Logic and Extent Elevate Suitability Models to New Levels

Previous "Beyond Mapping" discussions on suitability modeling used wildlife habitat mapping to illustrate the development of progressively more powerful modeling approaches: binary, ranking, permutation and rating models. All four approaches used the same set of basic criteria: Hugag preference for gentle slopes, southerly aspects and lower elevations (see Figure 1). The discussions focused on differences in how the processing takes place.

In the case of a *binary model*, each consideration is treated as good or bad and results in a habitat map that identifies just good and bad habitat areas. A *ranking model*, however, uses the same good/bad criteria, but it identifies the number of good factors for each map location, and higher values indicate increasingly higher habitat ranking. A *permutation model* provides additional information by identifying the unique combinations of good and bad factors occurring at each location.

Good Ratings

A *rating model* is the most powerful approach, and it breaks the good/bad dichotomy into a preference gradient most often expressed as 1 = very bad to 9 = very good. For example, the preference for gentle slopes (S_Pref in Figure 1) was assigned as 1 (very bad) = greater than 40 percent; 3 = 30-40 percent; 5 = 20-30 percent; 7 = 10-20 percent; and 9 (very good) = 0-10 percent.

In a similar manner, categories for aspect and elevation are calibrated and then averaged and masked for constrained areas to generate the overall suitability map shown in Figure 1. This result contains continuous habitat values—considerably more information than simply the spatial coincidence of discrete areas of good/bad classifications.

Separate Sub-Models

Although the processing approach is an important consideration, the model's logic and extent can be more important in determining accuracy. In practical applications, the habitat model likely would consider many more factors than simply terrain configuration.

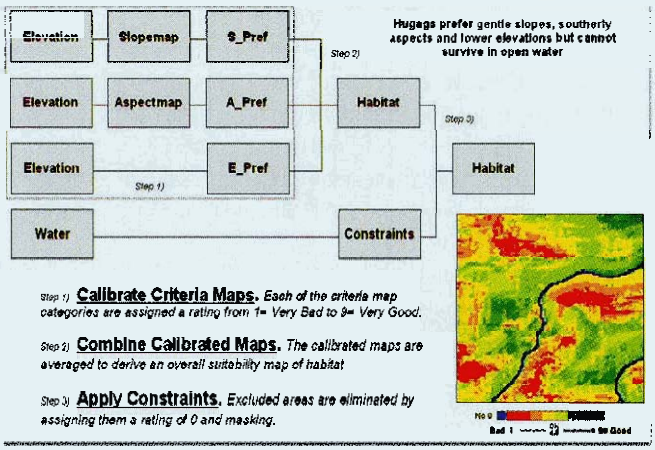

Figure 1. A graphic describes the model logic for basic Hugag habitat suitability mapping.

Figure 2 shows a flowchart of the extended model logic used to evaluate the additional criteria that "Hugags would prefer to be in forested areas" (Forest map), "Hugags would prefer to be near water" (proximity to Water map), and "Hugags would prefer to be far from roads" (proximity to Roads map). In suitability modeling, these considerations are treated as separate sub-models to derive the necessary criteria and then calibrated on the 1-9 preference scale and averaged with the basic set of terrain considerations for an overall habitat map shown in Figure 2.

Note that a large part of the model's strength or weakness is established in Step 1) Calibrate Criteria Maps. As much as possible, the identification of map criteria needs to reflect good science and/or expert opinion to capture factors that are important and easily measurable. Similarly, calibrating the maps into the 1-9 preference range needs to capture realistic relative values and not whimsical or biased assignments.

Important Relatives

Step 2) Combine Calibrated Maps also requires considerable understanding of the system being modeled. A simple average of the calibrated map layers assumes that all criteria are equally important. The right inset in Figure 3 shows the habitat results for "expert thinking" that Hugags are "10 times more concerned about slope, forest and water considerations than they are about aspect, elevation and roads considerations."

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The procedure for determining relative importance involves computing the weighted average of the six map layers and is analogous to a professor grading some exams more importantly than others in determining a class grade. In this particular example, map values correspond to student grades on each exam; each student is represented as a grid cell on the map—kind of like their desk seats in the classroom floor plan.

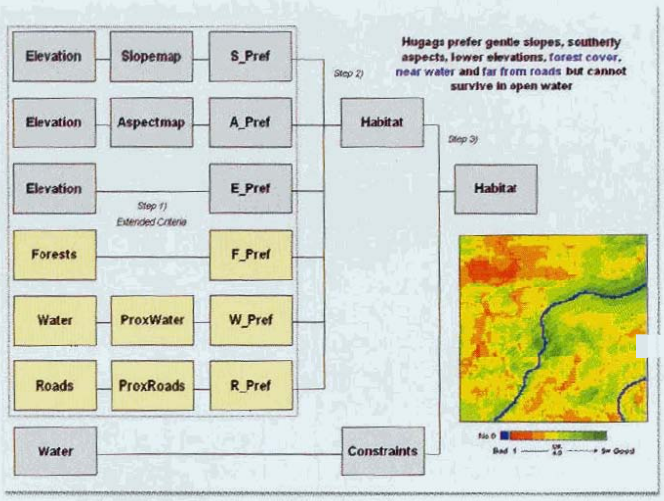
Note in Figure 3 the similarities and differences in the maps induced by the additional criteria (Extended) and relative weighting of map layers (Weighted). Provided that expert opinion is sound, the weighted map on the right would be considered the most accurate representation of Hugag habitat.

Also note that calibrating and weighting are critical steps in suitability modeling. Procedures such as Delphi and AHP can be used to derive these factors in a quantitative, objective, consistent and comprehensive manner (see "Author's Note," below). In addition, factors can be changed to reflect different assumption scenarios analogous to "what if" questions applied to traditional spreadsheet analysis.

From this perspective, it's how the suitability maps change that becomes information about a project area's sensitivity to the interplay of criteria, calibrations and weights. This takes us well "beyond mapping" and into assessing the spatial relationships within a system and their logical expression within a GIS.

As GIS technology matures, the focus is shifting from access of static map products depicting physical features for navigation and inventory to a dynamic environment that enables "thinking with a stack of maps" within decision-making contexts.

Author's Note: *For a discussion of Delphi and AHP procedures as well as a PowerPoint slide set, instructions and free evaluation software for classroom or individual "hands-on" experience in suitability modeling, visit the Web at* http://www.innovativegis.com/basis, *selecting "Column Supplements." Select the "Map Analysis" online book for a compilation of previous "Beyond Mapping" columns.* gw



model logic considers Hugag preferences for being in forests, near water and far from roads.

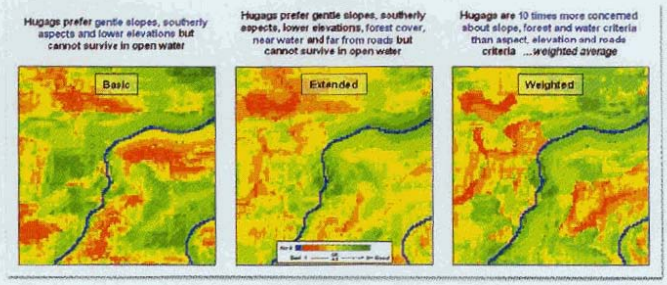


Figure 3. Habitat rating maps demonstrate progressively more powerful model logic and processing.