## Habitat Suitability Index Model: John Goodwin

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 both Arizona, specifically Buenos Aires National Wildlife Refuge, and northern Mexico. The habitat needs of masked bobwhites in Mexico and Arizona may differ for certain variables and this difference is reflected in the model below.

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 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. Adequate reproduction is essential to the recovery of the masked bobwhite. Reproduction of masked bobwhite in the wild must be successful enough to withstand substantial predation pressure. It is unclear whether reproductive success is currently limited by genetic weakness, poor habitat, or behavioral issues. This model is intended to address habitat conditions but it is recommended that all three of these potential problems are investigated. If available habitat provides adequate food, cover, and thermal refuge (described below) then the reproductive habitat needs of masked bobwhite are assumed to be met.

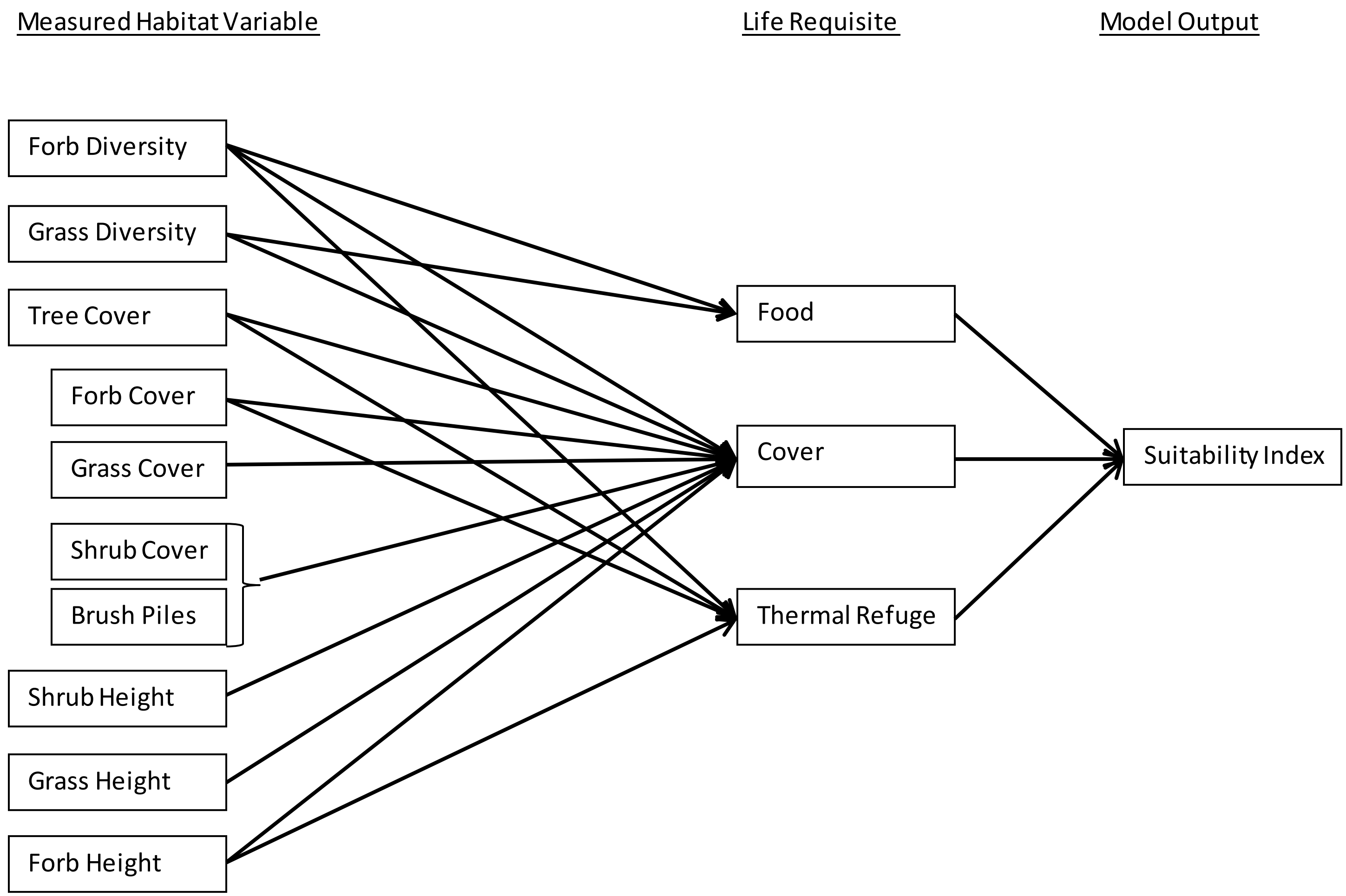
2. Food. Forb diversity is an important source of food for masked bobwhites. High forb diversity helps ensure habitat continuity by providing food during a larger portion of the year and during natural fluctuations in climate between years. A minimum of 10 to 15 species in reasonable abundance is necessary for adequate food while more is better. Grass diversity can also be an important source of food. Grass should be a mix of both perennials and annuals but perennials are more important. Large monocultures of any species are generally detrimental. Similar to forb diversity, a minimum of 10 to 15 grass species should be found in reasonable abundance across a given home range. In Mexico, higher forb diversity can make up for lower numbers of perennial grasses.

