30 years of aquatic macrophyte monitoring with the UK Upland Waters Monitoring Network

Ewan Shilland & Don Monteith

(based on a science partnership of UCL, CEH, QMUL and SG; supported by DEFRA, DOENI, Forestry Commission, NRW, SEPA, SG, SNH, WG, NERC CEH, ENSIS Ltd. & several volunteers)
UWMN Introduction

- Set up in 1988 to assess the chemical and biological response of acidified lakes and streams to emission reductions
- Originally 22 sites across UK in N-S, E-W gradients, with afforested and non-afforested pairs and NW “control” sites
- Water chemistry, fish, invertebrates, macrophytes, diatoms, temperature & physical variables at some sites eg flow
- Demonstrated the effects of reductions in S emissions – reduced xSO4
- Clear recovery evidence from chemistry but biological lags
- Despite N emission reductions demonstrated variable changes in NO3
- Demonstrated upwards trends in Dissolved Organic Carbon (DOC)
# UWMN Macrophyte Sampling & Funding

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Loch Coire nan An</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allt a Mhonachd</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allt na Coire nan Con</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loch Lomond</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loch Tarbert</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hound Loch of Arran</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loch Gruinmach</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dargall Lane</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scoot Tarn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burnmoor Tarn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>River Esterrow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old Lodge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Narrator Brook</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Llan I Lagi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Llyn Cwm Mynach</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Afon Hafren</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Afon Gay</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beaghe Burn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dencarron River</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue Loch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conwyglen Burn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conwyglen Burn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loch Coire Fionnaraich</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Danby Deck</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Badddoch Burn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DTM III**

- No planned sampling
- Funded, sampled and analysed
- Funded but unsampled (usually due to spate)
- Untunded, sampled and analysed
- Untunded, sampled but not analysed
- Untunded and not sampled
- Funded sampling

---

UWMN Macrophyte Methods - Streams

- Fixed 50 m section of stream
- Transect every 5 m from 0-50 m inclusive, substrate and macrophyte taxa (if any) recorded at three equidistant points.
- In the 5 m stream sections between each transect the stream bed is surveyed and the total amount of filamentous algae, plant cover (expressed as a percentage of submerged stream bed) and floristic composition of the plant assemblages are estimated visually.
- Substrate composition of the stream bed and percentage shade also recorded in these 5 m sections.
- Digital photographs taken of each 5 m section.
- Major morphological features and the location of notable growths of plants in the channel are annotated on to large scale sketch maps.
- Data summarised in annual reports showing estimated percentage of submerged stream bed throughout the 50 m length covered by each taxon.
UWMN Macrophyte Methods - Lakes

• Inshore survey
  – Inshore zone viewed either by walking the shoreline, wading or from a slow-moving boat. Emergent, floating and submerged macrophytes recorded and major stands annotated on a large scale map.

• Transect survey
  – Two to four fixed-point survey transects of 60 m in length. A fixed line is deployed along the transect and two replicates of water depth, substrate type, amount of plant material and relative abundance of species recorded at 10 m intervals, with an additional site 5 m from the shore.

• Trawl survey
  – Two to four transverse trawls are made across the lake by trawling a double headed rake attached to a long rope behind a boat travelling at a steady speed. Each traverse sub-divided into five approximately equal trawl sections for which the amount of plant material recovered and relative abundance of individual macrophyte taxa are recorded.

• Since 2009 Common Standards Monitoring Methodology for lake macrophyte sampling performed alongside the UK UWMN protocol.
  – Two to four additional 100 m shoreline transects
  – Strandline species recorded
  – Lake transects using both methods.
  – Long day..
# UWMN Macrophyte Results

