A Preliminary Assessment of Ecosystem Vulnerability to Climate Change in Panama

Laura Tremblay-Boyer & Eric Ross Anderson

Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC) - Panama City, Panama

2008 ESRI User Conference
San Diego, California
• An index of ecosystem vulnerability to climate change
  I. Sea level rise
  II. Ecosystem geometry
  III. Climatic space
  IV. Species sensitivity
• The main tool for this project was ArcGIS
Methods

• We calculate an index of vulnerability, in four parts, for each ecosystem patch of Panama, according to its ecosystem type.

• What’s the difference between an ecosystem “patch” and “type”?
Ecosystems: types and patches

- 37 ecosystem types and 1303 patches

Example: 1 ecosystem type has 27 separate and individual patches
Tropical broadleaf evergreen submontane rainforest (500-1000m Caribbean, 700-1200m Pacific) – no human intervention

• Select land in coastal zones with an elevation of zero to one meter
• Calculate the density of this land within each ecosystem patch
• Obtain a vulnerability value based on this density
1. Ratio: edge vs. core

is more vulnerable than

2. Relative perimeter

is more vulnerable than
EVCC$_2$ - Ecosystem geometry
Gower Metric for each 1 km² cell:

1. Predicted change in temperature and precipitation in 2025, 2050, and 2099

2. Intra-annual temperature and precipitation range

Calculation:

\[ \text{[Future – historic range]} \]

Historic values:
http://www.worldclim.org/worldclim_IJC.pdf

Regional climate change model:
Hernández et al. 2006.
http://www.servir.net/index.php?option=com_content&task=view&id=31&Itemid=68
EVCC$_3$ - Climatic space

3. Average the Gower metric of all cells within each ecosystem patch, for temperature and precipitation.

4. Independently rank this averaged Gower metric of all ecosystem patches on a scale of 1 to 10 for temperature and for precipitation.

Historic values:
http://www.worldclim.org/worldclim_IJC.pdf

Regional climate change model:
Hernandez et al. 2006.
http://www.servir.net/index.php?option=com_content&task=view&id=31&Itemid=68
EVCC$_3$: Climatic space
EVCC$_4$ – Species sensitivity

InfoNatura: Animals and Ecosystems of Latin America

http://www.natureserve.org/infonatura
EVCC₄ – Species sensitivity
According to the quality and pertinence of the data, the following is the rank of importance for each domain:

**Climatic space**

**Sea level rise**

**Ecosystem geometry**

**Species sensitivity**
Ecosystem Vulnerability to Climate Change: Focus Golfo de Chiriquí
Additional Applications

- Human intervention
- Humid ecosystems
- Protected areas
- Species richness
## EVCC & level of human intervention

<table>
<thead>
<tr>
<th>Level of intervention</th>
<th>Ave_EVCC$_1$</th>
<th>Ave_EVCC$_2$</th>
<th>Ave_EVCC$_3$</th>
<th>Ave_EVCC$_4$</th>
<th>Ave_EVCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0    None</td>
<td>5.10</td>
<td>6.41</td>
<td>4.68</td>
<td>2.27</td>
<td>18.45</td>
</tr>
<tr>
<td>1    Low</td>
<td>2.16</td>
<td>6.27</td>
<td>8.25</td>
<td>3.47</td>
<td>20.16</td>
</tr>
<tr>
<td>2    Medium</td>
<td>0.00</td>
<td>5.00</td>
<td>7.00</td>
<td>3.50</td>
<td>15.50</td>
</tr>
<tr>
<td>3    High, in mountains</td>
<td>0.00</td>
<td>5.77</td>
<td>7.43</td>
<td>4.09</td>
<td>17.29</td>
</tr>
<tr>
<td>4    High, in lowlands</td>
<td>2.70</td>
<td>6.32</td>
<td>8.52</td>
<td>2.87</td>
<td>20.41</td>
</tr>
<tr>
<td>5    10-50% natural</td>
<td>3.23</td>
<td>6.32</td>
<td>8.13</td>
<td>3.23</td>
<td>20.92</td>
</tr>
<tr>
<td>6    &lt;10% natural</td>
<td>4.57</td>
<td>6.37</td>
<td>9.15</td>
<td>2.74</td>
<td>22.83</td>
</tr>
<tr>
<td>7    Agroforestry</td>
<td>0.00</td>
<td>6.33</td>
<td>10.83</td>
<td>3.17</td>
<td>20.33</td>
</tr>
<tr>
<td>8    Shrimp / Salt</td>
<td>4.67</td>
<td>6.83</td>
<td>7.33</td>
<td>2.00</td>
<td>20.83</td>
</tr>
<tr>
<td>9    Populated place</td>
<td>3.90</td>
<td>6.76</td>
<td>8.57</td>
<td>3.14</td>
<td>22.38</td>
</tr>
</tbody>
</table>

Red = highest average; orange = second highest; yellow = third highest

Blue = most commonly ranked with high vulnerability
Average EVCC within all of Panama = 17.84
Average EVCC within protected areas = 17.63
Expanding the study

- *Regional* biodiversity
- *Regional* climate change severity index (similar to EVCC$_3$)
- Integration of both to identify **critical habitats**
Richness of Birds, Mammals, and Amphibians in Mexico, Central America, and the Dominican Republic

Potential Impacts of Climate Change on Biodiversity in Central America, Mexico, and the Dominican Republic, CATHALAC 2008.

Data derived from: NatureServe InfoNatura Species Distribution Grids.
Hadley A2 Scenario, 2050s

Potential Impacts of Climate Change on Biodiversity in Central America, Mexico, and the Dominican Republic, CATHALAC 2008.

Data derived from: WorldClim Climate Grids: Current and Future Conditions.
Critical areas: high species richness and climate change severity in Central America, Mexico, and Dominican Republic

Potential Impacts of Climate Change on Biodiversity in Central America, Mexico, and the Dominican Republic, CATHALAC 2008.

2050s A2 scenario

Species richness, current
- Areas with the top 10 percentile of species richness per country

Climate Change Severity Index, 2050s
- Pushing comfort zone limits
- Outside comfort zone
- Far outside comfort zone

Critical areas: an intersection of both factors
- High species richness, climatic changes pushing comfort zone limits
- High species richness, climatic changes outside comfort zone
- High species richness, climatic changes far outside comfort zone

Data derived from: NatureServe InfoNatura Species Distribution Grids.
WorldClim Climate Grids: Current and Future Conditions.
IUCN Climate Grids: Current and Future Conditions.
IUCN World Commission on Protected Areas, 2007.
Conclusions

• The EVCC index has the potential to be a very useful tool for conservation of large-scale biodiversity (e.g., identification of critical areas)

• It is important to include the uncertainties and to be flexible in the application of this index, always including and improving it with the latest scientific knowledge (e.g., more climate change scenarios)

• Climate change should be evaluated in conjunction with other factors that threaten ecosystems (e.g., land cover change scenarios)
Acknowledgements

• Our professors and supervisors, and host institutions
  – Emil Cherrington, CATHALAC
  – Roxana Segundo, CATHALAC
  – Roberto Ibáñez, STRI
  – Catherine Potvin, McGill University

• For more information, please visit: