Department
for Environment
Food & Rural Affairs

Report on the UK NECD Network to monitor the impacts of air pollution on ecosystems

UK Monitoring sites - revised submission

June 2019

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Contents

1. UK NECD Article 9 monitoring sites

The location of monitoring sites and the associated indicators used for monitoring air pollution impacts in the UK were submitted in June 2018.

An amended version of the submitted file, with additional information provided on parameters not reported in the original version has been prepared and re-submitted to the Eionet website, prior to the submission of monitoring data. Changes compared to 01 July 2018 reporting are documented below.

1.1 Legislative requirement

The revised NEC Directive (2016/2284)[1] requires that the ecosystem impacts of air pollution are monitored. Article 9 requires Member States to develop and implement a monitoring system which:

- Can identify negative impacts on air pollution on ecosystems (acidification, eutrophication and ozone damage),
- Covers a network representative of the Member State's habitats.

Annex V of the Directive sets out a list of optional parameters the Member States may use in implementing the obligation. The Directive states that 'Member States shall report the following information referred to in Article 9 to the European Commission and the European Environment Agency (https://rod.eionet.europa.eu/obligations/767).

- To report by 1 July 2018 and every four years thereafter, to the Commission and the European Environment Agency, the location of the monitoring sites and the associated indicators used for monitoring air pollution impacts (Article 10(4)(a));
- To report by 1 July 2019 and every four years thereafter, to the Commission and the European Environment Agency, the monitoring data referred to in Article 9.

1.2 Site location

Coordinates (Lat, Lon) for the UK monitoring sites were inadvertently reported the wrong way round in the 01 July 2018 submission. This has been corrected in the revised submission.

[1] Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC, OJ L 344, 17.12.2016, p. 1.

1.3 Site description (representativeness)

Article 9(1) of the NEC-Directive requires that Member States conduct monitoring on the basis of:

a. ecosystem types

'a network of monitoring sites that is representative of their freshwater, natural and semi-natural habitats and forest ecosystem types, taking a cost-effective and risk-based approach'.

and

b. The impacts of interest

'The air pollution impacts of interest for the ecosystem monitoring are in the first instance those relating to the substances for which reduction commitments are set in Annex II to the Directive (i.e. SO_2, NO_X, NMVOC, NH_3 and $PM_{2,5}$), that is: acidification, eutrophication, and ozone damage to vegetation growth and biodiversity. While the impacts of other pollutants (e.g. heavy metals) are also of concern, a stepwise approach is appropriate and it is proposed that the first phase of monitoring focus on these three impacts.'

A good representation across major ecosystem types and pollution gradients are covered by UK sites. The ICP Forests Level II also includes two paired sites with contrasting pollution inputs. Missing parameters and clarifications arising from the 01 July 2018 submitted file are documented below as are deviations from the ICP protocols where appropriate.

1.3.1 Ecosystem types: MAES classification

The ecosystem type of each UK site is assigned according to the MAES (Mapping and Assessment of Ecosystems and their Services) classifications[2] (For mapping, the most recently available UK land cover information for 2015 (LCM2015)[3] was used to identify and extract the main ecosystems and habitats of interest for each of the UK sites. LCM2015 is derived from satellite images and digital cartography and provides land cover information for the entire UK. The land cover is based on UK Biodiversity Action Plan Broad Habitats classes and 21 land cover classes are mapped. LCM data are available at 25m, 1 km and 5 km grid resolution. LCM 25m raster data was used to derive likely MAES classification/habitat for the UK sites. LCM2015 is available under license from the CEH

[2] MAES Technical Report 2016-095 "Mapping and assessing the condition of Europe's ecosystems: Progress and challenges. Mapping and Assessment of Ecosystems and their Services - 3rd Report – Final, March 2016. http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/MAESWorkingPaper2013.pdf"

[3] Land Cover Map 2015 Dataset documentation -https://www.ceh.ac.uk/sites/default/files/LCM2015_Dataset Documentation_22May2017.pdf

Data Licensing Team[3] and is also accessible via the CEH Environmental Information Platform[4].

Table 1: MAES (Mapping and Assessment of Ecosystems and their Services) classifications[2].

Major category (level 1)	MAES Ecosystem Type (level 2)
Terrestrial	Urban ecosystems
	Cropland
	Grassland
	Woodland and Forest
	Heathland and Shrub
	Sparsely or un-vegetated land
	Inland wetlands
Fresh water	Rivers and lakes
Marine	Marine inlets and transitional waters
	Marine-Coastal
	Marine-Shelf
	Open Ocean

Of the level 2 MAES ecosystem types (Table 1), six major categories of ecosystems are relevant for the NEC-Directive: Grasslands, Cropland, Forests and Woodlands, Heathland and Shrub, Wetlands, and Rivers and Lakes. These are all represented by the UK monitoring sites, with a few sites also falling into the cropland category. Although nutrient load by air pollution for croplands is less relevant compared to fertilisation and other measures, the cropland sites are relevant for assessing sensitivity of crops to ozone.

1.2.2 Ecosystem types: Eunis class (optional)

The main ecosystems and habitats of interest for the UK sites are classified according to the EUNIS classifications[5]. The EUNIS codes were obtained from the APIS oracle database and are only available when the location of the NECD site falls into a grid square with protected status (either SAC or SSSI), then the EUNIS codes are reported. If there is no SAC or SSSI designations, then no EUNIS codes are reported. SPA designated sites also do not have EUNIS classification codes as SPA sites are species focused. The EUNIS habitat classes (Level 1 and 2) in turn can be linked with the six major MAES categories, as shown in Table 2.

[4] https://www.ceh.ac.uk/services/land-cover-map-2015

Table 2: Overview of ecosystems and habitats and link between MAES ecosystem types and EUNIS habitat classes[5].

MAES Ecosystem type	EUNIS Habitat classes Level 1	EUNIS Habitat classes Level 2
Cropland	**I** Regularly or recently cultivated agricultural, horticultural and domestic habitats	I1 Arable land and market gardens I2 Cultivated areas of gardens and parks
Grassland	**E** Grasslands and land dominated by forbs, mosses or lichens	E1 Dry grasslands E2 Mesic grasslands E3 Seasonally wet and wet grasslands E4 Alpine and subalpine grasslands E5 Woodland fringes, clearings and tall forb stands E6 Inland salt steppes E7 Sparsely wooded grasslands
Woodland and forest	**G** Woodland, forest and other wooded land	G1 Broadleaved deciduous woodland G2 Broadleaved evergreen woodland G3 Coniferous woodland G4 Mixed woodland G5 Lines of trees, small woodlands, recently felled woodlands, early stage woodland, coppice
Heathland and shrub	**F** Heathland, scrub and tundra	F1 Tundra F2 Arctic, alpine and subalpine scrub F3 Temperate and mediterraneo-montane scrub F4 Temperate shrub heathland F5 Maquis, arborescent matorral and thermo-Mediterranean brushes F6 Garrigue F7 Spiny Mediterranean heaths F8 Thermo-Atlantic xerophytic scrub F9 Riverine and fen shrubs FA Hedgerows FB Shrub plantations
Wetlands	**D** Mires, bogs and fens	D1 Raised and blanked bogs D2 Valley mires, poor fens and transition mires D3 Aapa, palsa and polygon mires D4 Base-rich fens and calcareous spring mires D5 Sedge and reedbeds, normally without free-standing water D6 Inland saline and brackish marshes and reedbeds
Rivers and lakes	**C** Inland surface waters	C1 Surface standing waters C2 Surface running waters C3 Littoral zone of inland surface waterbodies

Source: https://biodiversity.europa.eu/maes/correspondence-between-corine-land-cover-classes-and-ecosystem-types

[5] European Nature Information System – EUNIS: https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification.

