Determination of physical–chemical conditions to predict macroinvertebrate communities in Machangara River (Southern Andes, in Ecuador)

Rubén Jerves-Cobo, I. Nopens, P. Goethals

Ruben.JervesCobo@UGent.Be

- Laboratory of Environmental Toxicology and Aquatic Ecology
- Department of Mathematical Modelling, Statistics and Bio-informatics
BACKGROUND AND OBJECTIVE

• Destruction of native vegetation.
• Fuelwood
• Land for livestock and agriculture
• High flow variation for dams presence
• Main source of water supply for the Cuenca City.
• Necessity to improve actual conditions
Objective

• Construction of Habitat Suitability Model (HSM) as decision makers tool

• How is the variation of the Ecological Water Quality (EWQ) in the basin?
2- MATERIALS AND METHODS

LOCATION:

MODSIM2015, Gold Cost, Australia, Date (03,12, 2015)
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Ruben.JervesCobo@UGent.be
BASIN CHARACTERISTICS:

- Area: 325 Km$^2$
- Protected Forest: 252 Km$^2$
- Altitude: 2,450 to 3,850 masl
- Annual Rainfall: 877 to 1,363 mm/year
- Average Temperature: 16.3 to 9 °C
BASIN CHARACTERISTICS:
DATA COLLECTION:
- 44 sampling locations
- Completed information on 33 locations

Physicochemical, hydraulic, microbiological

• Laboratory
  – BOD$_5$, COD, Nitrate + Nitrite, Ammonia, Organic Nitrogen, Phosphates, Total Phosphorus, Fecal and Total Coliforms, Real Color, Turbidity, Total Solids

• Field: Flow Velocity, Ph, Conductivity, Temperature, Dissolved Oxygen
Variables Variation

- Boxplot of BOD5
- Boxplot of COD
- Boxplot of Nitrate
- Boxplot of Phosphates
- Boxplot of Log_Fecal_Coliforms

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DATA COLLECTION:
Macrobenthos

• Kick Sweep Method
  – 3 minutes in 2.5 m²
  – Two times in same area
  – Standard net

• Identified a family level
  – Stereoscope
  – Identification Keys

• 39 families (taxa) found
ECOLOGICAL WATER QUALITY

- Biological Monitoring Working Party Index - Col
- BMWP-Col = f(Sensitivity of Macrobenothos)
- Sensitivity -> 1-10 (Low – High Sensitivity)

<table>
<thead>
<tr>
<th>Class</th>
<th>Quality</th>
<th>BMWP</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Very Good</td>
<td>&gt; 100</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Good</td>
<td>61 - 100</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Regular</td>
<td>36 - 60</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>Bad</td>
<td>16 - 35</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>Critical</td>
<td>≤ 15</td>
<td></td>
</tr>
</tbody>
</table>
Model development

Ecosystem

Training dataset

Validation dataset

Measurement set

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Methodology
Pruned Multi-target Clustering Trees (PMCT)

• Classification trees: searching for if-then rules (threshold values): 100% reliable and ‘safe’ models

• Weka
Methodology

Generalized Linear Model (GLM)

• Binomial fitting – Presence and Absence

• \[ R \]

\[ \pi(t_1, \ldots, t_n) = \frac{e^{-ao - a_1 x t_1 - \ldots - a_n x t_n}}{1 + e^{-ao - a_1 x t_1 - \ldots - a_n x t_n}} \]

\( t_i = \text{Variable } i \)

0 = Absence

1 = Presence
3- RESULTS

ECOLOGICAL WATER QUALITY

BMWP-Col:
- 9 good
- 15 moderate
- 6 poor
- 3 bad
**Perlidae (Plecoptera)**

- **Flow Velocity**
  - $\leq 0.26 \text{ m.s}^{-1}$
  - Perlidae Presence
  - $> 0.26 \text{ m.s}^{-1}$
  - Perlidae Absence

- **BOD_5**
  - $\leq 0.5 \text{ mg.l}^{-1}$
  - Perlidae Presence
  - $> 0.5 \text{ mg.l}^{-1}$
  - Perlidae Absence

**CCI = 73%**

Cohen’s Kappa Statistic = 0.44
Leptophlebiidae (Ephemeroptera)

CCI = 79%
Cohen’s Kappa Statistic = 0.45

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Scirtidae (Coleoptera)

CCI = 73%
Cohen’s Kappa Statistic = 0.42
**Scirtidae** (Coleoptera) ($R^2=59\%$, AIC=29.8)

$$\pi = \frac{e^{-21.4619-11.6893 \times BOD_5 + 1.4126 \times DO + 0.8286 \times COD + 56.7596 \times Nitra.Nitri + 140.335 \times Phosph}}{1 + e^{-21.4619-11.6893 \times BOD_5 + 1.4126 \times DO + 0.8286 \times COD + 56.7596 \times Nitra.Nitri + 140.335 \times Phosph}}$$
**Leptoceridae** (Trichoptera)  ($R^2=68\%, \text{AIC}=26.5$)

$$\pi = \frac{e^{(50.4797+6.4095\times \text{Log}\_\text{Fcolif} - 12.2656\times \text{Fl}\_\text{vel} - 12.4040\times \text{BOD}_5 - 5.3051\times \text{pH} - 1.1153\times \text{COD} - 0.0775\times \text{Cond})}}{1 + e^{(50.4797+6.4095\times \text{Log}\_\text{Fcolif} - 12.2656\times \text{Fl}\_\text{vel} - 12.4040\times \text{BOD}_5 - 5.3051\times \text{pH} - 1.1153\times \text{COD} - 0.0775\times \text{Cond})}}$$

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**Baetis** (Ephemeroptera) \((R^2=60\%, AIC=22.5)\)

\[
\pi = \frac{e^{(26.9459 - 2.8553 \times T_{\text{em}} - 0.4083 \times T_{\text{color}} + 0.1293 \times \text{Cond} + 0.7462 \times COD})}}{1 + e^{(26.9459 - 2.8553 \times T_{\text{em}} - 0.4083 \times T_{\text{color}} + 0.1293 \times \text{Cond} + 0.7462 \times COD})}
\]
Baetis (Ephemeroptera)
Trycorythidae (Ephemeroptera) ($R^2=60\%$, AIC=31.9)

$$\pi = \frac{e^{(-21.0763 + 3.5121 \times Fl_{VEL} - 1.4066 \times Turb - 1.2660 \times Tem + 3.3683 \times pH + 0.0947 \times Cond + 419.2533 T_{Phosph})}}{1 + e^{(-21.0763 + 3.5121 \times Fl_{VEL} - 1.4066 \times Turb - 1.2660 \times Tem + 3.3683 \times pH + 0.0947 \times Cond + 419.2533 T_{Phosph})}}$$
4- CONCLUSION AND FUTURE WORK

- Habitat Suitability Model (HSM) ->
  Predict absence or presence of some taxa

- *The statistical models are a Good Fit*
  - $EWQ = Critical \rightarrow \text{Absence of} \begin{cases} \text{Leptophlebiidae, Trycorythidae,} \\ \text{Leptoceridae and Scirtidae.} \end{cases}$

- *Models analyzed* ->
  - potentially used as decision support tools in river basin management

- Jerves, et al. - Invertebrate Community Composition Enables to Predict Compliance to Microbial Pathogen Related Standards of Rivers
Acknowledgement

- VLIR-UOS IUC Programme - Universidad de Cuenca
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Thank you
• **Bibliography:**
  
  
  
  
  