

## 2021 UK APIENs Expert Review Workshop



### Workshop Report

*Online meeting held via Zoom*  
*26<sup>th</sup> January 2021 (10:00 – 12:00)*

## About this report

This report summarises the discussions and conclusions from the UK APIENs expert review workshop, held on 26<sup>th</sup> January 2021. The workshop was jointly organised by the UKCEH and Defra. It took place online, via zoom.



Department  
for Environment  
Food & Rural Affairs

### Information on funders

This work was funded through a research partnership agreement between Defra, Natural England and the UK Centre for Ecology & Hydrology (UKCEH) number ECM\_54322, which builds upon work supported by the Natural Environment Research Council award number NE/R016429/1 as part of the UK-SCAPE programme delivering National Capability.

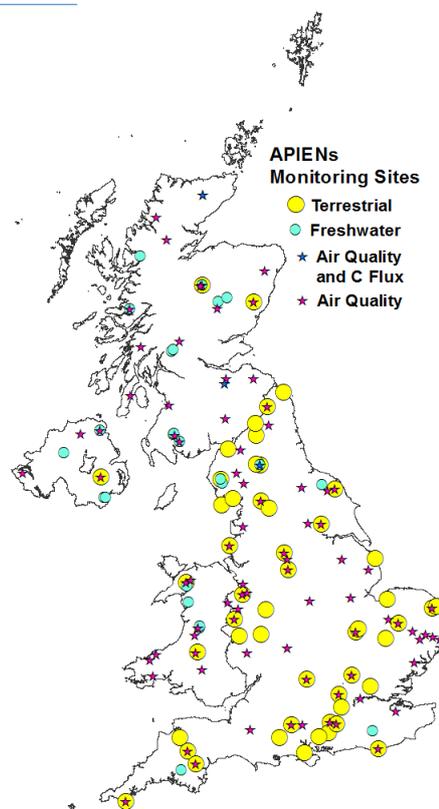
# OVERVIEW AND KEY OUTCOMES

## What is UK APIENs?

The UK **APIENs** (**A**ir **P**ollution **I**mpacts on **E**cosystems **N**etworks) was formed in 2018, to deliver data to the EU National Emission Ceilings Directive Article 9 data delivery requirement. UK APIENs integrates relevant data from existing UK **air quality** and **ecosystem** monitoring networks and schemes.

There are 129 sites currently included in UK APIENs, with representation across freshwater, forests, natural and semi-natural habitats in the UK, as well as the pollution and climate gradients.

UK APIENs networks use a range of established, cost-effective monitoring protocols to assess the impact of air pollution on the environment.



### The Purposes of UK APIENs:

- **Integrate** air quality and ecosystem data to assess the negative impacts of air quality (acidifying and eutrophying pollutants, ozone and biodiversity loss) on sensitive ecosystems, and to detect potential recovery from reduced emissions under targets set by NEC Regulations.
- Meet UK **reporting obligations**:
  - EU NECD Articles 9 / 10 (before 2020)
  - UK NECR 2018, Part 5 (after 2020) on same 4-year cycle
- Provide **evidence** beyond assessing air quality impacts, e.g., feed into new indicators to measure the progress on delivering commitments in the 25 Year Environment Plan and for other specific requirements of the UK's four administrations.
- Use historic data, where appropriate, to improve understanding of change across the range of habitats and environmental gradients within the UK. Four of the component API networks have long-term datasets with over 25 years of data.

On behalf of Defra, UKCEH is co-ordinating a second data integration exercise in 2021, in readiness for reporting of data on behalf of the UK Secretary of State under [NECR Part 5](#).

### Reporting schedule

- **01 July 2022**: Monitoring sites and indicators, and every 4 years thereafter
- **01 July 2023**: Monitoring data from the above sites, and every 4 years thereafter

## The expert review workshop

This is the first expert review workshop convened on 26<sup>th</sup> January 2021. A total of 46 participants from 15 organisations took part (see table below).