1.2.3 Site Status (protected, non-protected, unknown)

Protected sites are interpreted as those sites falling within designated areas, e.g. SAC, SSSI, and SPA.

1.2.4 Biogeographic region

The latest classification of the EU's biogeographical regions comprises eleven areas (Alpine, Anatolian, Arctic, Atlantic, Black Sea, Boreal, Continental, Macaronesian, Mediterranean, Pannonian and Steppic) shown in Figure 1 below. The whole of UK falls within the Atlantic Biogeographic region.

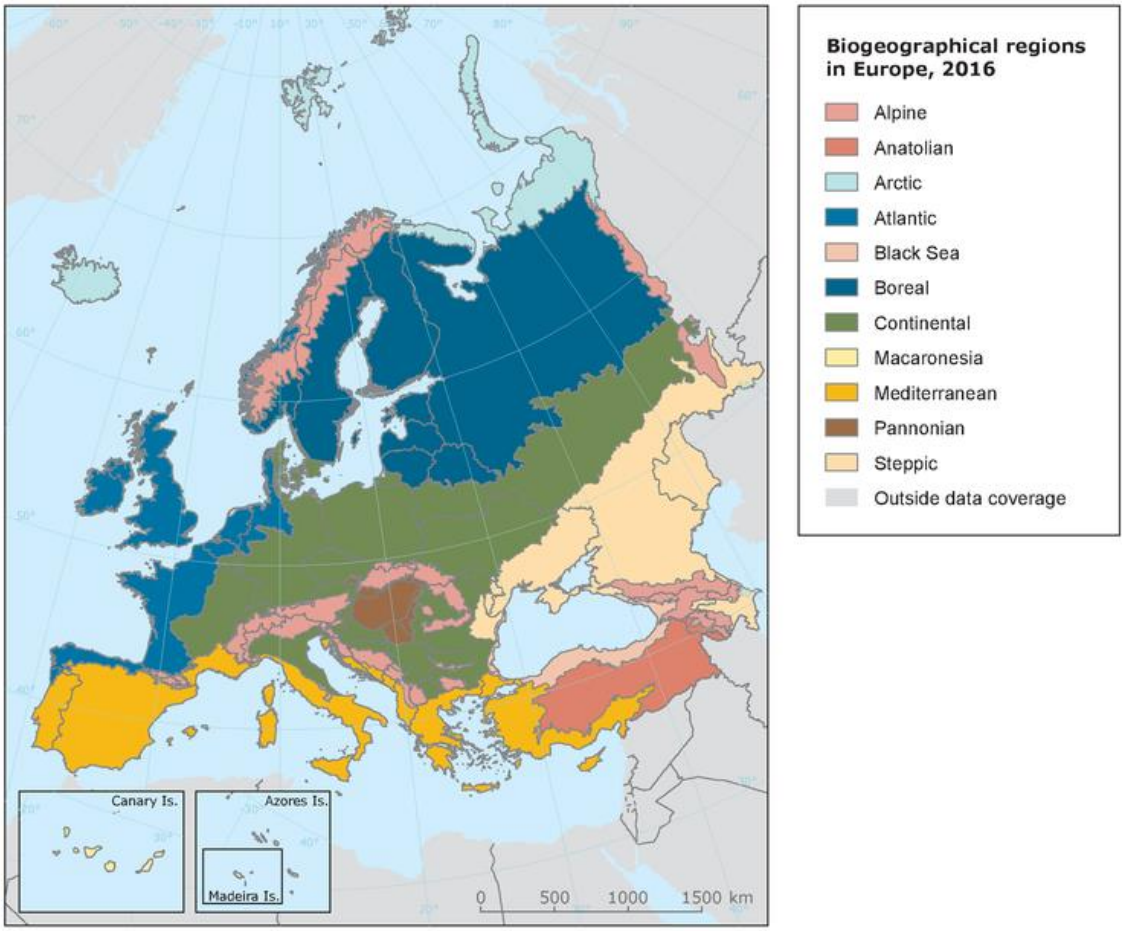


Figure 1: Map of the Biogeographical Regions in Europe. (Source: https://www.eea.europa.eu/data-and-maps/data/biogeographical-regions-europe-3)

1.2.5 Pollution class Acidification and Eutrophication (optional)

Exceedances of acidification, eutrophication and ozone are optional Indicators of pollution load to indicate representativeness of site selection in respect to gradients of high-medium-low pollution loads (eutrophication / acidification / ozone). For the UK NECD sites, critical load exceedances are reported for acidification, eutrophication and ozone, where EUNIS classification information is available for that site. The methodology is described below.

Critical Load exceedances for NECD sites

The critical load of a pollutant is the maximum rate of possible deposition whilst avoiding immediate or long-term damage. Critical Loads for acidity (CLa) and for nutrient-N (CLnutN) are defined for specific habitats (Hall et al., 2015)[6], e.g. “acid grassland”. For NECD sites with only a coarse habitat assignation, e.g. “grassland”, it is not possible to define CLa or CLnutN. Critical Load exceedances have been calculated for sites with at least one acidity- or N-sensitive EUNIS class at a sufficiently fine level (e.g. F4.11 Northern Wet Heath), which 43 of the 129 sites had. Firstly, Critical Load habitat classes were derived using the EUNIS classes recorded for the site. Many sites have several Critical Load habitat classes, and for these sites, exceedances are reported separately for each class. There were 188 site/habitat combinations. The Critical Load assigned to a habitat may be affected by local factors such as rainfall, so site-specific values (Hall et al. 2011)[7] were used for the calculations presented here.

Critical Load Exceedances were calculated using site-specific deposition rates of N and S in 2015-17, following the methodology described in Hall et al. 2019[8]. Critical Loads have been assigned by the UK National Focal Centre for every 1 km^2 grid cell where a particular habitat is present according to Land Cover Map 2000. Where, according to this dataset, the grid cell does not contain a habitat listed in the NECD site data, exceedances were not calculated. Following these exclusions, at least one CLa was defined for 20 sites, and at least one CLnutN was defined for 21 sites.

Critical load values for each site were assumed to be those relevant for the 1km^2 grid cell within which the site is located according to its latitude and longitude. Acidity exceedances were expressed as the distance of the site-specific nitrogen and sulphur deposition values from the critical load function (for equations and methods see Hall et al., 2015). For nutrient

[6] Hall, J., Curtis, C., Dore, T., Smith, R., (2015) Methods for the calculation of critical loads and their exceedances in the UK. http://www.cldm.ceh.ac.uk/publications/uk-status-reports#overlay-context=uk. CEH. Report to Defra under contract AQ0826.

[7] Hall, J., Emmett, B., Garbutt, A., Jones, L., Rowe, E., Sheppard, L., Vanguelova, E., Pitman, R., Britton, A., Hester, A., Ashmore, M., Power, S., Caporn, S., (2011) UK Status Report July 2011: Update to empirical critical loads of nitrogen. Centre for Ecology and Hydrology, UK. Report to Defra under contract AQ801 Critical Loads and Dynamic Modelling., p. 57.

[8] Hall J, Rowe E, Smith R, Dore T, Banin LF, Levy P & Sawicka K. Trends Report 2018; Latest CBED period 2014-16; https://uk-air.defra.gov.uk/library/reports?report_id=982, 2019.

Nitrogen exceedances, the grid cell CLnutN was subtracted from the site-specific total nitrogen deposition, to give an exceedance value.

Complexities arising from site definitions

- Critical Load exceedances could be calculated for a much higher proportion of NECD sites if there was information on which specific habitat(s) occur at each site.
- To determine which habitats occur, the definition of a "site" will need to be clarified. Sites vary greatly in size. The latitude and longitude refer to a point, but sites presumably extend to more than one point, since multiple habitats can occur.
- Time constraints prevented calculation of Critical Load exceedances where the habitat listed does not occur according to LCM2000. Critical Loads could be determined, using criteria defined either as in Hall et al. (2015) or by finding the nearest cell containing the habitat.

1.2.6 Pollution class ozone (optional)

Ozone fluxes and critical level exceedances modelled and mapped for the year 2014[9] are used in the current submission.

[9] Sharps K., Harmens H., Sawicka K., Vieno M., Steadman C. & Hayes F. NECD Reporting 2019 - Quantifying and mapping exceedances of ozone flux-based critical levels for vegetation in the UK (2014 – 2016). CEH Report March 2019.

2. Reporting on parameters for terrestrial vegetation and soil characteristics

The table below lists vegetation and soil surveys and frequencies recommended in the ICP Forests manual[10] that are relevant for reporting in the NECD Article 9 template

Table 3: Surveys to be carried out on Level II plots[11]

Survey	Provide data on	Methods (ICP Forests)	Target plots and frequency of assessment/measurement/sampling	
			Level II	Level II core
Plot description	Location, size and status of the plot,	Part II	5 yr	5 yr
Tree condition	Indicators of crown, branches and stem status of the trees	Part IV	1 yr	1 yr
Tree growth and yield	Actual periodic growth of the stand and of individual trees	Part V	5 yr	5 yr
Soil sampling and analysis	Soil profile and chemical concentration of elements and ions in soil solid phase. Information on soil water content	Part X	10 yrs	10 yrs
Soil solution collection and analysis	Chemical content of elements and ions in soil liquid phase	Part XI	-	1-2 weeks
Foliar sampling and analysis	Chemical concentration of elements in foliage of trees	Part XII	2 yrs	2 yrs
Sampling and analysis of litterfall	Amount, composition and chemical content of litter	Part XIII	-	1-2 weeks

[10] *Manual on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests. Part II Basic Design Principles for the ICP Forests Monitoring Networks. Version 2017*

2.1 Vegetation

UK NECD sites reporting vegetation data include all sites from the ICP Forest Level II, ECN and LTMN networks (Table 4). The NECD guidance, that a combination of intensive site and broad-scale monitoring is beneficial, is positively supported in the submission. Data from intensive sites (ICP, ECN and LTMN) are provided in the current submission. In terms of broad-scale monitoring, the submission of broad-scale data to the site identification and data reporting template poses challenges. Reporting on the terrestrial environment adjacent to a few atmospheric monitoring sites is also not going to be nationally representative.

With these caveats in mind, broad-scale vegetation data are available from the UK Countryside Survey[12] and UK National Plant Monitoring Scheme (NPMS)[13]. For the UK Countryside Survey, vegetation data from surveyed plots, where these are located within a 5 km radius of the UK NECD intensive sites, are reported (Table 4, Table 5). In the case of NPMS, vegetation plots adjacent to UK NECD intensive sites are also identified but are not reported, since NPMS vegetation data could not be matched to the NECD data templates.

The UK also reports every 6 years to the European Commission on the implementation of the EU Habitats Directive under Article 17 of the Directive, with the last report submitted in 2013. This offers an additional resource on ecosystem and vegetation data.

Table 4: UK networks reporting vegetation for the NECD Article 9 data submission.

UK Network	Number of sites (active in 2017)	Data source / comments	Most recently available data reported	Data availability
ICP Forest Level II	5	ICP Forests database in Germany http://icp-forests.net/ Data is by request via the website	2015	Data available from ICP forests since 1994.
ECN	11	https://catalogue.ceh.ac.uk/ All data available under the terms of the Open Government Licence	2012	Data available from ECN since 1994.
LTMN	37	http://publications.naturalengland.org.uk/ All data available under the terms of the Open Government Licence	2016	Data available from LTMN since 2009.
Countryside Survey	28 co-located sites (11 with vegetation sites, 17 with AQ sites)	Plot level data is available for licensed users to download CEH Environmental Information platform	2007	2000 Countryside Survey data and earlier data

[12] https://countrysidesurvey.org.uk/content/field-survey
[13] https://www.npms.org.uk/

Table 5: List of UK network sites monitoring vegetation and details (sites active in 2017, orange shading where more than one UK network at a site).

Site Code	NECD ID	Site name	Network
ICP512	NECD1	Alice Holt 2	ICP Forest Level II
T09			ECN
ICP919	NECD3	Coalburn	ICP Forest Level II
ICP922	NECD5	Llyn Brianne	ICP Forest Level II
1267			Countryside Survey
320			Countryside Survey
ICP718	NECD4	Rogate	ICP Forest Level II
ICP715	NECD2	Thetford (Stanford 2)	ICP Forest Level II
T12	NECD7	Allt a' Mharcaidh/Cairngorms	ECN
T02	NECD8	Glensaugh	ECN
T03	NECD9	Hillsborough	ECN
T11	NECD11	Llyn Llydaw / Snowdon	ECN
517			Countryside Survey
1259			Countryside Survey
T04	NECD6	Moorhouse / ECN Troutbeck	ECN
708			Countryside Survey
T05	NECD12	North Wyke	ECN
T10	NECD13	Porton Down	ECN
T06	NECD10	Rothamsted	ECN
T07	NECD14	Sourhope	ECN
809			Countryside Survey
T08	NECD15	Wytham Woods	ECN
241			Countryside Survey
LTMN34	NECD16	Dark Peak (River Etherow)	LTMN
588			Countryside Survey
LTMN28	NECD17	The Lizard (Goonhilly)	LTMN
LTMN4	NECD18	East Dartmoor Woods & Heaths (Yarner Wood)	LTMN
LTMN5	NECD19	Lullington Heath	LTMN
LTMN19	NECD20	Ainsdale Dunes & Sands NNR	LTMN
LTMN13	NECD21	Bure Marshes	LTMN
LTMN10	NECD22	Fenn's Moss	LTMN
LTMN1	NECD23	Ingleborough NNR	LTMN
658			Countryside Survey
LTMN6	NECD24	Monks Wood NNR	LTMN
LTMN15	NECD25	Stiperstones NNR	LTMN
LTMN25	NECD26	Lower Derwent Valley (Thorganby)	LTMN
637			Countryside Survey
LTMN8	NECD27	Thursley Common	LTMN
LTMN3	NECD28	Wardlow Hay Cop	LTMN
LTMN14	NECD29	Burnham Beeches NNR	LTMN
LTMN33	NECD30	May Moss NNR	LTMN
LTMN37	NECD31	Braunton Burrows	LTMN
LTMN27	NECD32	Chippenham Fen	LTMN
367			Countryside Survey
LTMN22	NECD33	Chobham Common	LTMN
LTMN35	NECD34	Cross Fell	LTMN
LTMN12	NECD35	Dersingham Bog	LTMN
480			Countryside Survey
LTMN21	NECD36	Downton Gorge	LTMN
LTMN31	NECD37	Ennerdale	LTMN
LTMN17	NECD38	Epping Forest	LTMN
LTMN9	NECD39	Finglandrigg Woods	LTMN
LTMN18	NECD40	Kielderhead	LTMN
LTMN20	NECD41	Lindisfarne	LTMN

Site Code	NECD ID	Site name	Network
LTMN26	NECD42	Ludham & Potter Heigham Marshes	LTMN
LTMN16	NECD43	Malham Tarn	LTMN
LTMN2	NECD44	Martin Down	LTMN
LTMN24	NECD45	Mottey Meadows	LTMN
LTMN7	NECD46	North Solent	LTMN
LTMN30	NECD47	North Walney	LTMN
LTMN11	NECD48	Old Winchester Hill	LTMN
LTMN32	NECD49	Roudsea Mosses	LTMN
LTMN23	NECD50	Saltfleetby-Theddlethorpe Dunes	LTMN
LTMN36	NECD51	Woodwalton Fen	LTMN
LTMN29	NECD52	Wyre Forest	LTMN
384			Countryside Survey
844	NECD76	Auchencorth Moss	Countryside Survey
995	NECD58	Baddoch Burn	Countryside Survey
1212	NECD84	Bannisdale	Countryside Survey
684	NECD61	Burnmoor Tarn	Countryside Survey
864	NECD95	Bush / Bush Estate	Countryside Survey
814	NECD97	Carradale	Countryside Survey
1219	NECD63	Danby Beck	Countryside Survey
734	NECD55	Dumfries/Loch Grannoch	Countryside Survey
460	NECD65	Llyn Cwm Mynach	Countryside Survey
464	NECD120	Llynclys Common	Countryside Survey
903	NECD121	Loch Awe	Countryside Survey
189	NECD122	London Cromwell Road 2	Countryside Survey
775	NECD87	Percy's Cross	Countryside Survey
424	NECD82	Stoke Ferry	Countryside Survey
286	NECD89	Tycanol Wood	Countryside Survey

2.1.1 Protocol, data availability and source

ICP Forest Level II: Monitoring under the Level II program is fully compliant with the ICP forests manual (unless otherwise stated) (Table 6). QA/QC procedures are followed, and the analysis laboratory of Forest Research participates in all ICP forest ring tests. Data are validated by the UK before being submitted annually (1 year in arears) to the Programme Co-ordinating Centre of ICP Forests (http://icp-forests.net/). Stringent QA procedures are carried out before the data is uploaded to the ICP forests database. NB submission is from UK. Data requests response pending.

Table 6: Details and frequency of the vegetation monitoring conducted at the five active UK ICP forest level II sites.

Measurement Level II Standard: Obligatory	No of plots	Frequency
Crown condition	till 2007	(annually) discontinued
Tree Growth	(20) **8**	(every 5 years) 5 years
Foliar Chemistry	(20) **5**	(every 2 years) 1-2 years
Ground vegetation	(20) **5**	(every 5 years) 3 years
Meteorology	(10) **5**	(continuously) Hour to day
Litterfall (Quantity and chemistry)	(13) **5**	(Continuously) 4 weeks
Ring tests		Yearly

ECN: All vegetation monitoring under ECN follows standard protocols developed for the network[14]. The ECN vegetation protocol (V) is sub-divided as shown in Table 7:

Table 7: ECN vegetation protocol.

Vegetation protocol	Description	Data availability
Baseline Survey (VB).	Whole site survey with up to 500 systematic 2m x 2m plots. Species presence based on National Vegetation Classification (NVC) scheme.	1991-2000
Coarse-grain sampling (VC).	50 random 2m x 2m grid plots surveyed every nine years. Species presence recorded in each of the 25 40cm x 40cm cells of the plot. Where plots fall in woodland, seedlings, dbh, height and dominance are recorded within a surrounding 10m x 10m plot (Woodlands (VW)).	Continuous records from 1993-2015
Fine-grain sampling (VF).	At least 2 10m x 10m plots randomly selected within each NVC type surveyed every three years. Species presence recorded in 40cm x 40cm cells.	Continuous records every three years (some sites record data annually) from 1994 to 2015
Other	Linear features (VH), permanent grass (VP) and cereals (VA)	

[14] The UK Environmental Change Network Protocols for Standard Measurements at Terrestrial Sites: Protocol on Vegetation to monitor change in semi-natural vegetation, permanent grass and cereals. http://www.ecn.ac.uk/measurements/terrestrial/v

Baseline vegetation survey (VB): Whole site survey with up to 500 systematic 2m x 2m plots to generate vegetation maps for identifying the areas within the site to be monitored. Species presence recorded are related to the National Vegetation Classification (NVC).

Coarse-grain vegetation data (VC): 50 2m x 2m plots are randomly selected within each vegetation type on the site and surveyed every nine years. Species presence is recorded in each of the 25 40cm x 40 cm cells randomly selected within these plots. Where plots fall in woodland, seedlings, dbh, height and dominance are recorded within a surrounding 10m x 10m plot (Woodlands (VW)).

Fine-grain vegetation data (VF)**:** At least 2 10m x 10m plots are randomly selected within each NVC vegetation type on the site and surveyed every three years - species presence is recorded in 40cm x 40 cm cells randomly selected within these plots.

Woodland vegetation data**:** This survey is conducted when plots surveyed during the coarse-grain survey fall in woodland. Seedlings, diameter at breast height (dbh), height and species dominance are recorded within a surrounding 10m x 10m plot. Vegetation survey data does not include the woodland data at present.

Countryside Survey: The field survey is a very detailed study of a sample of 1km squares, located all over England, Scotland and Wales. The individual squares are chosen so that they represent all major habitat types in the UK. During the 2007 Survey, 289 squares were surveyed in England, 195 in Scotland and 107 in Wales. Countryside Survey square level data is available for licensed users to download from the CEH Environmental Information Platform (https://eip.ceh.ac.uk/) for a wide range of geographic regions across Great Britain i.e. squares that fall within the boundaries of pre-determined political and geographic areas.

2.2 Vegetation structure (forests and other woodland)

Below the specific columns in the worksheet and UK data availability from networks other than the ICP Forests are summarised.

2.2.1 Column L: Type of tree species mixture (code)

ICP manual[15]: Codes for the "type of tree species mixture" on the plot (Table 8):

Table 8 ICP Dictionary: d_tree_species_mix

code	description	valid_from_survey_year
1	Monoculture	2011
2	Single tree wise mixture	2011
3	Group wise mixture	2011
4	Mixture by layers	2011
9	Irregular, none of the above	2011
99	Unknown	2011

Data availability: not reported. It may be possible to re-analyse surveyed data from the different networks to provide this data in the NECD template. ECN and LTMN records species data for all vegetation, for all plots, not just in plots with woodlands and forests

2.2.2 Column M: Species number (code)

ICP manual: A comprehensive list of species number (code) "d_species_list" is provided by ICP (https://icp-forests.org/documentation/Dictionaries/d_species_list).

Data availability: ECN reported species numbers are for all vegetation, for all plots, not just in plots with woodlands and forests. In the UK, species presence recorded and codes used are related to the National Vegetation Classification (NVC)[16]. The NVC is a phytosociological classification which requires extremely accurate descriptions of the original vegetation, including all of the principle grasses, sedges, mosses, liverworts and lichens.

