Techniques and Technology Note

Landscape Habitat Suitability Index Software

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ABSTRACT Habitat suitability index (HSI) models are traditionally used to evaluate habitat quality for wildlife at a local scale. Rarely have such models incorporated spatial relationships of habitat components. We introduce Landscape HSImodels, a new Microsoft Windows® (Microsoft, Redmond, WA)–based program that incorporates local habitat as well as landscape-scale attributes to evaluate habitats for 21 species of wildlife. Models for additional species can be constructed using the generic model option. At a landscape scale, attributes include edge effects, patch area, distance to resources, and habitat composition. A moving window approach is used to evaluate habitat composition and interspersion within areas typical of home ranges and territories or larger. The software and sample data are available free of charge from the United States Forest Service, Northern Research Station at http://www.nrs.fs.fed.us/hsi/. (JOURNAL OF WILDLIFE MANAGEMENT 71(2):668–670; 2007)

KEY WORDS habitat, index, landscape, model, software, suitability.

Habitat suitability index (HSI) models have been used since the early 1980s to determine wildlife habitat quality at the local scale based on field measurement data (U.S. Fish and Wildlife Service 1980, 1981). Habitat suitability ranges from 0 (low quality) to 1 (high quality) based on wildlife–habitat relationships such as vegetation type (e.g., grass, forb, woody), structure (e.g., stem density), canopy cover, and the presence or absence of known foods. Many existing HSI models are field-labor intensive and difficult to apply to large areas due to the fine-scale nature of required data. Further, advances in our understanding of wildlife–habitat relationships, especially in regard to area- or edge-sensitivity and interspersion of life requisites (Morrison et al. 1998), necessitates incorporation of spatial requirements in HSI models. We developed Landscape HSImodels software to provide wildlife biologists and managers a tool to evaluate wildlife habitat quality across large landscapes. Habitat suitability is basically evaluated at 2 scales: the pixel and the landscape surrounding the pixel.

The Landscape HSImodels software allows the user to incorporate landscape-scale habitat components such as area sensitivity, edge effects, distance to specific resources, and habitat composition within areas typical of animal home ranges or territories or larger. We accomplish this through the use of a moving window that systematically processes portions of the landscape representing home ranges or territories to determine resources immediately accessible to an individual. This moving window moves across the landscape until the entire landscape has been processed. The size of the moving window can be changed by altering its dimensions or by varying the resolution of the input data; however, users should keep in mind ecological processes (e.g., edge sensitivity) or species home-range size when selecting the appropriate resolution.

We combined landscape information with existing HSI models or through the creation of new HSI models to build models available in the software. Users can evaluate habitat quality at larger geographic extents than was typically done in the past. For example, the software may be used to evaluate maps of alternative forest management practices on wildlife, assesses habitat conditions prior to management activities, or identify focal areas for conservation or management (Fig. 1).

Habitat suitability index models are available in the software for 21 wildlife species. We developed HSI models through literature review of studies using empirical data, through adaptation of existing HSI models, and from expert opinion. Species models within the software include ovenbird (*Seiurus aurocapillus*), prairie warbler (*Dendroica discolor*), Henslow's sparrow (*Ammodramus henslowii*), hooded warbler (*Wilsonia citrina*), cerulean warbler (*Dendroica cerulea*), yellow-breasted chat (*Icteria virens*), pine warbler (*Dendroica pinus*), worm-eating warbler (*Helmitheros vermivorus*), wood thrush (*Hylocichla mustelina*), wild turkey (*Melagris gallopavo*), ruffed grouse (*Bonasa umbellus*), American woodcock (*Scolopax minor*), northern bobwhite (*Colinus virginianus*), gray squirrel (*Sciurus carolinensis*), black bear (*Ursus americanus*), bobcat (*Lynx rufus*), red bat

