Estimating Drivers of Change

Mark Cutler, Eirini Politi, & John Rowan | University of Dundee
Terry Dawson, Kings College London
Laurence Carvalho, Stephen Maberly & Steve Thackeray | Centre for Ecology & Hydrology
Lake Catchments

- Our ‘GloboLakes’ integrate responses from a vast proportion of the Earth’s terrestrial surface.
- Total GloboLakes Catchment Area (cumulative) ~ 131,180,824 km²
Lake Landscape Context

• To explain and interpret change in lake behaviour we need to understand the drivers of change
• To do this globally requires bringing together global standardised datasets and information
  • GloboLakes Catchment database
  • Mixture of pre-existing datasets, literature-derived and modelled data for our 997 Globolakes

(Sorrano et al., 2009)
Lake Landscape Context

- Sensitivity factors
  - Lake morphometry
  - Lake location, residence time etc
  - Geology/soils/river network

- Spatio-temporal variable drivers
  - Atmospheric (e.g. air temp)
  - Catchment (e.g. productivity, land cover, population)

- Drivers:
  - Atmospheric (e.g. air temp)
  - Catchment (e.g. productivity, land cover, population)

- Other factors:
  - Geology/soils/river network

- Spatial-temporal variable drivers
  - Air temperature
  - Precipitation

- Land cover
  - Vegetation indices
  - Elevation
  - Soil Type
  - Livestock
  - Ecoregion
  - Mean Annual Surface Runoff
  - Population density
  - Soil organic carbon
  - Socioeconomic indices
  - Rivers & Dams
  - Geology
  - Fertilisers
  - Soil Type
  - Livestock
  - Ecoregion
  - Mean Annual Surface Runoff
  - Population density
  - Soil organic carbon
  - Socioeconomic indices
  - Rivers & Dams
  - Geology
  - Fertilisers

- Additional data sets:
  - Air temperature (CRUv3.22, 1971-2013)
  - Precipitation (CRUv3.22, 1971-2013)
  - Mean Annual Surface Runoff (ECMWF)
  - Land cover (ESA CCI Land Cover 2000-2015)

- Lake Balaton
  - Vegetation indices
  - Elevation
  - Soil Type
  - Livestock
  - Ecoregion
Lake vulnerability – our conceptual approach

Aim of study:

- To estimate global lake vulnerability based on human pressures in the catchment and lake/catchment system characteristics.
- Exploitation of the GloboLakes Catchment Database v2.1

<table>
<thead>
<tr>
<th>Increasing pressure risk</th>
<th>Increasing sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lakes with low risk of pressures but high sensitivity</td>
<td></td>
</tr>
<tr>
<td>- Shallow lake</td>
<td></td>
</tr>
<tr>
<td>- Long residence time</td>
<td></td>
</tr>
<tr>
<td>- Steep catchment</td>
<td></td>
</tr>
<tr>
<td>- High human pressures</td>
<td></td>
</tr>
<tr>
<td>Lakes with high risk of pressures but low sensitivity</td>
<td></td>
</tr>
<tr>
<td>- Deep lake</td>
<td></td>
</tr>
<tr>
<td>- Short residence time</td>
<td></td>
</tr>
<tr>
<td>- Low relief catchment</td>
<td></td>
</tr>
<tr>
<td>- Low human pressures</td>
<td></td>
</tr>
</tbody>
</table>
Lake vulnerability at global scales

**RISK FACTOR**

- **Human Pressures** - Data used*:
  - Dominant Catchment Land cover (2010)
  - GDP (2000-2012)
  - Fertilisers (Nitrogen + Phosphate) (2002-2010)
  - Total livestock (2000-2010)

**LAKE SENSITIVITY TO CHANGE**

- **Lake/Catchment system** – Data used:
  - Mean depth
  - Volume-to-Shoreline-length ratio
  - Residence time
  - Ohle’s index (i.e., catchment surface area over the lake surface area)
  - Catchment relief ratio

Risk factor + Lake sensitivity = Lake vulnerability
Lake vulnerability at global scales

Scoring approach*:

Step 1: Current condition (“the present”)

Low  Medium  High  Very high  No data

*Variables classified into classes according to statistical properties, reference to WFD, World reference standards and literature
## Lake vulnerability at global scales

**Scoring approach:**

<table>
<thead>
<tr>
<th>Step 1: Current condition (“the present”)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 2: Past trend (magnitude of change in last decade)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ / -</td>
</tr>
<tr>
<td>++ / --</td>
</tr>
<tr>
<td>+++ / ---</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

### Weighted average classified into five classes: low, medium, high, very high & critical
Lake Risk Factor

Legend

Pressures (Risk)
- Low
- Medium
- High
- Very high
- Critical
Lake vulnerability at global scales

Scoring approach:

Step 1: Current condition ("the present")
- Low
- Medium
- High
- Very high
- No data

Step 2: Past trend (magnitude of change in last decade)
- + / -  Slow increase/decrease
- ++ / --  Fast increase/decrease
- +++ / ---  Very fast increase/decrease
- 0  No change

Step 3: Integrate risk and sensitivity
Lake (risk and) vulnerability at global scales

Legend

Vulnerability
- Low
- Medium
- High
- Very High

Risk Factor

Lake vulnerability

Legend

Pressures (Risk)
- Low
- Medium
- High
- Very High
- Critical
Key Messages

• We have put together a lake / catchment database of lake properties and drivers of change
  • Global datasets
  • Sensitivity factors (lake properties) and climatic and terrestrial spatio-temporal variables
• Aim is to release this in an appropriate format to the community in due course

• Understanding patterns of lake vulnerability important for societal response and resilience to environmental change (especially in the context of SDGs)

• We have modelled lake vulnerability by analysing ‘human pressure risk’ and ‘lake sensitivity’

• At an early stage, but:
  • Hot spots of lake vulnerability

• Requires integration with observed responses and analytical/empirical analysis.....more on that after lunch!
Thank you

Mark Cutler
Geography, School of Social Sciences
University of Dundee
Dundee, DD1 4HN
+44 1382 385446
m.e.j.cutler@dundee.ac.uk
www.dundee.ac.uk/geography-environmental-science

www.globolakes.ac.uk
@globolakes

This research was funded by the Natural Environment Research Council (NE/E009328)
Lake vulnerability at global scales

Risk factor per catchment pressure

- GDP per capita
- Population density
- Catchment land cover
- Fertilisers
- Livestock

Sensitivity class per lake/catchment characteristic

- Mean depth
- Volume/Shoreline length
- Residence time
- Ohle’s Index
- Catchment relief