| Site                  | Species                        | 95 | 96 | 97 | 98 | 99 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|-----------------------|--------------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| **LAKES**             |                                |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Lochnagar             | Subularia aquatica             | X  | X  | X  | X  | X  | X  | X  | X  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Loch Chon             | Elatine hexandra               | ✓  | ✓  | ✓  | ✓  | ✓  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|                      | Subularia aquatica             | ✓  | ✓  | ✓  | ✓  | ✓  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|                      | Chara virgata                  | X  | X  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|                      | Subularia aquatica             | ✓  | ✓  | ✓  | ✓  | ✓  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Loch Tinkers          |                                |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Round Loch of Glenhead| Myriophyllum alterniflorum     | X  | ✓  | X  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Burnmoor Tarman       | Elatine hexandra               | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |     |     |     |     |     |     |     |     |     |     |     |     |     |
|                      | Chara virgata                  | X  | X  | X  | X  | X  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|                      | Nitella translucens            | X  | X  | X  | X  | X  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|                      | Potamogeton berchtoldii        | X  | X  | X  | X  | X  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Llyn Llagi            | Galitrichia hannulata          | X  | X  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|                      | Nitella flexilis agg.          | X  | X  | X  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|                      | Elatine hexandra               | X  | X  | X  | X  | X  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Llyn Cwm Mynach       | Eleogiton fluitans             | X  | X  | X  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|                      | Isoetes lacustris              | X  | X  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| **STREAMS**           |                                |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Allt na Coire nan Con| Fontinalia antipyretica         | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |     |     |     |     |     |     |     |     |     |     |     |
| Dargall Lane          | Blindia acuta                 | X  | X  | X  | X  | X  | X  | X  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| River Etherow         | Hydrocharis ochraceum          | X  | X  | X  | X  | X  | X  | X  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Old Lodge             | Hydrocharis armoricum          | X  | X  | X  | X  | X  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Afon Hafren           | Hydrocharis armoricum          | X  | X  | X  | X  | X  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Afon Cwy              | Fontinalia antipyretica         | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Coneyglan Burn        | Hydrocharis armoricum          | X  | X  | X  | X  | X  | X  | X  | X  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |

**Key.** ✓ species recorded during survey, X species not recorded during survey, • no survey
Recovery – lake macrophytes

UKUWMN lake sites with new macrophyte taxa since 1995

Lochnagar (Subularia aquatica, 2009)
Loch Chon (Chara virgata, 1999)
Loch Tinker (Subularia aquatica, 1995)
Round Loch of Glenhead (Myriophyllum alterniflorum, 2003)
Llyn Cwm Mynach (Eleogeton fluitans, 1999)

Increasing ANC (Acid Neutralising Capacity – overall buffering capacity against acidification) allows species that extract carbon from the water column, rather than sediments, to establish.
Llyn Llagi shows the greatest signs of macrophyte recovery

Gained several new submerged plant species:
- *Subularia aquatica* 1993
- *Callitriche hamulata* 1999
- *Nitella flexilis agg.* 2009
- *Elatine hexandra* 2009

Site has moved from the C1 to the C2 category in Duigan et al.'s. (2007) lake classification scheme.
### UWMN Macrophyte Results – Lakes

#### Round Loch of Glenhead

The elodied species *Myriophyllum alterniflorum*, increasingly established in the Round Loch of Glenhead after 2003.

ANC (Acid Neutralising Capacity – overall buffering capacity against acidification) ~10 microequivalents
Lochnagar

Increase in area of *Juncus bulbosus*

Gained *Subularia aquatica* in 2009 – again at around 10 microequivalents ANC.

JNCC joint altitude record with nearby Sandy Loch – also possible response to changing temperatures and ice environment.

Ruderal annual – seeds prolifically
Recovery – stream macrophytes

UKUWMN stream sites with new macrophyte taxa since 1995

Allt na Coire nan Con (Fontinalis antipyretica, 2007)
Dargall Lane (Blindia acuta, 2003)
River Etherow (Hygrohypnum ochraceum, 2005
Hyocomium armoricum, 2010)
Old Lodge (Hyocomium armoricum, 2000)
Afon Gwy (Hyocomium armoricum, 2008)
Coney Glen Burn (Hyocomium armoricum, 2011)

Bryophyte floras getting gradually richer.
New species usually less acid-tolerant mosses.
Hyocomium armoricum has been recorded when average ANC in the streams has risen above around 10 μeq l⁻¹
Afon Hafren

Three additions to the submerged taxa:
- *Hyocomium armoricum*
- *Fontinalis squamosa*
- *Marsupella emarginata*

Possible increases in Filamentous algae

Significant linear changes in inverts and
UWMN Macrophyte Results – Streams

Afon Gwy

_Hyocomium armoricu_m established in 2008

Sporadic acid-sensitive _Lemanaea sp._ alga after 2006.