2.2.3 Column O: Forest Type

ICP manual: The forest type of the plot is reported following the nomenclature of the European Environment Agency (EEA 2006)[17], and further developed by UNECE/FAO

[15] https://icp-forests.org/documentation/Dictionaries/index.html

[16] https://jncc.defra.gov.uk/pdf/pub06_NVCusershandbook2006.pdf

[17] https://www.eea.europa.eu/publications/technical_report_2006_9

(2010). The forest type on the plot is reported in 14 classes, as defined in the ICP manual (Table 9)

Table 9 ICP Dictionary: d_forest_type

code	description	valid_from_survey_year
1	Boreal forest	2011
2	Hemiboreal and nemoral coniferous and mixed broadleaved-coniferous forest	2011
3	Alpine forest	2011
4	Acidophilous oak and oakbirch forest	2011
5	Mesophytic deciduous forest	2011
6	Beech forest	2011
7	Mountainous beech forest	2011
8	Thermophilous deciduous forest	2011
9	Broadleaved evergreen forest	2011
10	Coniferous forests of the Mediterranean, Anatolian and Macaronesian regions	2011
11	Mire and swamp forest	2011
12	Floodplain forest	2011
13	Non-riverine alder, birch or aspen forest	2011
14	Introduced tree species forest Forests dominated by introduced trees above categories.	2011
99	Unknown	2011

Data availability: not reported. It may be possible to re-analyse surveyed data from the different networks to provide this data in the NECD template. ECN and LTMN records species data for all vegetation, for all plots, not just in plots with woodlands and forests.

2.2.4 Column P: Age class

ICP manual: The mean age of the dominant storey is given in age classes (20-year classes), as defined by ICP[4] (Table 10):

Table 10 ICP Dictonary: D_tree_age

Code	description	valid_from_survey_year	valid_to_survey_year	value_min	value_max
1	<= 20	2009		0	20
2	21 - 40	2009		21	40
3	41 - 60	2009		41	60
4	61 - 80	2009		61	80
5	81 - 100	2009		81	100
6	101 - 120	2009		101	120
7	121 - 140	2009		121	140
8	141 - 160	2009		141	160
9	> 160	2009		161	1000

Data availability: not reported. It may be possible to re-analyse surveyed data from the different networks to provide this data in the NECD template. ECN and LTMN records species data for all vegetation, for all plots, not just in plots with woodlands and forests

2.2.5 Column Q: Numbers of tree layers (code)

ICP manual: The number of tree layers on the plot is reported in four classes, as defined by ICP (Table 11):

Table 11 Dictionary: d_tree_layers

code	description	valid_from_survey_year
1	One Layer	2011
2	Two layers (each min of 10 % coverage)	2011
3	Multi-layered (each min of 10% coverage)	2011
9	Irregular	2011
99	Unknown	2011

Data availability: not reported. It may be possible to re-analyse surveyed data from the different networks to provide this data in the NECD template. ECN and LTMN records species data for all vegetation, for all plots, not just in plots with woodlands and forests

2.3 Soil profile description and soil horizon characterisation

UK sites reporting soil survey data include all sites from the ICP Forest Level II, ECN and LTMN networks (Table 12). In addition, soil data from ICP forest soil survey "BIOSOIL" sites, where the surveyed plots are located within a 5 km radius of the UK NECD sites, are also reported.

Table 12: UK networks reporting soil data for the NECD Article 9 data submission.

UK Network	Number of sites (active in 2017)	Data source / comments	Most recently available data reported	Data availability
ICP Forest Level II	5	ICP Forests database in Germany http://icp-forests.net/ Data is by request via the website	2017	1996-2017
ICP Forest BioSoil	10 co-located sites (3 with ICP/ECN/LTMN, 7 with air quality sites)	ICP Forests database in Germany http://icp-forests.net/ Data is by request via the website	2006	Forests soil survey "BIOSOIL" undertaken in 2006 on a 16km grid across the UK focused in woodland
ECN	11	https://catalogue.ceh.ac.uk/ All data available under the terms of the Open Government Licence	2012	1996-2017
LTMN	37	http://publications.naturalengland.org.uk/ All data available under the terms of the Open Government Licence	2014	2009 - 2015

Table 13: List of UK network sites monitoring soils and details (sites active in 2017, orange indicates more than one networks at site).

Site Code	NECD ID	Site name	Network
ICP512	NECD1	Alice Holt 2	ICP Forest Level II
T09			ECN
ICP919	NECD3	Coalburn	ICP Forest Level II
ICP922	NECD5	Llyn Brianne	ICP Forest Level II
ICP718	NECD4	Rogate	ICP Forest Level II
ICPBio22			ICP Forest BIOSOIL
ICP715	NECD2	Thetford (Stanford 2)	ICP Forest Level II
T12	NECD7	Allt a' Mharcaidh/Cairngorms	ECN
T02	NECD8	Glensaugh	ECN
T03	NECD9	Hillsborough	ECN
T11	NECD11	Llyn Llydaw / Snowdon	ECN
T04	NECD6	Moorhouse / ECN Troutbeck	ECN
T05	NECD12	North Wyke	ECN
T10	NECD13	Porton Down	ECN
T06	NECD10	Rothamsted	ECN
T07	NECD14	Sourhope	ECN
T08	NECD15	Wytham Woods	ECN
ICPBio41			ICP Forest BIOSOIL
LTMN34	NECD16	Dark Peak (River Etherow)	LTMN
LTMN28	NECD17	The Lizard (Goonhilly)	LTMN
LTMN4	NECD18	East Dartmoor Woods & Heaths (Yarner Wood)	LTMN
LTMN5	NECD19	Lullington Heath	LTMN
LTMN19	NECD20	Ainsdale Dunes & Sands NNR	LTMN
LTMN13	NECD21	Bure Marshes	LTMN
LTMN10	NECD22	Fenn's Moss	LTMN
LTMN1	NECD23	Ingleborough NNR	LTMN
LTMN6	NECD24	Monks Wood NNR	LTMN
LTMN15	NECD25	Stiperstones NNR	LTMN
LTMN25	NECD26	Lower Derwent Valley (Thorganby)	LTMN
LTMN8	NECD27	Thursley Common	LTMN
LTMN3	NECD28	Wardlow Hay Cop	LTMN
LTMN14	NECD29	Burnham Beeches NNR	LTMN
LTMN33	NECD30	May Moss NNR	LTMN
LTMN37	NECD31	Braunton Burrows	LTMN
LTMN27	NECD32	Chippenham Fen	LTMN
LTMN22	NECD33	Chobham Common	LTMN
LTMN35	NECD34	Cross Fell	LTMN
LTMN12	NECD35	Dersingham Bog	LTMN
LTMN21	NECD36	Downton Gorge	LTMN
LTMN31	NECD37	Ennerdale	LTMN
LTMN17	NECD38	Epping Forest	LTMN
LTMN9	NECD39	Finglandrigg Woods	LTMN
LTMN18	NECD40	Kielderhead	LTMN
ICPBio108			ICP Forest BIOSOIL
LTMN20	NECD41	Lindisfarne	LTMN
LTMN26	NECD42	Ludham & Potter Heigham Marshes	LTMN
LTMN16	NECD43	Malham Tarn	LTMN
LTMN2	NECD44	Martin Down	LTMN
LTMN24	NECD45	Mottey Meadows	LTMN
LTMN7	NECD46	North Solent	LTMN
LTMN30	NECD47	North Walney	LTMN
LTMN11	NECD48	Old Winchester Hill	LTMN
LTMN32	NECD49	Roudsea Mosses	LTMN
LTMN23	NECD50	Saltfleetby-Theddlethorpe Dunes	LTMN

