Identifying Sensitive Species
A Noble Application of Big Data

Robert Howe and collaborators
University of Wisconsin-Green Bay

17 April 2018
Summary

Premises:

• Most bird species are sensitive to habitat degradation.
• Some species are more sensitive than others.
• Sensitive species are absent or rare in degraded habitats.
• Large data sets provide opportunities for quantifying species’ sensitivities.

Conclusions/Applications:

• Bird species assemblages are excellent indicators of ecosystem health.
• Rigorous analysis of bird assemblages can guide effective habitat management.
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Sensitivity of breeding birds to the “human footprint” in western Great Lakes forest landscapes

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Abstract. Breeding birds in forest ecosystems are generally diverse, habitat selective, and easily sampled. Because they must integrate environmental variables across space and time, local populations of forest birds (like other animal and plant taxa) may provide meaningful signals of local forest health or degradation. We evaluated 949 breeding bird surveys in areas ranging from degraded urban/suburban forest remnants to relatively pristine old growth forests in the western Laurentian Great Lakes region of North America. The “human footprint” across this landscape was represented by a one-dimensional numeric gradient derived from land cover variables, forest fragmentation metrics, and publicly available data on housing density and transportation corridors. We used an iterative, maximum likelihood approach to quantify species-specific responses to this human disturbance gradient. Many species showed significant directional responses, consistent with known life history attributes. Other species were most commonly detected at intermediate levels of anthropogenic disturbance, yielding unimodal responses. Relationships between the “human footprint” and occurrences of 36 bird species were illustrated by general Gaussian functions that represented both unidirectional and unimodal patterns. These bivariate response (BR) functions were combined into a bird-based index of ecological condition (IEC) ranging from 0 (maximally degraded) to 10 (minimally degraded). We described a successful application of the IEC method at the Wild Rivers Legacy Forest (WRLF), a ~360 km² conservation landscape in northeastern Wisconsin, USA, managed primarily under a working forest conservation easement established in 2006. In general, areas within the WRLF yielded high IEC values (7.0–9.0), but nearby forest areas not under the conservation easement were characterized by significantly lower IEC values based on breeding bird assemblages.

Key words: bird assemblage; disturbance gradient; ecological indicators; forestry management; northern mesic forest; western Great Lakes (USA).

Received 30 October 2014; revised 16 December 2014; accepted 7 January 2015; final version received 20 February 2015; published 8 June 2015. Corresponding Editor: W. A. Boyce.

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Wild Rivers Legacy Forest

At more than 64,600 acres, The Wild Rivers Legacy Forest is exceptionally rich in diversity.

A project of the Wisconsin Department of Natural Resources, Conservation Forestry LLC, Forest Investment Associates and The Nature Conservancy.

WHY YOU SHOULD VISIT:
More than 14 miles of two Wild Rivers—the Pine and the Popple—flow through the Wild Rivers Legacy Forest. The property also contains one of the finest remaining wild lakes complexes in Wisconsin, composed of Savage, Dorothy, Mud and Robago lakes. Sugar maple, basswood, hemlock and yellow birch trees preside over a forest understory of maidenhair ferns, club mosses and great white trillium. Wildlife, including bears, flying squirrels and porcupines, is abundant.
Sensitivity of Wisconsin Forest Birds

Which species are sensitive to forest habitat loss/degradation?
Sensitivity of Wisconsin Forest Birds

949 points sampled with same field method (10 minute point count)
Sensitivity of Wisconsin Forest Birds

Variables are combined into a single “human footprint” gradient.
Species (Biotic) Response Functions

Frequency (probability) of occurrence is plotted across the “human footprint” gradient.
These responses can be described by a 3 parameter function (µ, σ, h).
Species (Biotic) Response Functions

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>$\mu$</th>
<th>$\sigma$</th>
<th>$h$</th>
<th>LOF $P_{\Delta/\Delta}$</th>
<th>$R^2_{\Delta}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>European Starling</td>
<td>Sturnus vulgaris</td>
<td>-0.64</td>
<td>2.23</td>
<td>6.37</td>
<td>0.32</td>
<td>1.00</td>
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<td>House Sparrow</td>
<td>Passer domesticus</td>
<td>-3.97</td>
<td>2.67</td>
<td>20.22</td>
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<tr>
<td>Ovenbird</td>
<td>Seiurus auricapilla</td>
<td>7.93</td>
<td>3.29</td>
<td>7.96</td>
<td>1.45</td>
<td>0.91</td>
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<td>Red-eyed Vireo</td>
<td>Vireo olivaceus</td>
<td>8.32</td>
<td>3.81</td>
<td>8.99</td>
<td>0.85</td>
<td>0.86</td>
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<tr>
<td>Common Grackle</td>
<td>Quiscalus quiscula</td>
<td>-10.00</td>
<td>5.89</td>
<td>50.36</td>
<td>1.60</td>
<td>0.80</td>
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<td>Mourning Dove</td>
<td>Zenaida macronia</td>
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<td>Black-throated Green Warbler</td>
<td>Setophaga virens</td>
<td>8.38</td>
<td>2.24</td>
<td>3.38</td>
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<td>American Crow</td>
<td>Corvus</td>
<td>1.86</td>
<td>4.37</td>
<td>7.74</td>
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<td>0.58</td>
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<td>brachyrhynchos</td>
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<td>Rose-breasted</td>
<td>Pheucticus</td>
<td>8.01</td>
<td>2.90</td>
<td>4.08</td>
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<td>Grosbeak</td>
<td>Indovicianus</td>
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<td>Yellow-bellied</td>
<td>Sphyrapicus varius</td>
<td>8.40</td>
<td>2.27</td>
<td>2.92</td>
<td>0.24</td>
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<td>Sapsucker</td>
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<td>Hermit Thrush</td>
<td>Catharus guttatus</td>
<td>7.80</td>
<td>2.58</td>
<td>2.88</td>
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<td>Least Flycatcher</td>
<td>Empidonax minimus</td>
<td>20.00</td>
<td>6.49</td>
<td>23.76</td>
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<td>0.43</td>
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<tr>
<td>Blackburnian Warbler</td>
<td>Setophaga fusca</td>
<td>9.35</td>
<td>2.30</td>
<td>2.08</td>
<td>0.18</td>
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<td>Mourning Warbler</td>
<td>Geothlypis</td>
<td>8.82</td>
<td>2.82</td>
<td>2.44</td>
<td>0.67</td>
<td>0.34</td>
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</tbody>
</table>
Index of Ecological Condition (IEC)

A quantitative indicator based on explicit stress-response relationships

1. Define an environmental reference gradient (stressor)
   • Scale from 0 (poorest condition) to 10 (best or ideal condition)

2. Quantify species’ responses to the gradient (3 parameter function)
   • Estimate parameters for each species

3. Given the species’ functions, estimate IEC values for new sites
   • Use maximum likelihood algorithm based on biotic response functions
   • IEC value ranges from 0 (poorest condition) to 10 (best condition), similar to reference gradient
Estimating IEC Values

Presence/abundance of Species A will contribute to higher IEC.

Presence/abundance of Species B will contribute to lower IEC.
Why Measure Ecosystem Health?

- Identify priorities
- Assess outcomes
- Set conservation targets
- Protect critical sites
- Promote sustainable resource use
Opportunities from Big Data

Anich 2017
Opportunities from Big Data

Which points are minimally degraded?

Which points are degraded?

Anich 2017
Opportunities from Big Data

Create a “toolbox” of species’ responses to habitat/landscape degradation.
What about the gradient?

Specific stressors or specific regions may be of interest.
Geographic coverage
Geographic coverage
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