Increases in Filamentous algae

Significant linear changes in inverts and diatoms
UWMN Macrophyte Results – Streams

River Etherow

Two new submerged taxa: *Hyocomium armoricum*  
*Hygrohypnum ochraceum*

“Flashy” site on W Pennines and prone to high flow events
UWMN Macrophyte findings so far

- Macrophyte species richness increasing slightly at over half of the sites.
- New taxa have been found in seven out of eleven lake sites and seven out of eleven stream sites.
- Of the sites with new taxa nine are unafforested and five forested.
- Species composition at eight sites has not changed significantly since the study onset. Whilst this includes a few cleaner “control” sites it also includes sites with improving trends in deposition and surface chemistry eg Scoat Tarn,
- Changes due to improving deposition not expected at “control sites” and no apparent signs of climate driven taxa changes
- No sites are exhibiting significant species losses. Where change is occurring macrophyte diversity is generally increasing.
- Macrophyte changes tend to lag behind chemical improvements and responses of diatoms and invertebrates – isolation/dispersal?
- Increasing ANC allows species that extract carbon from the water column to establish - at lake sites with new species the taxa that have arrived are those unable to extract carbon directly from lake sediments. This is consistent with reduced acidity, increased ANC and the subsequent higher availability of inorganic carbon in the water column for plant metabolism.
- The primary changes observed in UWMN streams have been the more recent detection of aquatic mosses, albeit in very small amounts, at sites previously dominated almost solely by acid tolerant liverworts. In some sites *Hyocomium armoricum* has been recorded when average ANC in the streams has risen above around 10 μeq l⁻¹
- Aquatic mosses tend to dominate the least acidic streams on the Network.
UWMN Macrophytes – what next

- PhD. Accepted onto the London NERC Doctoral Training Partnership 2018.
- Microscope ID stream & lake bryophyte voucher backlog
- Database results – eg historic transect data
- Literature review
- Possibility to include data from Water Framework Directive, SAC/SSSI site surveys, River Habitat Surveys – harmonisation with UWMN datasets
- Rigorous data analysis – explore drivers of change: 1. Lakes 2. Streams
  - Acidity changes – main or secondary driver?
  - Climate - changes in flow/hydrology/storminess/sea salt events/lake exposure?
  - Climate – changes in minimum/maximum temperatures?
  - Nutrients esp. N deposition – increases in fil alg?
  - Lakes increasing DOC / light regime changes?
  - Biomass/productivity changes – PVI?
  - Changes in biotic pressures – grazing/biofilms?
- Add current biomonitoring metrics to database – explore development of low alkalinity metrics?
- 3. Lake sediment DNA/macrofossils – explore viability of sediDNA technique/taphonomy against 30-year recorded time-series, establish reference conditions and compare to current trajectories with changes in eg climate, nutrients. Test seed bank viability to determine recolonisation pathways – sediment v dispersal
UWMN Supporting Data

- Water chemistry, including DOC, Al
- Deposition chemistry
- Biology – fish/inverts/diatoms
- Flow for some sites eg Mharcaidh/Dargall Lane
- Temperature / lake thermal regime
- Lake Secchi depths
- O2 profiles
- Stream physical/morphological data (including fish section HABSCORES)
- Planning on TLS scans of stream sections 2018
- Food webs - plants not included (Clare Gray IC)
- Heavy metals
Questions?

Thanks to the funders

(based on a science partnership of UCL, CEH, QMUL and SG; supported by DEFRA, DOENI, Forestry Commission, NRW, SEPA, SG, SNH, WG, NERC CEH, ENSIS Ltd. & several volunteers)