### Attendance by organisations

Government/Agencies		Universities/Academia		Consultancies/Industry	
Defra (organiser)	1	UKCEH (presenters)	9	Ricardo EE	2
Defra (attendees)	2	UKCEH (attendees)	7	ENSIS	1
Environment Agency	5	Lancaster University	1		
Forest Research	2				
JNCC	3				
ONS	1				
Natural England	5				
NIEA (N. Ireland)	2				
NRW (Wales)	3				
Scottish government	1				
Welsh government	1				
TOTAL	26	TOTAL	17	TOTAL	3
TOTAL: 46					

Since it was not possible to hold a face-to-face workshop in the time of COVID-19, the workshop was held online. The agenda is shown in Table 1 .

The format was presentations by speakers to introduce specific topics with discussions in parallel breakout rooms convened by chairs + rapporteurs after each topic was introduced.

- David Vowles and Christine Braban introduced the workshop and Defra policy perspective.
- Cristina Martin Hernandez and Philip Taylor managed the meeting.
- Sim Tang led this project, this report and organised the workshop.

Table 1: Agenda for UK APIENs expert review workshop 26<sup>th</sup> January 2021.

Time	Topic
10:00	<b>Welcome to the workshop and policy perspective</b> (David Vowles, Christine Braban)
10:10	<b>Workshop objectives</b> (Sim Tang, Ed Rowe)
10:20	<p><b>Priority metrics</b> for monitoring and assessing negative impacts of air pollution on ecosystems: <b>Drivers, Pressures and Impacts.</b></p> <p><b>Breakout rooms – 3 parallel sessions</b></p> <ol style="list-style-type: none"> <li><b>Vegetation and soil</b> (Chair: Laurence Jones. Rapporteur: Felicity Hayes, Ed Rowe)</li> <li><b>Freshwater</b> (Chair: Don Monteith, Rapporteur: Phil Taylor, Cristina Martin Hernandez)</li> <li><b>Air pollutants</b> (Chair: Sim Tang, Rapporteur: Christine Braban)</li> </ol>
10:45	<b>Report back (and opportunity to add anything from other groups)</b> – 5 mins max per group
11:00	<p><b>Data collation and web presence for UK APIENs</b> (Phil Taylor, Cristina Martin Hernandez)</p> <ul style="list-style-type: none"> <li>Collation of most recently available and historic data</li> <li>Demonstration of how the data is presented and can be visualised on APIS</li> </ul>
11:20	<p><b>Monitoring sites:</b> gaps, synergies with HD and WFD and new ecosystem networks. Integrating air quality and ecosystem data and analysis.</p> <p><b>Breakout rooms – 2 parallel sessions</b></p> <p><b>1</b> (Sim Tang, Felicity Hayes, Laurence Jones)</p> <p><b>2</b> (Christine Braban, Don Monteith, Ed Rowe)</p>
11:40	<b>Report back (and opportunity to add anything from other group)</b> – 5 mins max per group
11:55	<b>Wrap-up, next steps</b> (David Vowles, Christine Braban, Sim Tang)

## Workshop Objectives

Now that APIENS has been formed, we have an opportunity to:

- **clarify** data from the different networks to improve their value, e.g. their structure, site location, inter-operability, sampling frequency, methodologies, data format etc.
- better understand the **synergies** with other monitoring and reporting requirements, e.g. the Habitats, Birds and Water Framework directives

The overall purpose of the workshop was **cross-stakeholder engagement**:

- To bring together measurement and modelling contract funders, policy makers, UK air quality and ecosystem network managers and experts with interest in air quality and ecosystems effects (acidification and eutrophication and ozone damage).
- Maximising the future evidence benefits of UK APIENs by providing a forum to consult, discuss and share ideas for the second cycle of the APIENs reporting.

Specific objectives were to:

- Discuss and **identify key metrics (mandatory and optional)** that can be linked more clearly with indicators of direct air pollution effects + impacts on ecosystems (acidification, eutrophication and ozone damage)
- **Recommend** list of core parameters to be measured at each site for monitoring and reporting in the UK APIENs.
- **Review monitoring sites**: identify gaps, synergies with the Habitats Directive and Water Framework Directives and other ecosystem networks. Integrating air quality and ecosystem data and analysis.