3. Cover. Forb diversity is important for providing adequate cover and habitat continuity as described above. Forb cover is an important component of masked bobwhite habitat. Optimal values of forb cover are lower in Arizona than Mexico. In Arizona 20 to 30 percent of the ground should be covered by forb canopy whereas in Mexico 30 and 40 percent of the ground should be covered by forb canopy. Forb cover should be composed of an adequate number of species as described for forb diversity. There is no optimal height for forbs, rather, forbs should have high structural diversity. High structural diversity is likely to be achieved if there are an adequate number of forb species present. Grass cover is an important substrate for nesting and loafing. Grass canopy cover is optimal between 20 and 30 percent. Grass diversity is important for maintaining adequate grass cover during dry years. Similar to forbs, grass should have high structural diversity. Large monocultures of any grass species are detrimental to masked bobwhite habitat. Shrub cover is also an important cover component and should be between 10 and 15 percent canopy cover. Additionally, shrub cover should be distributed in clumps across the landscape so that shrub patches are no more than 100 yards apart. Shrub height can vary quite a bit but should be above 3 or 4 feet. Brush piles can substitute for shrubs when shrubs are not available on the landscape or if there is inadequate shrub cover. Arroyos can also be valuable as movement corridors and tree cover can provide some level of cover as well. Bare ground is important for movement; 15 - 20 percent bare ground should be present in optimal habitat in Arizona and 30 - 40 percent bare ground should be present in optimal habitat in Mexico. The distribution of each cover component should be such that each component is available within approximately 100 yards.

4. Thermal Refuge. Forb diversity and cover are both important for thermal regulation. Evapotranspiration from forbs can create a cooler microclimate under the forb canopy and

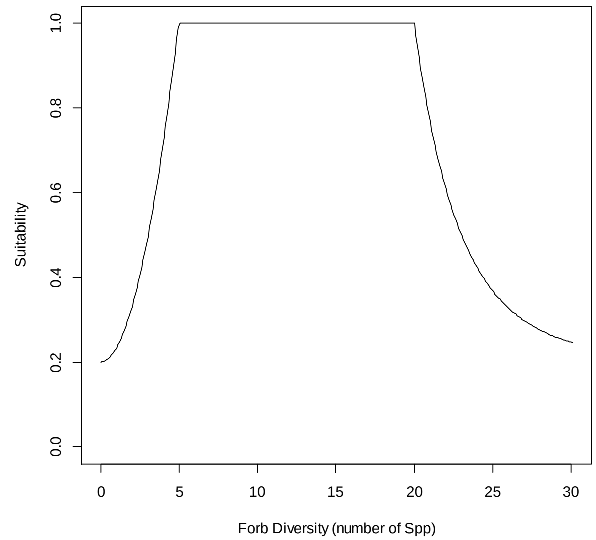
provide respite from high ambient temperatures. Forb diversity improves habitat continuity between and within years because high species diversity will result in a higher likelihood of having forb species which can tolerate a wide range of climactic conditions. Tree cover is also important for temperature and humidity regulation by providing shaded perches with greater airflow than is found on the ground.

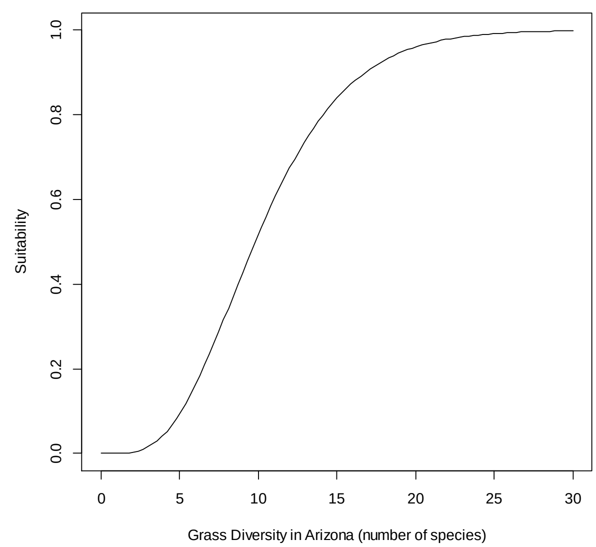
**Figure 1.** The relationship between measured habitat variables, critical life history requirements, and habitat suitability for masked bobwhites.



