The Use of GIS in Habitat Modeling

In 1981, the U.S. Fish and Wildlife Service established a standard process for modeling wildlife habitats, the Habitat Suitability Index (HSI) and Habitat Evaluation Procedures (HEP). These models incorporate the basic life needs of a species, and use various modeling approaches to assign values to different areas relating to how well they provide for the basic needs of that species. Geographic Information Systems (GIS) and Remote Sensing (RS) have become useful tools in the development of these models (Donovan 1987). The use of GIS has become essential in this field because the large scale that predictive models may cover makes it nearly impossible to maintain an updated HSI using only field studies (Osbourne 2001).

Habitat models can be used for many different purposes. One of the most common is for the conservation of a declining habitat or species (Periera 1991, Lauver 2002, Tash 2007). By modeling potential habitats of a particular species, conservation, restoration and translocation areas can be identified. These models are not only created for species of concern, but for species that play a major role in the health and biodiversity of an area as well (Mollot 2008).

In all of the papers reviewed, the same basic steps were used in creating the final habitat model or HSI. The first step is data collection, and there are several ways this can be done. Data can be collected empirically (on the ground data collection, surveys, telemetry etc.), through expert information or through literature reviews Depending on the scale of the study, GIS can be used to not only execute the habitat models, but also produce the data needed (Store 2003). A combination of all of these approaches is commonly used to get the best data for the model because, as Clevenger (2002) shows in his study, each method has strengths and weakness. Expert information and literature reviews will provide important information on the habitat requirements of the species being studied, but will not provide specific locations of a species in most cases. Empirical data will show the researcher the exact locations where a species is found. All of the studies reviewed used some combination of the different data types to provide the strongest predictive model.

After data collection is complete, GIS may be used as a modeling approach to identify habitat preference. Variables representing common habitat features are identified based on known locations of the species in order to create a model (Donovan 1987, Tash 2007). Such variables may include soil type, elevation, cover type, distance to habitat features or other species, water type, wetland, etc. Without the use of a GIS, information on all of these variables would need to be collected on the ground, which is incredibly time and labor intensive. With GIS, information on these variables is found in datasets that can be layered on the map with raw empirical data for easy classification.

The next step in creating a habitat model is assigning suitability values to each pixel in the GIS based on the strongest variables. There are many ways to calculate these values and depending on the overall goal of the study, and the data that is collected, some analyses will give better results than others. Therefore it is important to test different analyses before collecting data in order to ensure the production of a strong model (Guisan 2000, Hirzel 2001). The most common method in the papers reviewed is some form of a multivariate regression.
Weighted variables are not included in all HSI models, either because all variables are assumed to have the same importance in the model or the actual importance is not known requiring weight assumptions (Tash 2007). Once analyses are complete the pixels are assigned a value, they can be arbitrarily symbolized to predict habitat suitability (Mollot 2008).

A final step that is not always completed is ground-truthing (Clevenger 2002, Mollot 2008). Many studies involving modeling habitats with GIS stop once a map of predictive suitability has been produced. However, because of the large scale of most of these studies, it is very important to field-test the model. Using untested models to aid in management decisions may prove a costly mistake in expensive operations such as aiding the conservation of a species or habitat. If problems arise during the testing phases, new data can easily be put into the GIS to create a more accurate model, a major benefit of using a GIS.

GIS based habitat models are not only used in the conservation biology and ecology fields. Community planning is another field where habitat models can be useful. By adding data layers specific to an HSI within a GIS, planning decisions could be made to benefit a species. Clevenger’s 2001 work on black bears in Canada shows that by simply putting data layers for development and roads into a predictive occurrence model, community planners can learn the best places to place “bear crossing” signs, and plan for future placement of roads. Community planners may also leverage HSI modeling to protect public health. The habitat of a blacklegged tick was modeled by Guerra (2002) in order to predict areas that are high risk for the incidence of Lyme disease. Data was collected on the current location of ticks carrying Lyme disease and entered into a GIS. The areas that were identified as “good” tick habitat by the HSI produced let people in the area know where they should be most concerned about contracting Lyme disease.