## Key Outcomes

- The workshop strongly endorsed the value of bringing together the UK APIENs Stakeholders and component network operators. It was agreed that at least annual meetings were needed.
- Raised Stakeholder awareness of UK APIENs and its purpose for UK environmental evidence of air pollution impacts on ecosystems.
- Demonstrated UK APIENs data and information tool functionalities on APIS website. Product was well received. The product will meet FAIR data access principles and allow data integration from a wide range of UK monitoring and modelling.
- The meeting clearly identified **funding insecurities** of UK APIENs component networks and this is a key risk to future data delivery by UK APIENs into the NECR Part 5 process.
- UK APIENs **priorities** for the future were discussed

## Next steps

- **Future meetings** - recommend to continue meeting as a group at least once a year.
- Form **sub-groups** to focus on specific topics (in particular to develop expert agreed methods and sites for the long-term future reporting. However this requires funds to allow participation.
- **Reporting template:** improve the reporting frameworks for NECR Part 5, through the work of UK expert groups, consultation with experts and networks managers, ICP vegetation (Chair = Felicity Hayes, UKCEH Bangor) and EU Expert Group on Reporting under the directive (Article 9).
- **Automate** transfer of data from the different networks to UK APIENs database.
- Make all collected measurement and modelled data **machine readable** – steps are made towards this by putting all data on a single database in the APIS website.
- Develop protocol and R codes to **ingest floristic data** (with vegetation codes assigned) and **output required metrics (e.g. Ellenberg N index) – expert input required for translation.**
- **Synergies** with other monitoring and reporting requirements, e.g. the habitats, birds and water framework directives.
- **Engage with key stakeholders** to discuss and agree an approach to **analyse** the data to **detect** changes in ecosystem response to reductions in air pollutant emissions.

# IDENTIFY KEY METRICS

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**Objective:** Discuss and **identify key metrics (mandatory and optional)** that can be linked more clearly with indicators of direct air pollution effects + impacts on ecosystems - acidification, eutrophication and ozone damage.

**It is noted that the bullets below reflect the comments and inputs of the discussion participants and are not a final position on future directions which will be decided at a later date.**

## *General discussions*

- Need to **identify standardized approach** to collect and report biological and ecological indicators.
- Take into consideration different timescales for terrestrial impacts – time lag in ecosystem response.
- Combining long-term data with those derived from broad-scale vegetation monitoring strengthens the approach taken, providing greater representation and power to detect soils and vegetation responses to changing pollution inputs; an approach supported in the Commission’s guidance<sup>3</sup>. The UK also has data from additional, historic monitoring schemes (e.g. countryside surveys) and experiments (N manipulation sites) which can be used to help understand long-term trends and interpret the causes underlying current impacts.
- A **new template** to allow reporting of key indicators from non-forest habitats, which will fulfil UK needs.

## *Critical loads and levels*

- Reporting of ecological impacts of atmospheric N pollution in the NECD Article 9 template in 2019 rely to a large extent on **critical load** and **levels exceedances** as a **proxy** for whole ecosystem damage.
- Critical load (CLo) exceedances are different for different habitats. For grasslands, improved grasslands do not have protected status (no EUNIS classifications), so are not assigned CLo values. Split grasslands, e.g. calcareous grasslands that are acid sensitive?
- Further work needed to characterise and update  $v_d$  for  $\text{NH}_3$ .
- NRW has allocated the **nutrient nitrogen critical load** and the **ammonia critical level** to NVC (National Vegetation Classification) level for nearly all SSSI. In some cases also for the animal or plant species if that is the feature of the SSSI.
- The APIS tool will show total N dep, but it is also possible to do N dep by  $\text{NH}_x$  and  $\text{NO}_x$  split, and by wet and dry deposition as well, if users want it.
- This could be useful for the future APIENs data collation, as the different components contributing to total N deposition are likely to diverge in the next decade

- APIS could offer NVC for SSSI habitats in the system where they have been defined.
- There was a question about data resolution and the applicability of grid square values to point measurements (and vice versa) CBED = 5km<sup>2</sup>, PCM = 1 km<sup>2</sup>.