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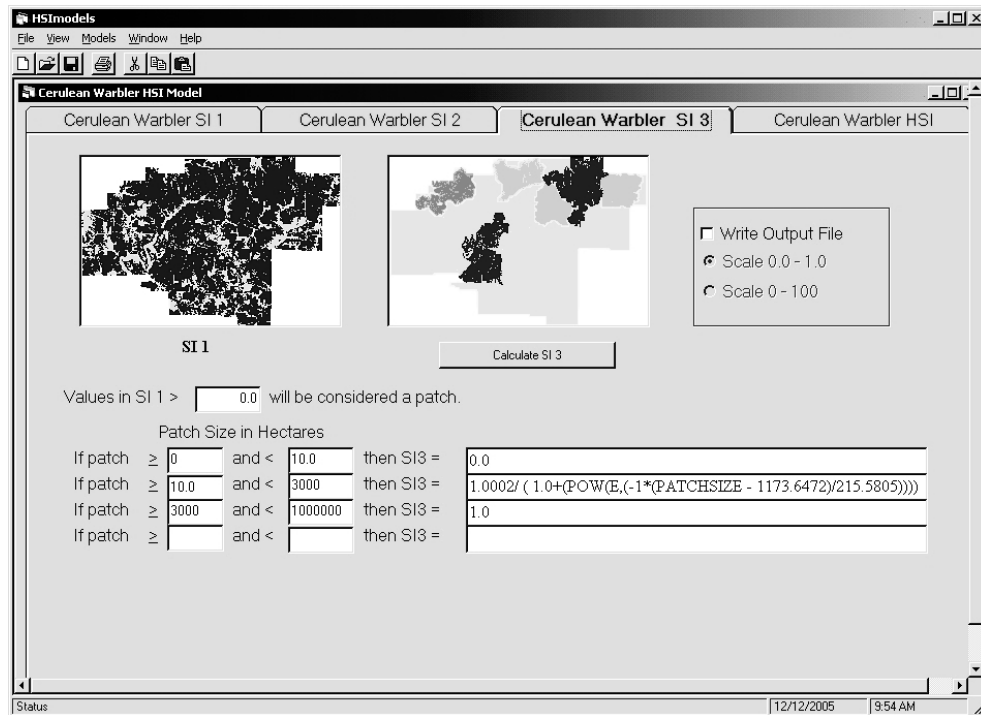
Figure 1. Cerulean warbler suitability index map for the Patoka management unit of the Hoosier National Forest in south-central Indiana, USA. Habitat values are based on forest patch size and range from 0 (light grey, poor-quality habitat) to 1 (black, high-quality habitat).

(*Lasiurus borealis*), northern long-eared bat (*Myotis septentrionalis*), Indiana bat (*Myotis sodalis*), red backed salamander (*Plethodon cinereus*), and timber rattlesnake (*Crotalus horridus*). The user can modify the assumed habitat relationships for each species or build models for new species using the functions in the software.

Each species model includes suitability indices that represent habitat components and spatial relationships. Input data layers for suitability indices include tree age, dominant tree species, ecological land type, land cover, and fire history. Input and output data formats are American Standard Code for Information Interchange (ASCII) rasters, which may be created in ArcView 3.x by exporting a data source, in ArcGIS using ArcToolBox, and in ArcInfo by issuing the gridascii command. The ASCII rasters created in other Geographic Information System software packages need to follow the Environmental Services Research Institute format for header lines. The software guides users through the calculation of each suitability index (SI) and finally through the overall HSI by combining the previously calculated SIs (Fig. 2). Expressions for SI and HSI calculations may include numerical constants and mathematical (e.g., ×, exponents, natural logarithm), comparison (e.g., >, <, ≥), and logical (e.g., if, and, or) operators (Larson et al. 2003).

Measures of many habitat components (e.g., vegetation structure) are not available at a landscape scale. So, the models rely on ecological relationships and inference from ecological attributes that may be available and mapped at landscape scales, such as ecological land type or forest size-class. Therefore, knowledge of how forest structure is related

to tree species, forest age, and ecological land type is required for many of the models. Much of that information can be garnered from the United States Forest Service, Forest Inventory and Analysis data (Miles et al. 2001) or previously conducted studies.

Users can customize models to adapt them to their data values, geographical area of interest, and understanding of species–habitat relationships. These modifications can be saved in a file that can later be opened to restore the user's own parameters. A generic model also is provided so that users can select individual SIs from different species to create models for new species.

