Quantifying Relationships Between Impervious Surface Cover, Disturbance, and Chick Performance in *Troglodytes aedon*

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Impervious Surface Cover, Disturbance, and Chick Performance

- How variables are related
- Why they matter
- What has already been done
- Our questions defined
- Methods for data collection
- Methods for analysis
- Results and conclusions
- Discussion and future research
Introduction:
Justifications

- James City County is undergoing rapid expansion and development (Hellier and Timmons 2006)
- Human presence causes disturbance which can impact wildlife productivity
  - Frequently studied using birds (Beissinger and Osborne 1982, Lens et al. 1999, Juricic 2000)
  - Chick performance—which relates to breeding productivity—impacts population
- Determining impact is lengthy and expensive
- Can we predict impact without having to do field studies?
Introduction:
Background

• Habitat modeling has been done for other species (Birkhead 2006)
• Relationship between urban habitat and disturbance has not been studied
  – Urban areas have a unique ecology (Kaye et al. 2006)
• Impervious surface cover (ISC) (Paul and Meyer 2001, Shuster et al. 2005)
  – Readily accessible
  – Frequently used in other fields
Questions

• Is there a relationship between ISC and disturbance?

• Is there a relationship between disturbance and chick performance?

• Is there a relationship between ISC and chick performance?
Methods:
Impervious Surface Cover

• GIS
  – Digitized ISC
  – Categorized ISC
    • Building
    • Parking surface
    • Pedestrian surface
    • Recreational surface
    • Road
  – Calculated area and perimeter
Methods: Disturbance

• Study site: 57 bird boxes in woodland or woodland edge habitat
• 1-5 observations 90 minutes each
  – Duration
  – Proximity
  – Source
    • Automobile
    • Pedestrian
    • Animal
    • Bicycle
    • Golf cart
    • Other motorized vehicle
    • Pedestrian with animal
Methods:
Productivity

• House wrens
  \( (Troglodytes\ aedon) \)
  as study species
  – Tolerant of human activity
  – Abundant
  – Preference for man-made bird boxes
  – Commonly studied
    – (Johnson 1998)
Methods:
Chick Performance

- Chicks measured once each week of growth (1-3 measurements/box)
  - Adjusted brood condition
  - Adjusted growth rate
  - Number of chicks fledged
Methods: Analysis techniques

• Principal component analysis for disturbance data to reduce variables

Component Matrix for Disturbance Independent of Source

<table>
<thead>
<tr>
<th></th>
<th>Component 1</th>
<th>Component 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln_number_events</td>
<td>.757</td>
<td>.255</td>
</tr>
<tr>
<td>ln_variance_proximity</td>
<td>.645</td>
<td>-.103</td>
</tr>
<tr>
<td>ln_mean_proximity</td>
<td>.171</td>
<td>.893</td>
</tr>
<tr>
<td>ln_minimum_proximity</td>
<td>-.217</td>
<td>.897</td>
</tr>
<tr>
<td>ln_variance_duration</td>
<td>.835</td>
<td>-.085</td>
</tr>
<tr>
<td>ln_mean_duration</td>
<td>.811</td>
<td>-.200</td>
</tr>
<tr>
<td>ln_total_duration</td>
<td>.948</td>
<td>.064</td>
</tr>
<tr>
<td>diversity</td>
<td>.686</td>
<td>.128</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis. 2 components extracted.
Methods:
Analysis techniques

• ISC to disturbance relationships: multiple regression

• Disturbance to chick performance: bivariate correlation

• ISC to chick performance: multiple regression
Conclusions:
Impervious Surface Cover and Disturbance

• Impervious surface cover can predict disturbance patterns for a specific location – Source independent ($F_{4,52}=19.72$, $p<0.001$, $r^2=0.603$)
## Conclusions: Impervious Surface Cover and Disturbance

### Significant relationships by category

<table>
<thead>
<tr>
<th>ISC category/measure</th>
<th>Component</th>
<th>Associated disturbance</th>
</tr>
</thead>
<tbody>
<tr>
<td>High road area within 50m</td>
<td>PC1</td>
<td>Lots of bike and pedestrian disturbance (F(_{2,54})=23.185, p&lt;0.001, r(^2)=0.462)</td>
</tr>
<tr>
<td>High pedestrian area within 50m</td>
<td>PC3</td>
<td>Little of “other” motorized vehicle disturbance (F(_{1,55})=6.948, p=0.011, r(^2)=0.112)</td>
</tr>
<tr>
<td>High building area within 50m</td>
<td>PC2</td>
<td>Little animal disturbance, lots of golf car disturbance (F(_{1,55})=8.774, p=0.005, r(^2)=0.138)</td>
</tr>
</tbody>
</table>
Conclusions:
Disturbance and Chick Performance

• Relationship between disturbance and productivity can be quantified
  – Source independent disturbance has no relationship with chick performance
Conclusions: Disturbance and Chick Performance

But the source of disturbance does matter

<table>
<thead>
<tr>
<th>Chick performance</th>
<th>Component</th>
<th>Associated disturbance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Many chicks fledged</td>
<td>PC3</td>
<td>Lots of “other” motorized vehicle disturbance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$(r=0.453, p=0.045)$</td>
</tr>
<tr>
<td>Good brood condition</td>
<td>PC1</td>
<td>Little bike and pedestrian disturbance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$(r=-0.487, p=0.029)$</td>
</tr>
<tr>
<td>Good brood condition</td>
<td>PC2</td>
<td>Lots animal disturbance, little of golf car disturbance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$(r=0.613, p=0.004)$</td>
</tr>
</tbody>
</table>
Conclusions:
Impervious Surface Cover and Chick Performance

- ISC can be used to predict chick performance
  - As ISC area increases and perimeter of ISC decreases, HOWR productivity decreases
    \((F_{4,17}=3.375, p=0.033, r^2=0.443)\)
Conclusions:
Impervious Surface Cover and Chick Performance

• The type of ISC again matters
  – Pedestrian surface area within 100m negatively correlated with adjusted brood condition
    \( (F_{1,20}=5.141, \ p=0.035, \ r^2=0.204) \)
  – Parking surface area within 50m negatively correlated with number chicks fledged
    \( (F_{1,20}=7.805, \ p=0.011, \ r^2=0.281) \)
Discussion and Future Questions

• Impervious surface cover can be used to predict disturbance patterns for a specific location
  – Future research: are these predictions accurate in other locations? Can a general model be created?
• Relationship between disturbance and chick performance can be quantified (but the source of disturbance does matter)
  – Future research: effect of disturbance on chicks of other species
• ISC can be used to predict chick performance
  – Future research: testing these predictions in
    • Other locations
    • Other species
• Chick performance, especially productivity, has implications on population
  – Future research: incorporating this effect into population models
Acknowledgments

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Literature Cited

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• Lens, Luc; Stefan van Dongen, Christine M. Wilder, Thomas M. Brooks and Erik Matthysen. 1999. Fluctuating asymmetry increases with habitat disturbance in seven bird species of a fragmented afrotropical forest. *The Royal Society.* 266: 1241-1246.