### *Vegetation metrics:*

- **Floristic surveys:** cover data preferable to presence/absence. Include all species, even bryophytes etc.
- **Metrics** of choice can be derived from floristic data, if we have the data, e.g. biodiversity & trait-based metrics such as Ellenberg N index, acidophytes:nitrophytes score, Nitrophiles:nitrophobes score etc.
- **NVC versus CSM surveys?** Which one to use? Standardise across UK APIENs? Collaborate with JNCC on CSM for Natura 2000 sites?
- **Indicator species** Indicator species vs species groups were discussed. Perhaps at a wider range of sites than the full survey sites, but need to be very careful to do correctly. One option would be supplemented monitoring by other people.
- **Vegetation codes:** ECN together with LTMN have developed harmonised codes. But these are developed for the UK, and independently of ICP vegetation codes.
- **Foliar N (and C and P)** would be useful to be at annual (or more frequently) at some sites, for forests, as well as semi-natural) (bryophytes – ICP moss sampling protocol).
- **Lichen N** for woodland and sites with trees
- **Lichen surveys**, e.g. Lichen app in APIS website
- **N-accumulation** and change in total N deposition would be key derived parameters useful for long-term change.
- It was noted by participants that there are large gaps in data currently, e.g. semi-natural grasslands and a coherent approach across the whole of the UK and all relevant ecosystem types would deliver to NECR Article 5
- Record **ozone injury** (presence/absence) on a few selected species when surveyed

### *Soil metrics*

- Total **Soil N and C** useful even though change is slow – however for the long-term ecosystem health, long-term indicators are required.
- **N-accumulation** and change in total N deposition would be key derived parameters useful for long-term change.
- **Soil pH**, but need to distinguish between organic and mineral layer.
- Need to know some of the **soil data/characteristics**, but not necessarily to monitor them continuously. Gives a strong argument for fixed plots.

- Soils are very important in determining how atmospheric deposition influences terrestrial and aquatic ecosystems. But selection of all three of organic, mineral, organo-mineral classes within each ecosystem category would potentially triple the number of sites required, and costs. Although of course you don't get all three of these soil types in most ecosystem categories.

### *Soil and vegetation sampling design*

- Need sufficient **replication** to assess risk. Recommend replicated surveys: **10 - 20 plots** per priority habitat type across the risk gradient to increase statistical power for detection of change.
- Need to take into consideration different timescale for terrestrial impacts
- Should a subset of sites be sampled every year? Even for cover, to show variability year to year, but this will be expensive.
- How would it work better? If we are going to achieve something and provide sensible data, it needs to be centralised so that a small team of people are collecting the data, not spread the sampling over lots of groups.

### *Air quality metrics*

- **Changing pollutant climate**, do existing measurements capture this?
- Measurements provide important ground-truthing for models.
- Harmonised protocol across UK and quality management system to maintain high standards and ensure comparability of data across networks.
- Make clear whether reported data is measured or modelled.
- Make clear distinction between measured wet deposition (e.g. direct measurements from bulk or daily wet only collector), or modelled deposition (e.g. CBED takes deposition data from Precip Net concentrations and calculates deposition using Met Office Met data and topography – seeder-feeder orographic enhancements). Possibly need validation measurements for wet deposition modelling as there are significant uncertainties particularly over complex terrain.
- It was suggested that **daily wet only** deposition measurements are better than **bulk**, because of potential collection of dry deposited gases and aerosol on funnel surface of bulk collectors. There was suggestion to expand to more than the current 2 daily sites in UKEAP Precip-net (Auchencorth near Edinburgh in Scotland and Chilbolton near Andover in England).
- **HCl** is a parameter which is missing but would be very useful - currently only measured at EMEP Supersites). Measurement of HCl in the UK AGANet stopped at the end of 2015.
- Cost benefit of on-site measurement at all sites should be further discussed, particularly for NH<sub>3</sub> which is spatially very variable.