Site Code	NECD ID	Site name	Network
LTMN36	NECD51	Woodwalton Fen	LTMN
LTMN29	NECD52	Wyre Forest	LTMN
ICPBio63	NECD57	Afon Hafren (Severn)	ICP Forest BIOSOIL
ICPBio117	NECD97	Carradale	ICP Forest BIOSOIL
ICPBio94	NECD79	High Muffles	ICP Forest BIOSOIL
ICPBio139	NECD53	Polloch / Allt na Coire nan Con	ICP Forest BIOSOIL
ICPBio47	NECD89	Tycanol Wood	ICP Forest BIOSOIL

2.3.1 Protocol, data availability and source

ICP Forest Level II: All monitoring under the Level II program is fully compliant with the ICP forests manual (unless otherwise stated). QA/QC procedures are strictly followed, and the analytical laboratory of Forest Research participates in all ICP forest ring tests. Data is validated by the UK before being submitted annually (1 year in arears), to the Programme Co-ordinating Centre of ICP Forests (http://icp-forests.net/). Stringent QA procedures are carried out before the data is uploaded to the ICP forests database. Requests for access to this data are made via a web portal. At some ICP Forests sites and other forest and terrestrial ecosystem sites, additional ecosystem measurements can be made including nitrogen concentration, heavy metals and selected persistent organic pollutants in mosses). In the UK, heavy metals moss surveys have been undertaken and reported to ICP Vegetation (http://icpvegetation.ceh.ac.uk).

Table 14: Details and frequency of the suite of monitoring conducted at the five active UK ICP forest level II sites.

Measurement Level II Standard: Obligatory	No of plots	Frequency
Phenology	(20) **5**	(several times per year) 4 weeks
Soil Solution	(10) **5**	(continuously) 4 weeks
Increment	(20) **5**	5 years
Continuous increment	(10) **4**	4 weeks
Leaf area index	(10) **1**	annual
Air quality	(10) **0**	2-4 week
Ring tests		yearly

ICP Forest Biosoil: In addition to the full-scale ICP forest monitoring program (Level II), a further ICP forests soil survey “BIOSOIL” was undertaken in 2006 on a 16km grid across the UK focused in woodland. This resulted in 167 additional soil sampling points.

ECN: In the UK, the ECN soil Properties protocol[18] is sub-divided as follows:

- ***Soil survey and classification (SB)***[19]***.*** *Initial survey at 1:10 000 or 1:25 000 scales*
- ***Five-yearly monitoring (SF).*** *Samples from cores analysed for major ions*
- ***20-yearly monitoring (SC).*** *Samples from soil pits analysed for major ions, heavy metals and physical properties.*

Data availability: UK data are reported when possible, where the soil survey data in the ECN database matches the headings in the NECD template.

LTMN: ECN protocols are adopted by all LTMN sites.

Data availability: Data are reported, when possible, where the soil survey data in the LTMN database matches the headings in the NECD template.

[18] http://www.ecn.ac.uk/measurements/terrestrial/s

[19] Avery BW (1980). Soil Classification for England and Wales (Higher Categories). Soil Survey Technical Monograph No. 14. Harpenden

2.4 Soil profile description (physical pedological characterisation)

Soil profile and horizon characterisation and codes in the ICP soil protocol[20] are based on the World Reference Base for soil resources (WRB IUSS reference)[21]. In the UK, the British system for soil classifications[22] are implemented in the ECN/LTMN networks. It would be possible to match the profile descriptions to FAO classes for soil type, qualifiers etc., but this would require extensive translation and transformation of the UK data. UK soils data based on the British system is therefore reported.

Table 15: Simplified guide to the WRB Reference Soil Groups (RSGs) with suggested codes

	Description	RSG	Code
1	**Soils with thick organic layers**	Histosols	HS
2	**Soils with strong human influence –**		
	With long and intensive agricultural use	Anthrosols	AT
	Containing significant amounts of artefacts	Technosols	TC
3	**Soils with limitations to root growth –**		
	Permafrost-affected	Cryosols	CR
	Thin or with many coarse fragments	Leptosols	LP
	With a high content of exchangeable Na	Solonetz	SN
	Alternating wet-dry conditions, shrink-swell clays	Vertisols	VR
	High concentration of soluble salts	Solonchaks	SC
4	**Soils distinguished by Fe/Al chemistry –**		
	Groundwater-affected, underwater and in tidal areas	Gleysols	GL
	Allophanes or Al-humus complexes	Andosols	AN
	Subsoil accumulation of humus and/or oxides	Podzols	PZ
	Accumulation and redistribution of Fe	Plinthosols	PT
	Low-activity clay, P fixation, many Fe oxides, strongly structured	Nitisols	NT
	Dominance of kaolinite and oxides	Ferralsols	FR
	Stagnating water, abrupt textural difference	Planosols	PL
	Stagnating water, structural difference and/or moderate textural difference	Stagnosols	ST
5	**Pronounced accumulation of organic matter in the mineral topsoil –**		
	Very dark topsoil, secondary carbonates	Chernozems	CH
	Dark topsoil, secondary carbonates	Kastanozems	KS
	Dark topsoil, no secondary carbonates (unless very deep), high base status	Phaeozems	PH
	Dark topsoil, low base status	Umbrisols	UM
6	**Accumulation of moderately soluble salts or non-saline substances –**		
	Accumulation of, and cementation by, secondary silica	Durisols	DU
	Accumulation of secondary gypsum	Gypsisols	GY
	Accumulation of secondary carbonates	Calcisols	CL
7	**Soils with clay-enriched subsoil –**		
	Interfingering of coarser-textured, lighter coloured material into a finer-textured, stronger coloured layer	Retisols	RT

[20] https://www.icp-forests.org/pdf/manual/2016/ICP_Manual_2016_01_part10.pdf

[21] IUSS Working Group WRB. 2015. World Reference Base for Soil Resources 2014, update 2015 International soil classification system for naming soils and creating legends for soil maps. World Soil Resources Reports No. 106. FAO, Rome

[22] Avery BW (1980). Soil Classification for England and Wales (Higher Categories). Soil Survey Technical Monograph No. 14. Harpenden

	Description	RSG	Code
	Low-activity clays, low base status	Acrisols	AC
	Low-activity clays, high base status	Lixisols	LX
	High-activity clays, low base status	Alisols	AL
	High-activity clays, high base status	Luvisols	LV
8	**Soils with little or no profile differentiation –**		
	Moderately developed	Cambisols	CM
	Sandy	Arenosols	AR
	Stratified fluviatile, marine and lacustrine sediments	Fluvisols	FL
	No significant profile development	Regosols	RG

2.4.1 Column V: Soil type / soil group (WRB), code

This refers to diagnostic horizons (WRB). A diagnostic horizon is a soil layer containing a combination of characteristics typical of that kind of soil. These characteristics may be of structure, origin. The World Reference Base for soil resources (WRB IUSS reference), refers to 39 diagnostic horizons (Table 15) and is adopted by ICP soil protocol.