## 3. Suitability Functions and Graphs

| Variable | Description | Suitability Function | Suitability Graph |
|---|---|---|---|
| FD | Forb Diversity measured as the total number of forb species found in reasonable abundance on a given home range throughout the year | $F(x) = \begin{cases} 0.2 + \frac{x}{5.5}^{2} & x < 5 \\ 1 & 5 < x < 20 \\ 0.2 + \frac{1.024e9}{x^7} & x > 20 \end{cases}$ | |
| GD | Grass Diversity measured as the total number of both annual and perennial grass species found in reasonable abundance on a given home range throughout the year. Optimal levels of grass diversity differ in Arizona and Mexico. | Arizona: $F(x) = \frac{\int_0^{x/.476} t^4 e^{-t} dt}{\Gamma(5)}$ (Gamma CDF with α=5, β=0.476) | |

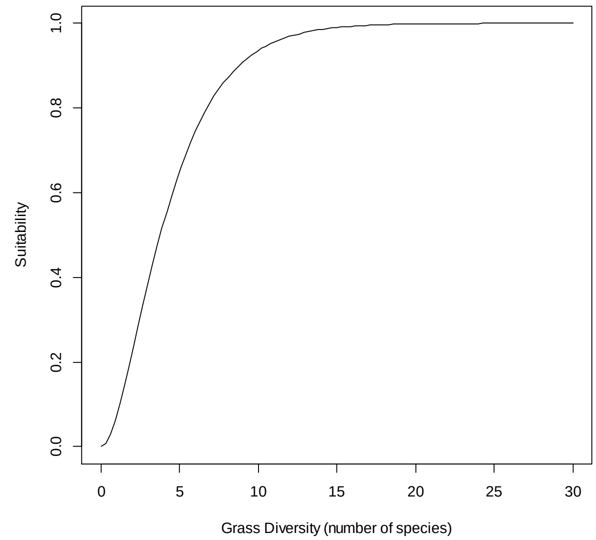


Mexico:

$$F(x) = \frac{\int_0^{x/.444} t^1 e^{-t} dt}{\Gamma(2)}$$

(Gamma CDF with α=2, β=0.444)



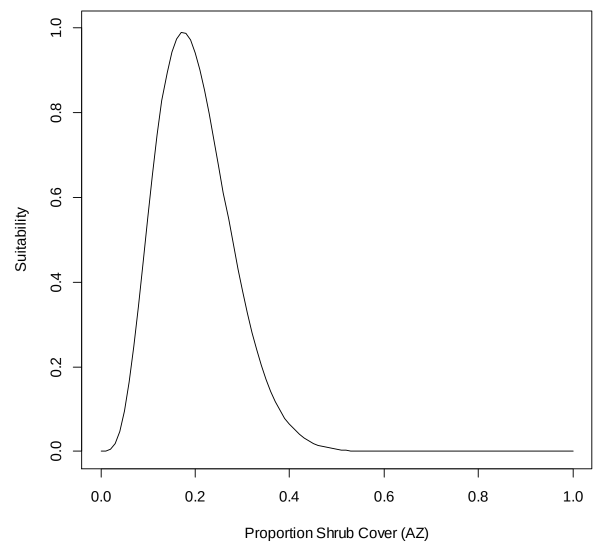

SC

Shrub cover measured as the average canopy cover of shrubs throughout the year. Shrub cover should be distributed in clumps approximately 100 yards apart.

Arizona:

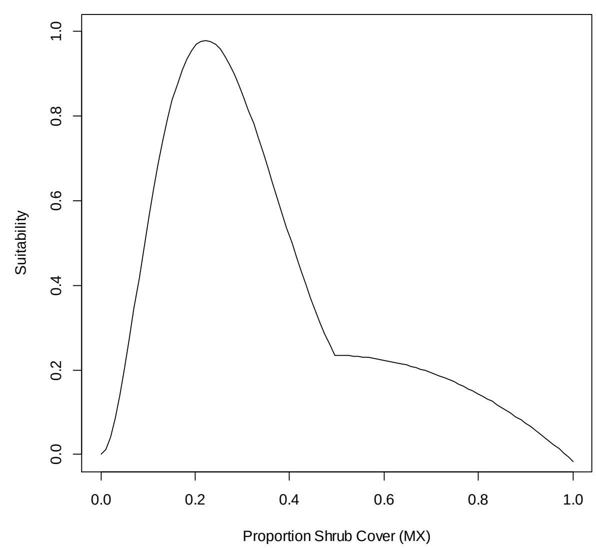
$$F(x) = \frac{x^4(1-x)^{19}}{B(5,20)}$$

