GIS-Based Expert Systems Model for Predicting Habitat Suitability of Blackside Dace

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GIS-Based Expert Systems Model For Predicting Habitat Suitability Of Blackside Dace
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Abstract
This study presents a GIS-based predictive habitat suitability model for the blackside dace, a federally-listed threatened species of the Upper Cumberland River basin in southeastern Kentucky. The model is a rules-based system which incorporates expert knowledge about habitat preferences for the species. The five habitat factors identified by experts and included in this model are stream gradient, canopy coverage, riparian vegetation type, riparian zone width, and stream order. Using GIS, the five habitat parameters were parameterized and combined across the entire stream network. Combinations were evaluated by blackside dace experts in terms of habitat suitability. The resulting model was tested against known blackside dace occurrences using locational modeling statistics. This analysis demonstrates success at identifying stream areas of both high and low likelihood of occurrences. Model results could be of particular usefulness to transportation planners in identifying sensitive areas in the landscape that may impact transportation planning.

Habitat Parameters

<table>
<thead>
<tr>
<th>Habitat Factor</th>
<th>(Low)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradient (stream level)</td>
<td>&gt;6%</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>&lt;2%</td>
</tr>
<tr>
<td>Canopy (percent coverage)</td>
<td>0% – 50%</td>
<td>50 – 70%</td>
<td>70 – 90%</td>
<td>&gt;90%</td>
<td></td>
</tr>
<tr>
<td>Riparian Vegetation</td>
<td>Cultivated, Developed, Barren</td>
<td>Grass, Herbaceous, Pasture (hay)</td>
<td>Shrubs, Scrub</td>
<td>Forested</td>
<td></td>
</tr>
<tr>
<td>Riparian Zone Width</td>
<td>&lt;6 meter</td>
<td>6-12 meter</td>
<td>12-18 meter</td>
<td>&gt;18 meter</td>
<td></td>
</tr>
<tr>
<td>Stream Order (Strahler)</td>
<td>6 – 7</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

GIS Layers
A single stream raster was created containing data for habitat factors conducive to predicting Blackside Dace presence along stream segments
- Gradient
- Canopy
- Riparian Width
- Stream Order
- Land Cover

Expert Systems Modeling

\[ S = \sum Wi Xi \]

Where:
- \( S \) = surface of total probability score
- \( W \) = influence or weight factor of the ith factor
- \( X \) = Criteria score for the ith parameter

Model Results
Analyzed using locational modeling statistics (Kvamme 2006)

<table>
<thead>
<tr>
<th>Rating</th>
<th>Suitability</th>
<th>M (Cells in model)</th>
<th>S (Dace occurrences)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Low</td>
<td>176,789</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Below Average</td>
<td>138,361</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>Above Average</td>
<td>164,272</td>
<td>52</td>
</tr>
<tr>
<td>4</td>
<td>High</td>
<td>141,428</td>
<td>145</td>
</tr>
</tbody>
</table>

Where:
- \( P(M) \) = Base rate or chance probability that a model will indicate a site; proportion of study region mapped to M
- \( P(S/M) \) or \( P(S/M') \) = Model improvement ratio; indicates how many times more likely an occurrence is in M versus M'

Expert Systems Modeling

\[ S = \sum Wi Xi \]

Where:
- \( S \) = surface of total probability score
- \( W \) = influence or weight factor of the ith factor
- \( X \) = Criteria score for the ith parameter