**Habitat Suitability Index Model: Sally Gall and Dan Cohan**

The following habitat suitability index model is the result of information obtained from the consensus of two species experts. Aspects of the model for which the experts failed to reach a consensus 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 two species experts.

1.Model Applicability:

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

1.2 Season. This model was developed to evaluate habitat needs of masked bobwhites over the entire year. The suitability of certain variables differs among seasons and these differences are noted and described in the model.

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. Reproduction. Available habitat for masked bobwhites must contain adequate cover for nesting and brooding. Perennial bunch grasses of 1-2 feet in height are necessary for nesting substrate. Tree cover provides important perches for calling. Optimal values of tree cover are described under “Cover”. Structural diversity is important for providing the appropriate mix of nesting and brooding habitat. If all other cover components are at optimal levels, structural diversity is assumed to be optimal as well.
2. Food. Forb cover is an important source of food for both adults and juveniles. Masked bobwhites use forb foliage directly and indirectly by eating the insects which are associated with forbs. Optimal canopy cover of forbs is approximately 50 percent from the late summer through the winter whereas in the spring and early summer the optimum ranges from 35 to 65 percent. Forb diversity is important for food year round, primarily because a diverse forb community will result in a diverse insect community. Forbs are also used directly as a food source early in the summer and forb height should be lower during that time to allow for access to the foliage by masked bobwhites. Food bearing shrubs are an important source of food in the winter when other sources of food are scarce. Structural diversity is important year round for food. High structural diversity creates a wide array of micro-habitats which increases species richness of insect prey and diversity of herbaceous plants. Woodland-grassland edges improve habitat by providing a greater variety of options for food within a relatively small area. Leaf litter can provide additional food by improving insect abundance.
3. Cover. The height of forbs in the fall and winter should be at a minimum of 6 inches but is most suitable at a height of greater than 20 inches to provide adequate cover. Forbs provide an important cover component with optimal values described above under “Food”. Shrubs are also an important cover component. Optimal values of shrub canopy cover differed between experts. Both experts stated optimal cover should be 10-60 percent; however one expert stated any value between these two would be optimal whereas the other expert stated 40 percent is the optimal value with diminishing suitability above and below this value. Both experts agreed that shrubs should be between 3 and 5 feet with an optimal height of 4 feet. Brush piles can substitute for shrubs when shrub cover is not adequate. Brush piles should be approximately 50 feet in diameter and 50 yards apart. Brush piles should be low (<6 feet) and dense. Brush piles should be placed in areas lacking natural cover, near natural cover and in uplands to provide additional cover during breeding. Perennial bunch grasses are important year round for cover. Optimal canopy cover of perennial grasses is 55 percent. Annual grasses also provide an important cover component in the summer and fall with an optimal canopy cover of 45 percent. The proportion of perennial grasses to annual grasses should be approximately 80:20. The optimal height of grasses differed between the two experts. One expert stated optimal grass height is 4-5 feet whereas the other expert stated optimal grass values are 2-5 feet. Trees are used as cover and provide structural complexity. Tree cover is optimal at low values (5 percent) of canopy cover in the uplands and slightly higher (30 percent) canopy cover in arroyos. Small trees can serve the same cover function as shrubs. Structural diversity is important the entire year for cover. Woodland-grassland edges provide a greater variety of options for cover within a small area. Bare ground is important year round for mobility but is most important in the fall to provide escape corridors after chicks begin to disperse. The optimal value of bare ground is 25 percent.
4. Thermal Refuge. Tree cover provides an important source of shade and perch sites for thermoregulation of masked bobwhites. Leaf litter is also important for thermoregulation by retaining moisture.

**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

Forb Cover

Reproduction

Forbs

Forb Diversity

Forb Height

Food

Grass Cover

Suitability Index

Grass

Grass Diversity

Cover

Grass Height

Shrubs

Shrub Cover

Thermal Refuge

Brush Piles

Shrub Height

Bare Ground

Leaf Litter

**3. Suitability Functions and Graphs**

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Description | Suitability Function | Suitability Graph |
| FC | Forb cover measured as the average canopy cover of forbs. The optimal canopy cover of forbs differs between the fall and winter and the spring and summer. | Late Summer/Fall/Winter: | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dan and Sally\FC Fall-winter Sally-Dan.emf |
|  |  | Spring/ Summer: | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dan and Sally\FC Spring-summer Sally-Dan.emf |
| FD | Forb Diversity measured as the total number of forb species found in reasonable abundance on a given home range throughout the year. | (Gamma CDF with α=22.5, β=1) | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dan and Sally\FD Sally-Dan.emf |
| FH | Forb height measured as the average height of forbs. Optimal forb height differs between the spring and summer and the fall and winter. | Fall/ Winter:  (Gamma CDF with α=13, β=1) | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dan and Sally\FH Fall-winter Sally-Dan.emf |
|  |  | Spring/ Summer:  (Gamma CDF with α=13, β=1) | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dan and Sally\FH Spring-summer Sally-Dan.emf |
| GC | Grass cover measured as the percent canopy cover of grass. The optimal canopy cover of grass differs between perennial and annual grasses. | Perennials: | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dan and Sally\GC Perennial Sally-Dan.emf |
|  |  | Annuals: | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dan and Sally\GC Annual Sally-Dan.emf |
| GD | Grass diversity measured as the total number of grass species found on a given home range. The optimal number of species differs between perennial and annual grasses. | Perennials:  (Gamma CDF with α=7, β=2.33) | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dan and Sally\GC Perennial Sally-Dan.emf |
|  |  | Annuals:  (Gamma CDF with α=5, β=2.5) | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dan and Sally\GD Annual Sally-Dan.emf |
| GH | Grass height measured as the average height of grass on a given home range. | Expert 1: | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dan and Sally\GH Dan.emf |
|  |  | Expert 2 Cover: | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dan and Sally\GH Sally Cover.emf |
|  |  | Expert 2 Nesting: | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dan and Sally\GH Sally Nesting.emf |
| SC | Shrub cover measured as the average canopy cover of shrubs. The two experts differed in their assessment of optimal shrub cover. | Expert 1: | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dan and Sally\SC Dan.emf |
|  |  | Expert 2: | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dan and Sally\SC Sally.emf |
| SH | Shrub height measured as the average height of shrubs. |  | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dan and Sally\SH Sally-Dan.emf |
| TC | Tree cover measured as the average canopy cover of trees. The optimal value of tree cover differs between the uplands and arroyos. | Uplands: | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dan and Sally\TC Uplands Sall-Dan.emf |
|  |  | Arroyos: | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dan and Sally\TC Arroyos Sally-Dan.emf |
| BG | Bare ground measured as the average canopy cover of bare ground. Bare ground should be in the form of a matrix interspersed with other canopy components |  | C:\Documents and Settings\cnadeau\My Documents\Work\Masked Bobwhite\Graphs\Suitability Functions\Dan and Sally\BG Sally-Dan.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).