- **Ozone:** Flux validation measurement in the UK are needed to validate/ground truth modelled flux: specifically ozone and for deposition of N species. Consider using a COTAG (Conditional Time Averaged Gradient?) network?
- **PODy** require high resolution measurement ozone data and meteorology.
- **UKEAP and all UK air quality** networks were being reviewed in 2019-2020 by the Environment Agency and Defra is also reviewing the networks. Therefore it is likely that potential **re-designs of the rural** air quality measurement networks may occur in the coming decade.
- Ed Rowe (UKCEH) is on Clean Air Advisory Panel (Wales) – focus on particulates and air pollution, with an interest in ecosystems.
- Roger Herbert (Welsh government) is working on Clean Air Strategy for Wales, with a broad remit on air quality and monitoring.

### *Freshwater metrics*

- UWMN: chemical (abiotic) metrics to examine drivers of acidification and recovery. Biotic: commonly measured species used to indicate acidification.
- Other components are biological response such as diatoms, invertebrates and fish measured up to 2014.
- Consensus on frequency of sampling are well defined.

### *Other metrics*

- **Meteorology:** Co-located additional parameters key for interpretation: met data, solar radiation, humidity. Alignment of meteorology at as many sites in APIENs as feasible would be useful for interpretation of long-term change at sites
- Needed for validation against modelled data. Currently a mix of using met Office validation sites (141 sites currently).
- As well as concentration measurements, **deposition velocity** ( $v_d$ ) measurements are needed as many have not been measured since the late twentieth century, and the chemical composition, surface characteristics and climate have all changed since then. Therefore, it is necessary to make sure model parameters are relevant for the modern chemical climate as used in ALL models
- **Land use and land management** should also be considered. How to report land management? Check how it is done under Habitats Directive reporting? Smart land use recording approaches and activity data recording would allow higher resolution understanding of air pollution pressures on ecosystems

### *Economics:*

- APIENs is not a funded network. It is an umbrella project delivering data collation, integration, metric calculation and reporting (currently funded to the end of March 2021).

- Component networks on shoestring budgets after a decade of austerity following the 2009 recession. This is a risk to UK APIENS and NECR Part 5 reporting in 2023.
- Economics is key for UK APIENS to be a success. The ecosystem networks in particular are not funded directly by the Government, and have no secure long-term funding. The money needs to be available. Everything needs to be joined up.
- **ECN** is currently under review.
- Development of APIENS and site selection should take into account potential synergies offered by linking with developing UK environmental RIs (research infrastructures), aligning with local authority monitoring and other long-term environmental efforts.
- Ambition should not be limited by costs in the first instance, the measurements in APIENS should be fit for purpose.
- UKCEH is currently involved in a number of European environmental RIs (and others), e.g. ECN, eLTER and ICOS network – all at different stages of development. All would ultimately require governmental backing if UK involvement is to go ahead. If (big if) UK government decides it wants to invest in more than one of these, there would be clear financial (and scientific) benefits in some co-location, and the same would apply for any other networks it is trying to establish. So it's important to remember they are all out there during the APIENS design phase. Some ECN sites have been proposed for joining eLTER.
- NRW (Simon Bareham): Responsibility across the agencies - are there opportunities for some funding to come from Welsh Government for example?
- Welsh government (Roger Herbert): Discussion in Welsh government and talking to ministers to consider opportunities for funding.

# RECOMMENDED LIST OF CORE PARAMETERS

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## Objectives

**Recommended** list of core parameters to be measured at each site for monitoring and reporting in the UK APIENs.

## General

- There are always pressures to add additional parameters, but for terrestrial impacts monitoring, what we need is a simple, balanced design with a simple set of rather infrequent measurements. This would potentially make things more cost-effective and allow enough replication, for each of the habitats included, to provide robust evidence. However a costed assessment will be needed.