Data availability: ECN / LTMN: not reported

2.4.2 Column W: Soil qualifiers and specifiers (WRB), code

Qualifiers are meant to complete the soil description through Reference soil groups (RSG), to indicate depth of occurrence, or to express the intensity of soil characteristics. These qualifiers are either prefixes or suffixes. For each RSG, there are several possible prefixes and suffixes. When using qualifiers, prefixes are listed before the RSG, while suffixes are placed between brackets following the RSG name. For each RSG, there are several possible prefixes and suffixes.

Specifiers: There are ten specifiers used in the World Reference Base for soil resources.

Data availability: ECN / LTMN: not reported

2.4.3 Column AA: Parent Material

ICP recommends that parent material should be described at least on the major class level, following the classifications by Lambert et al., 2003[23]. There are nine major classes summarised below in Table 16:

[23] J.J. Lambert, J. Daroussin, M. Eimberck, C. Le Bas, M. Jamagne, D. King and L. Montanarella. 2003. Soil Geographical Database for Eurasia & The Mediterranean: Instructions Guide for Elaboration at scale 1:1,000,000, Version 4.0. European Soil Bureau Research Report N°8. EUR 20422 EN 64 pp. Office for Official Publications of the European Communities, Luxembourg

Table 16 ICP dictionary: d_parent_material

Code	Description of Major Class level
0000	No information
1000	Consolidated-clastic-sedimentary rocks
2000	Other sedimentary rocks (chemically precipitated, evaporated, or organogenic or biogenic in origin)
3000	Igneous rocks
4000	Metamorphic rocks
5000	Unconsolidated deposits (alluvium, weathering residuum and slope deposits)
6000	Unconsolidated glacial deposits / glacial drift
7000	Aeolian deposits
8000	Organic materials
9000	Anthropogenic deposits

Data availability: ECN / LTMN not reported

Parent material are not recorded in soil surveys in the UK Networks. This information may be extracted from UK surveys, but data licensing issues for extracting and publishing this data would be required.

2.5 Soil horizon characterisation

2.5.1 Column AF: Horizon number

Soil horizons are identified by a number: horizon 1 = 1, horizon 2 = 2, etc.

Data availability: ICP reported; ECN / LTMN: not reported

2.5.2 Column AI: Horizon name

The horizon name is made up of one or two capital letters that designate the type of master horizon (or transitional horizon) (Table 17).

Data availability: ECN: not reported; ICP and LTMN: reported

Table 17: Horizon designation (ICP Dictionary: **d_hori_master)**

code	description	code_icp_forests	code_fscc	valid_from_survey_year	valid_to_survey_year
A	A horizon	1	1	1984	
AB	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	1	1984	
A/B	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	1	1984	
AC	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	1	1984	
A/C	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	1	1984	
AE	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	1	1984	
A/E	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	1	1984	
AI	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
A/I	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
AR	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	1	1984	
A/R	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
B	B horizon	1	1	1984	

code	description	code_icp_forests	code_fscc	valid_from_survey_year	valid_to_survey_year
BA	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter)	0	1	1984	1985
BC	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	1	1984	
B/C	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	1	1984	
BE	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	0	1	1984	1985
B/E	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	1	1984	
BI	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
B/I	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
BR	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	1	1984	
B/R	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
C	C horizon	1	1	1984	
CA	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	1	1984	
CB	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	1	1984	
CI	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
C/I	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
CR	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	1	1984	
C/R	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
CS	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	0	1	1984	1985
D		0	1	1984	1985
E	E horizon	1	1	1984	

code	description	code_icp_forests	code_fscc	valid_from_survey_year	valid_to_survey_year
E/A	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons	0	1	1984	1985
EB	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	1	1984	
E/B	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
EC	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
E/C	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
EI	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
E/I	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
ER	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
E/R	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
H	H horizon	1	1	1984	
HA	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
H/A	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
HB	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
H/B	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
HC	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
H/C	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
HE	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
H/E	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
HI	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate	1	0	1984	

code	description	code_icp_forests	code_fscc	valid_from_survey_year	valid_to_survey_year
	properties of another master horizon (symbolized by the second letter).				
H/I	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
HO	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
H/O	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
HOF	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
H/OF	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
HOH	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
H/OH	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
HOL	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
H/OL	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
HR	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
H/R	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
I	I(ce) layer	1	1	1984	
O	O horizon	1	1	1984	
OA	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	1	1984	
O/A	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OB	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
O/B	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OC	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
O/C	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	

code	description	code_icp_forests	code_fscc	valid_from_survey_year	valid_to_survey_year
OE	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
O/E	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OF	OF horizon	1	1	1984	
OFA	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OF/A	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OFB	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OF/B	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OFC	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OF/C	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OFE	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OF/E	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OFH	Combination of on top of OH though OH is smaller than 1 cm and so difficult to sample and describe separately	0	1	1984	1985
OFI	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OF/I	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OFOH	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OF/OH	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	1	1984	
OFR	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OF/R	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OH	OH horizon	1	1	1984	
OHA	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate	1	0	1984	

code	description	code_icp_forests	code_fscc	valid_from_survey_year	valid_to_survey_year
	properties of another master horizon (symbolized by the second letter).				
OH/A	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OHB	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OH/B	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OHC	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OH/C	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OHE	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OH/E	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OHI	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OH/I	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OHR	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OH/R	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OI	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
O/I	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OL	OL horizon	1	1	1984	
OLA	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OL/A	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OLB	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OL/B	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OLC	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate	1	0	1984	

code	description	code_icp_forests	code_fscc	valid_from_survey_year	valid_to_survey_year
	properties of another master horizon (symbolized by the second letter).				
OL/C	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OLE	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OL/E	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OLI	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OL/I	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OLOF	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OL/OF	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OLOH	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OL/OH	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OLR	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
OL/R	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OOF	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
O/OF	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OOH	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
O/OH	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OOL	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
O/OL	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
OR	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	

code	description	code_icp_forests	code_fscc	valid_from_survey_year	valid_to_survey_year
O/R	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
P	Mineralischer Unterbodenhorizont, > 45 Masse-% Ton, entstanden aus Ton- oder Tonmergelgestein (P von Pelosol)	0	1	1984	1985
PS	Transitional horizon	0	1	1984	1985
R	R(ock) layer	1	1	1984	
RC	Transitional horizon	0	1	1984	1985
RI	Transitional horizon dominated by properties of one master horizon (symbolised by the first letter) but having subordinate properties of another master horizon (symbolized by the second letter).	1	0	1984	
R/I	Transitional horizon in which distinct parts have recognizable properties of two kinds of master horizons.	1	0	1984	
S	Mineralbodenhorizont mit Stauwassereinfluss (typisch fÃ¼r Pseudogley)	0	1	1984	1985

2.5.3 Column AJ: Upper and lower limit horizon

This refers to the depth of the upper and lower boundary of each horizon (e.g. Figure 2), measured in centimetres from the surface of the mineral soil. The limit between organic and mineral horizons corresponds to 0 cm. For organic horizons, the limits are negative values. For mineral horizons, the limits are positive values.

