf |
| SH | Shrub Height measured as the average height of grass on a given home range |  | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dave Ellis\SH Ellis.emf |
| TrC | Tree cover measured as the percent canopy cover of trees on a given home range |  | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dave Ellis\TrC Ellis.emf |
| GC1 | Grass Canopy Cover measured from above the grass canopy as the amount of ground covered by grass foliage on a given home range |  | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dave Ellis\GC1 Ellis.emf |
| GC2 | Grass Cover from the side measured as the average amount of distance until complete visual obstruction on a given home range. |  | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dave Ellis\GC2 Ellis.emf |
| GC3 | Grass basal area measured as the average area occupied by stems of grass on a given home range. | (B(5,20) is the Beta function evaluated at α=5, β=20) | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dave Ellis\GC3 Ellis.emf |
| TC | Total Cover measured as the average total canopy cover of all vegetation (and brush piles) on a given home range. Suitability of total cover differs in winter and summer. | Winter:  (B(3,7) is the Beta function evaluated at α=3, β=7) | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dave Ellis\WTC Ellis.emf |
|  |  | Summer:  (B(4,4) is the Beta function evaluated at α=3, β=7) | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dave Ellis\STC Ellis.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).