## Air pollutants/atmospheric parameters

- Concentrations of NH<sub>3</sub>, HNO<sub>3</sub>, O<sub>3</sub>, HCl,
- particulate matter composition,
- wet chemical deposition,
- O<sub>3</sub> fluxes, NH<sub>3</sub> and HNO<sub>3</sub> fluxes
- CO<sub>2</sub>, H<sub>2</sub>O and CH<sub>4</sub> fluxes
- Meteorology

## Vegetation

- **Floristic data** from **permanent plots**: cover data. But NVC or CSM protocols? Or develop habitat-specific protocols for UK APIENs.
- **Key metrics** from floristic data: Ellenberg N, possibility to look at nitrophile:nitrophobes.
- **Foliar N (and C and P)** would be useful to be at annual (or more frequently) at some sites, for forests, as well as semi-natural) (bryophytes – ICP moss sampling protocol).
- **Ozone injury** (presence/absence) on a few selected species – need protocol for non-cropland sites.

## Soil

- Total **Soil N and C** useful even though they don't change much over time.
- **Soil pH**, but need to distinguish between organic and mineral layer.
- **Soil characteristics** at start – advocate fixed plots
- Synlocated sampling: soil C/N, soil pH, moss %N
- High temporal resolution soil moisture

## Freshwater metrics

- Abiotic – chemistry metrics to examine drivers of acidification and recovery.
- Biotic - commonly measured species used to indicate acidification.
- Consensus on frequency of sampling are well defined.

# MONITORING SITES

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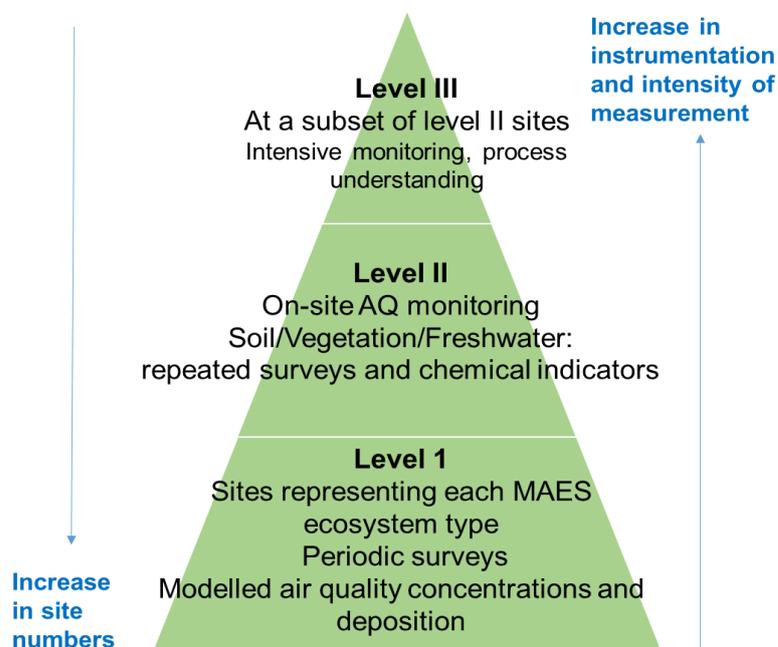
## Objectives