For all of the benefits of using GIS to create habitat models, there are some disadvantages to relying solely on this technique. In many cases, the scale is fairly large, which gives a very coarse picture of the habitat. There are also limitations with the datasets that are available for use in a GIS. In many land cover data sets, there is very little information on understory characteristics (Clevenger 2001, Lauver 2002, Tash 2007). Depending on the species this fine-scale information may not be very important, but for many smaller animals, the role of understory vegetation is an extremely important variable (Lauver 2002, Tash 2007) the lack of this data will affect the overall strength of the final model.

Using GIS to create habitat models is a great technique and is extremely valuable in species conservation and management. Many of the disadvantages of using such a large-scale approach can be mitigated by supplementing the available GIS datasets and remotely sensed imagery with data collected at a fine scale, and having the ability to easily update models in the GIS platform as new information becomes available allows researchers and professionals to produce a stronger model over time.

**Literature Cited (not in annotated bibliography)**


Annotated Bibliography


The goals of this study were to use three different approaches to modeling the habitat of black bears in Canada as they relate to major roadways. The investigators used empirical data, expert knowledge and literature reviews to compile three models of the best bear habitat along different road classes in Canada. These models are meant to highlight areas were there may be a high incidence of road kills. This paper was particularly interesting because many examples of habitat modeling focus on large regional scales, but this study was very specific in its scale. The methods proposed in this paper would be useful not only for professionals interested in habitat conservation, but also professionals who make decisions on the best placement of roads.


This article was very interesting because it does not focus on creating a model for the purpose of restoration or conservation, but rather for identifying risk areas for contracting Lyme disease. Both small scale (field collected soil and vegetation data) and large scale (Landsat images, land cover data) were entered into a GIS to generate a habitat model to predict the occurrence of Lyme carrying ticks. The scientific design was very simple, but yielded what seem to be high quality results. My one criticism of this study is that the size of pixels used to predict presence was fairly large in comparison to the scale of the data used. However, the authors mention that as more data on the presence of ticks becomes available, the model can be easily altered and become more accurate.


This study uses a virtual species to compare two different methods for compiling a habitat suitability model in GIS. Each method had its advantages and disadvantages, the most important being that one method only required the input of presence data, while the other
method required both presence and absence data. Because there are many ways to use GIS to develop a model, it is important to know which methods will work best for the data that is available. By using a virtual species combined with real environmental data in your GIS, it is possible to determine the best possible method for creating a habitat suitability model.


The authors of this study tested an adapted version of an existing habitat suitability index (HSI) for several bird species. Their goal was to determine which variables in the existing HSI were most important, and if the existing information would ring true when put to a finer scale. By using sighting data for the bird species they found that that the model was accurate, but they were not able to accurately predict the quality of the habitat where the birds were found. This study illustrates some of the short-comings of using GIS to create habitat suitability models, mainly that fine scale data is often sacrificed, and that when looking at vegetation, it is often difficult to get reliable information on lower level shrubs and herbaceous plants.


This study focuses on identifying forest restoration areas using remotely sensed data. I found this study particularly interesting because of the information and tools used to complete the modeling. LiDAR elevation data was used, rather than USGS DEM data, so a much finer resolution was obtained to identify riparian forest restoration sites, but it was still noted that the models obtained using GIS should always be ground-truthed to check for accuracy and artifacts of analysis.


This study introduces methods for developing a multi-scale habitat suitability index (HSI) and follows up with a case study to demonstrate the methods. While many HSI’s are available for individual species, the authors are trying to develop a reliable way to combine models for different species that share similar habitats. The problems that are addressed in trying to accomplish this is the importance of properly weighing habitat variables. To get an accurate picture of the habitat model, the variables included should be weighed for importance, and when dealing with several species, it is very difficult to accurately weigh the variables to create a reliable HSI.


In this study, the authors use a range-wide survey of cottontails to identify important habitat characteristics to identify sites for restoration and relocation. Presence/absence data was
added to a GIS with a USGS NLCD layer to identify important variables in areas with known cottontail populations in order to predict other areas that they could inhabit. Other variables, such as snow cover were also used to identify restoration sites. One problem I found with this study is the scale. The study covers a very large area (all of New England) and the authors are recommending very specific areas as restoration areas. Because the scale of the data used is so large, I feel that it is important to perform ground-truthing, or perhaps doing a follow up study each specific population identified to try and get finer scale cover data before applying time and funds towards restoring the areas that were identified.