The minimum computer system recommended is a personal computer with a 1.7 gigahertz (GHz) processor and 500 megabytes of random access memory (RAM). We also recommend using a 17-inch or larger monitor. Computers with faster processors and more RAM will reduce model processing time. A computer with the above configuration was successfully used to process a 1,200 row by 1,200 column landscape. A landscape with 2,000 rows and 3,000 columns was modeled on a computer with a 3.0 GHz processor and 2 gigabytes of RAM. The maximum size of a landscape that can be processed will vary from model to model based on the number of individual suitability indices incorporated into the model and the complexity of the calculations that need to be processed within the model. Some models using large moving windows on large landscapes take several hours to complete. Microsoft Windows® (Microsoft, Redmond, WA) does not allow any single computer application to access >2 gigabytes of processor memory so the software will not take advantage of computers
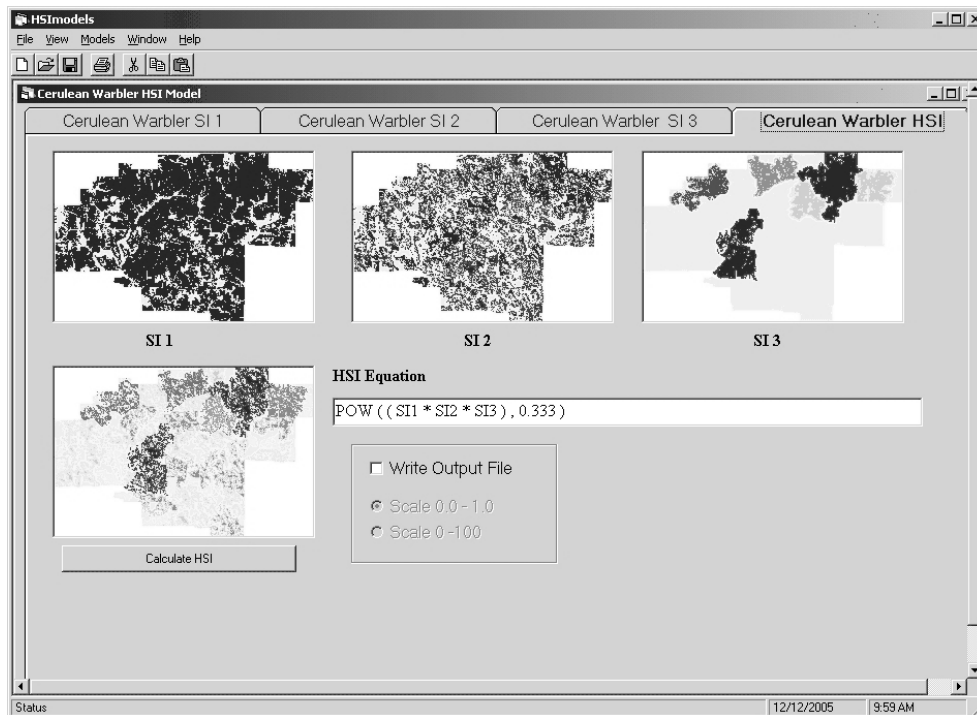
Figure 2. Cerulean warbler final habitat suitability index map for the Patoka management unit of the Hoosier National Forest in south-central Indiana, USA. Final map is based on the combination of 3 suitability index maps. Habitat quality ranges from 0 (light grey, poor-quality habitat) to 1 (black, high-quality habitat).

with >2 gigabytes of RAM. This limitation is the ultimate limiting factor in the size of the landscape that can be successfully processed.

MANAGEMENT IMPLICATIONS

Managers need to evaluate current and future habitat conditions for various species when developing management plans. Through the use of spatially explicit forest-simulations models such as LANDIS (Mladenoff et al. 1996) managers can determine temporal cumulative effects of management decisions on forested landscapes. Applying Landscape HSImodels to forest-simulation model output provides managers a tool to contrast the effects of forest management practices with current habitat quality for a variety of wildlife species (Shifley et al. 2006). The software, which includes sample data, is available free of charge at: http://www.nrs.fs.fed.us/hsi/.

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