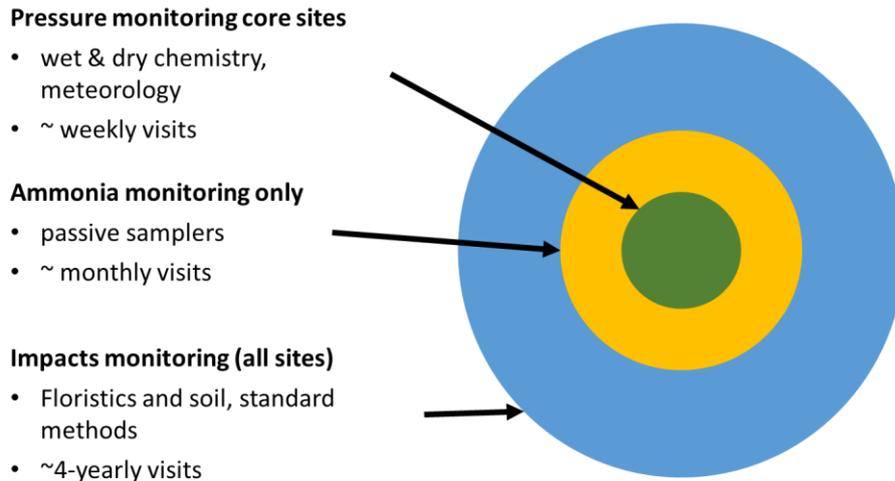
**Monitoring sites:** identify gaps, synergies with Habitats, Birds and Water Framework directives and new ecosystem networks. Integrating air quality and ecosystem data and analysis.

**Reinforce** UK APIENs to determine the state of, and predict changes in, terrestrial & freshwaters ecosystems in a long-term perspective with respect to impacts of acidification, eutrophication and ozone.

## Tiered network

- Tiered network discussed - A core network, based on UK sites in the **ICP Forest Level II, ECN, LTMN network**, and **synergies** with, e.g. **Defra/ELM, Habitats, Water Framework and Birds directives**.





## General

- UK APIENs need to consider good **statistical design while maintaining existing long-term datasets and other location decisions in component networks**
- **Hierarchical** approach – can't measure everything everywhere. Mapped data will complement measured air quality data
- Scoping for new network of sites – Natural Capital Ecosystems Assessment (**NCEA**) to provide evidence in support of 25 YEP.
- Management of UK APIENs – central management (UKCEH Edinburgh) by a specialist team.
- To be cost effective, ideally review and adopt existing sites.
- As part on **N futures** by JNCC, a large number of scenarios are run across the UK in terms of atm. N input, at 15 local sites. N futures' 1 km<sup>2</sup> model output can potentially be utilised. We could also look at the sites themselves (the 15 local ones + further sites). The additional sites are of interest for all nations to look further and see what can be pull out from this N futures data. Potentially help APIENs with data.

## Representation across UK: terrestrial

- Priority habitats: Forests, grassland (acid + calcareous), heaths and bogs. But how to also incorporate the sensitive but more rare habitats?
- Very few sites in Scotland, NI and Wales.
- Pristine to polluted gradients + soil types. Note that 10 sites per priority habitat type might not be enough.
- Need good coverage, stratified across habitats to detect change.
- Carly Stephens has a network of acid/calcareous grassland sites
- **Co-location (air quality + ecosystem plots) really important.**

## *Representation across UK: Freshwater*

- Most monitoring is either in UWMN or in large lowland catchments where land inputs will dominate chemistry. Small acid insensitive lowland headwater catchments potentially sensitive to effects of deposited N are currently missing from the proposed site design and merit further consideration. For small lowland catchments, we might have a better chance of picking up an air pollution effect where there is one.
- There are some relatively low altitude catchments on UWMN, but they are all acid sensitive systems. What's arguably missing, are better buffered headwaters in lowland non-agricultural settings that may be sensitive to atmospheric N inputs. Don Monteith can think of a couple currently monitored. There may be suitable locations from Countryside Survey sites.