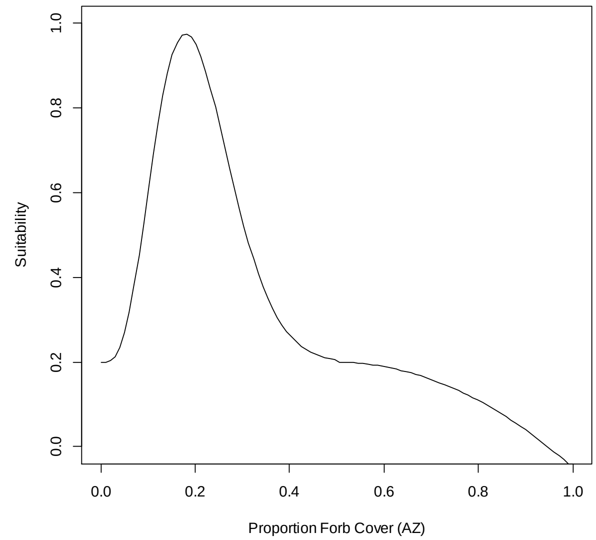
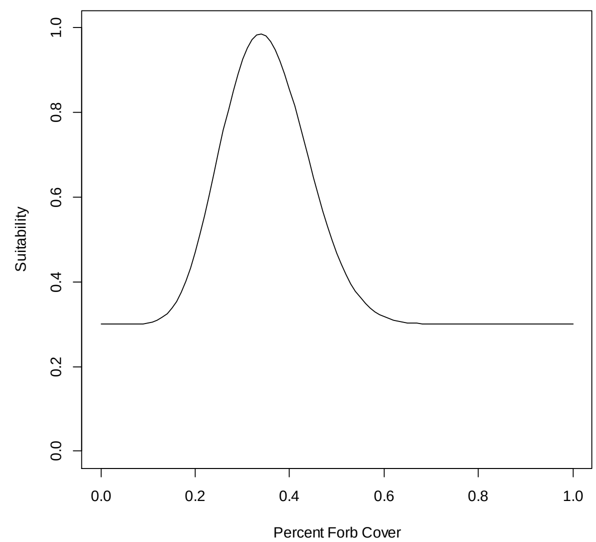
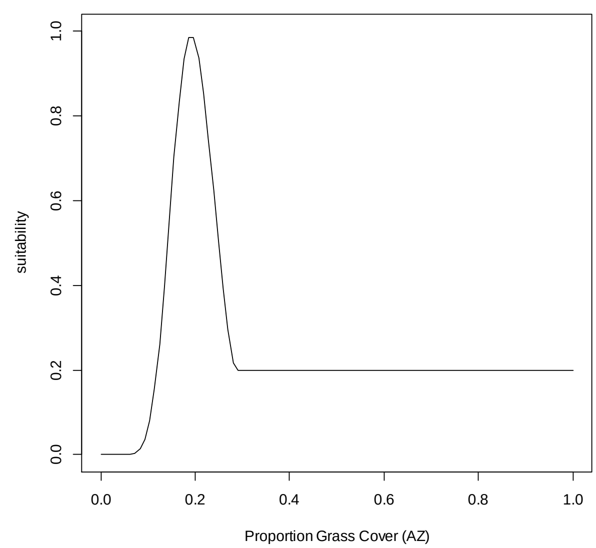
(Beta PDF with α=5, β=20)




Mexico:

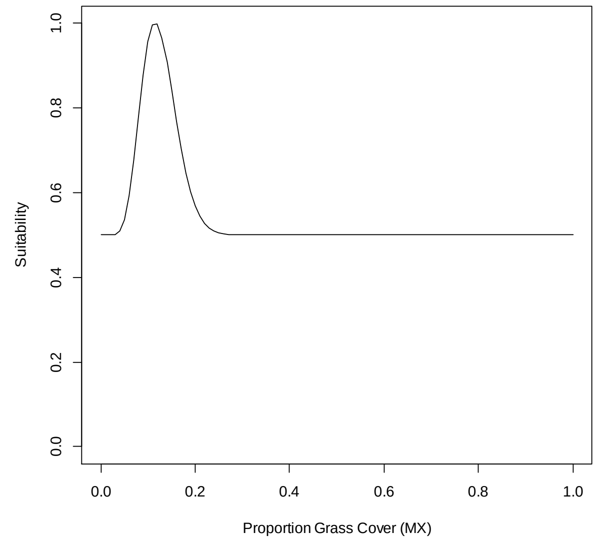
$$F(x) = \begin{cases} \frac{x^2(1-x)^{6.909}}{B(3,7.909)} & x \leq .5 \\ x - x^2 - .0157 & .5 < x \end{cases}$$



| | | | |
|---|---|---|---|
| FC | Forb cover measured as the average canopy cover of forbs. Suitability differs in Arizona and Mexico. | Arizona: $F(x) = \begin{cases} .2 + \frac{x^4(1-x)^{18}}{B(5,19)} * \frac{1}{6.4} & x \leq .5 \\ x - x^2 - .05, & x > .5 \end{cases}$ |  |
| | | Mexico: $F(x) = .3 + \frac{x^9(1-x)^{17.57}}{B(10,17.57)6.5}$ |  |
| GC | Grass cover measured as the average canopy cover of grass. Suitability differs between Arizona and Mexico. | Arizona: $F(x) = \begin{cases} \frac{x^{14}(1-x)^{59}}{B(15,60)8.8}, & x \leq .28 \\ 0.2, & x > .28 \end{cases}$ |  |

Mexico:

$$F(x) = .5 + \frac{x^9(1-x)^{59}}{B(10,60)22}$$

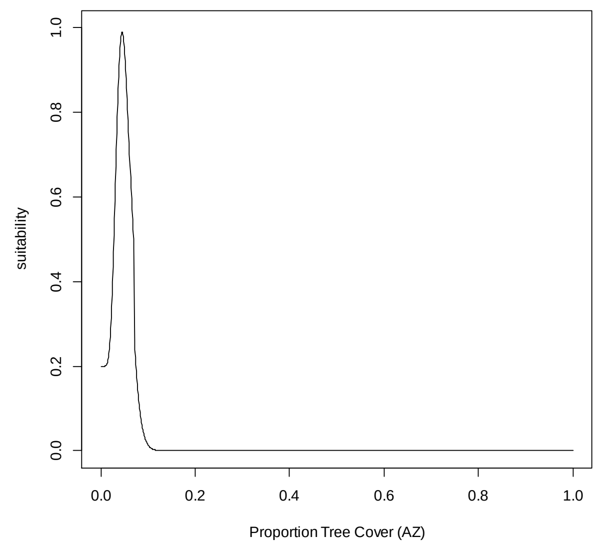



TC

Tree cover measured as the average canopy cover of trees. Suitability of tree cover differs between Arizona and Mexico.

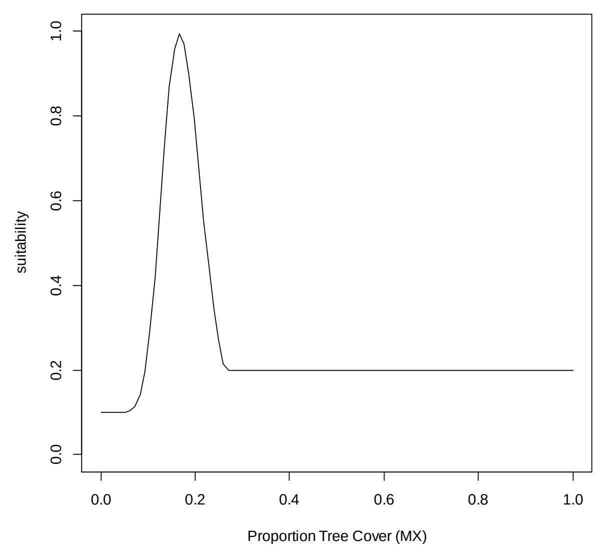
Arizona:

$$F(x) = \begin{cases} .2 + \dfrac{x^9(1-x)^{189}}{B(10,190)34}, x \leq .07 \\ \dfrac{x^9(1-x)^{189}}{B(10,190)34}, x > .07 \end{cases}$$




Mexico:

$$F(x) = \begin{cases} .1 + \dfrac{x^{14}(1-x)^{69.7}}{B(15,70.7)34}, x \leq .26 \\ 0.2, \quad x > .26 \end{cases}$$



**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).

$$Food = \frac{GD + FD}{2}$$

$$Cover = \frac{(FD * FC)^{1/2} + (GD * GC)^{1/2} + TC + SC}{4}$$

$$Thermal\ Refuge = \frac{(FD * FC)^{1/2} + TC}{2}$$

$$HSI = Lowest\ score\ from\ Food, Cover\ or\ Thermal\ Refuge$$