## Annex 1: List of presenters and contact details

Name	Organisation	Email
Ed Rowe	UKCEH Bangor	<a href="mailto:ecro@ceh.ac.uk">ecro@ceh.ac.uk</a>
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## Annex 2: List of Participants

Name	Organisation
David Vowles	Defra
Elizabeth Trinder	Defra
Philip Taylor	Defra
Andy Rogers	EA
Danielle Tinker	EA
Jo-Anne Pitt	EA
Jonathon Brookes	EA
Rick Gould	EA
Rob Kinnersley	EA
Roger Herbert	Welsh government
Ulli Dragosits	Scottish Government / UKCEH Edinburgh
Ewan Shilland	ENSIS
Elena Vanguelova	Forest Research
Sue Benham	Forest Research
Clare Brewster	JNCC
Susan Zapalla	JNCC
Alexandra Cunha	JNCC
Carly Stephens	Lancaster University
Dan Pedley	NE
Holly Jenkinson	NE
Kate Fagan	NE
Lydia Knight	NE
Aine O'Reilly	NIEA
Keith Finegan	NIEA
JipIng Shi	NRW
Khalid Aazem	NRW
Simon Bareham	NRW
Hazel Trenbirth	ONS
Keith Vincent	Ricardo
Trevor Davies	Ricardo
David A. Norris	UKCEH Bangor
Bill Bealey	UKCEH Edinburgh
Matthew J. Jones	UKCEH Edinburgh
Cristina Martin Hernandez	UKCEH Edinburgh
Philip Taylor	UKCEH Edinburgh
Ute Skiba	UKCEH Edinburghr
Clare S. Rowland	UKCEH Lancaster
Simon Smart	UKCEH Lancaster
Susannah Rennie	UKCEH Lancaster
Emma Bennett	UKCEH Wallingford

## Annex 3: List of Networks in UK APIENs and URLs

Network	URL
<p><b>UKEAP</b> UK Eutrophying &amp; Acidifying Atmospheric Pollutants networks)</p>	<p><a href="https://uk-air.defra.gov.uk/">https://uk-air.defra.gov.uk/</a></p>
<p><b>AURN</b> Automatic monitoring network</p>	<p><a href="https://uk-air.defra.gov.uk/">https://uk-air.defra.gov.uk/</a></p>
<p><b>ICP Forests</b> International Cooperative Programme Forests network <b>Level II</b></p>	<p><a href="https://www.forestresearch.gov.uk/search/?s=ICP+Forest+level+II">https://www.forestresearch.gov.uk/search/?s=ICP+Forest+level+II</a>  <a href="https://www.icp-forests.org">https://www.icp-forests.org</a></p>
<p><b>ECN</b> Environmental Change Network</p>	<p><a href="http://www.ecn.ac.uk">www.ecn.ac.uk</a></p>
<p><b>LTMN</b> Long-term Monitoring Network</p>	<p><a href="http://publications.naturalengland.org.uk/">http://publications.naturalengland.org.uk/</a></p>
<p><b>UWMN</b> Uplands Waters Monitoring Network (partly reports to <b>ICP Waters</b>)</p>	<p><a href="http://www.ecn.ac.uk">www.ecn.ac.uk</a></p>
<p><b>UKSCAPE GHG-Flux</b></p>	<p><a href="https://www.ceh.ac.uk/carbon-catchment-sites">https://www.ceh.ac.uk/carbon-catchment-sites</a></p>
<p><b>ICP Forests Biosoil</b></p>	<p><a href="https://www.forestresearch.gov.uk/research/integrated-forest-monitoring/">https://www.forestresearch.gov.uk/research/integrated-forest-monitoring/</a></p>
<p><b>Countryside Survey</b></p>	<p><a href="https://countrysidesurvey.org.uk/">https://countrysidesurvey.org.uk/</a></p>
<p><b>National Plant Monitoring Scheme</b></p>	<p><a href="https://www.npms.org.uk/">https://www.npms.org.uk/</a></p>
<p>Derived and modelled data for UKAPIENs sites were used from the following projects:  <b>Critical Loads and Dynamic Modelling</b></p>	<p><a href="http://www.cldm.ceh.ac.uk/uk-critical-loads-and-dynamic-modelling">http://www.cldm.ceh.ac.uk/uk-critical-loads-and-dynamic-modelling</a></p>
<p><b>ICP Vegetation and Effect mapping</b></p>	<p><a href="https://icpvegetation.ceh.ac.uk/about-us">https://icpvegetation.ceh.ac.uk/about-us</a></p>