Data availability: ECN: not reported; ICP and LTMN: reported

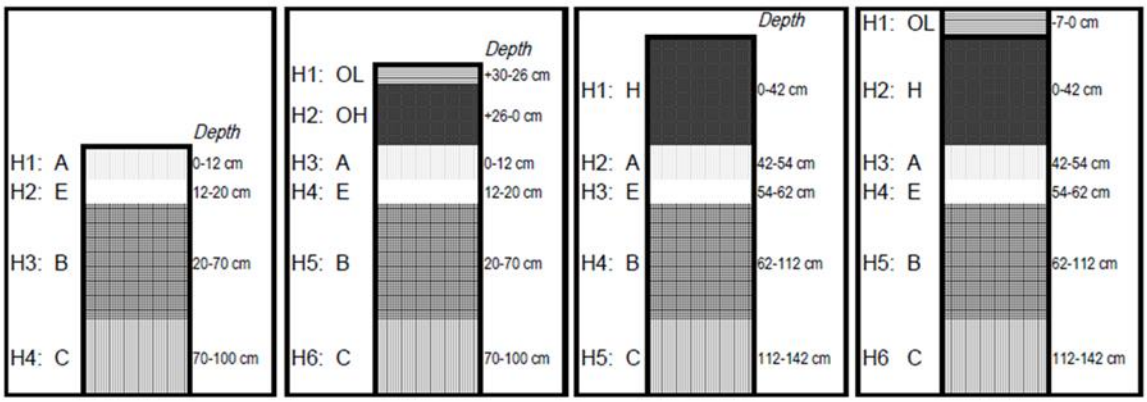


Figure 2: Examples of how the horizon depth should be recorded in the field.

2.5.4 Column AK: Horizon distinctness and topography

The distinctness of the lower horizon boundary refers to the thickness of the boundary zone in between adjacent horizons. The topography of the boundary indicates its shape (Figure 3).

Table 18 ICP dictionary: d_hori_disctinct

code	description	thickness_of_boundary_zone	valid_from_survey_year
1	Extremely abrupt	0.3 - 1 cm	1984
2	Very abrupt	1 - 2 cm	1984
3	Abrupt	0 - 2 cm	1984
4	Clear	2 - 5 cm	1984
5	Gradual	5 - 15 cm	1984
6	Diffuse	>15 cm	1984

Table 19 ICP dictionary: d_hori_topography

code	description	valid_from_survey_year
1	Smooth - Nearly plane surface	1984
2	Wavy - Pockets shallower than they are wide	1984
3	Irregular - Pockets deeper than they are wide	1984
4	Broken - Discontinuous	1984
5	Complex	1984

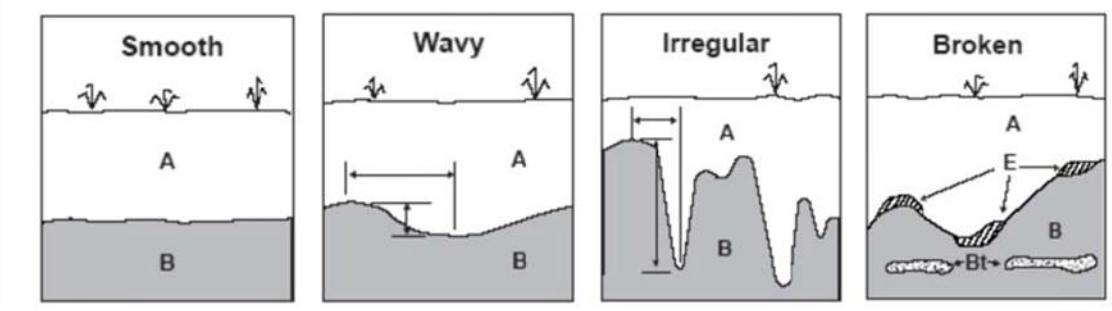


Figure 3: Illustration of the most common horizon topographies, which is the lateral undulation and continuity of the boundary between horizons (ICP soils manual).

Data availability: ECN/LTMN: not reported; ICP reported

2.5.5 Column AL: Structure

Codes for describing soil structure are summarised below in Table 20.

Table 20 ICP dictionary: d_soil_structure

code	Description	valid_from_survey_year
1	Platy	1984
2	Prismatic	1984
3	Columnar	1984
4	Angular blocky	1984
5	Subangular blocky	1984
6	Granular	1984
7	Crumbly	1984
8	Massive	1984
9	Single grain	1984
10	Wedge-shaped (e.g. slickensides)	1984

Data availability: ECN/LTMN: not reported; ICP reported

2.5.6 Column AM: Munsell colour

ICP dictionary_d_colour

code	description	valid_from_survey_year	valid_to_survey_year
1	Yellow	1984	2003
2	Red/brown	1984	2003
3	Grey	1984	2003
4	Blue	1984	2003
5	Bronze	1984	2003
9	Other (specify)	1984	2003

Data availability: ECN not reported; LTMN reports moist Munsell colour only. Dry Munsell colour are not recorded; ICP reported

2.5.7 Column AN: Textural class

Soil texture class are coded according to FAO guidelines (1990)[24] – see **Data availability:** ECN not reported; LTMN textural class data are based on hand texturing in field which is matched to a key for soil textural classes as shown in Table 21.

Table 21 and **Figure 4**.

Data availability: ECN not reported; LTMN textural class data are based on hand texturing in field which is matched to a key for soil textural classes as shown in Table 21.

Table 21: Key to soil textural classes

				~% clay
1	Not possible to roll a wire of about 7 mm in diameter (about the diameter of a pencil)			
1.1	not dirty, not floury, no fine material in the finger rills:	sand	S	< 5
	• if grain sizes are mixed:	unsorted sand	US	< 5
	• if most grains are very coarse (> 0.6 mm):	very coarse and coarse sand	CS	< 5
	• if most grains are of medium size (0.2–0.6 mm):	medium sand	MS	< 5
	• if most grains are of fine size (< 0.2 mm) but still grainy:	fine sand	FS	< 5
	• if most grains are of very fine size (< 0.12 mm), tending to be floury:	very fine sand	VFS	< 5
1.2	not floury, grainy, scarcely fine material in the finger rills, weakly shapeable, adheres slightly to the fingers:	loamy sand	LS	< 12
1.3	similar to 1.2 but moderately floury:	sandy loam	SL (clay-poor)	< 10
2	Possible to roll a wire of about 3–7 mm in diameter (about half the diameter of a pencil) but breaks when trying to form the wire to a ring of about 2–3 cm in diameter, moderately cohesive, adheres to the fingers			
2.1	very floury and not cohesive			
	• some grains to feel:	silt loam	SiL (clay-poor)	< 10
	• no grains to feel:	silt	Si	< 12
2.2	moderately cohesive, adheres to the fingers, has a rough and ripped surface after squeezing between fingers and			
	• very grainy and not sticky:	sandy loam	SL (clay-rich)	10–25
	• moderate sand grains:	loam	L	8–27
	• not grainy but distinctly floury and somewhat sticky:	silt loam	SiL (clay-rich)	10–27
2.3	rough and moderate shiny surface after squeezing between fingers and is sticky and grainy to very grainy:	sandy clay loam	SCL	20–35
3	Possible to roll a wire of about 3 mm in diameter (less than half the diameter of a pencil) and to form the wire to a ring of about 2–3 cm in diameter, cohesive, sticky, gnashes between teeth, has a moderately shiny to shiny surface after squeezing between fingers			
3.1	very grainy:	sandy clay	SC	35–55
3.2	some grains to see and to feel, gnashes between teeth			
	• moderate plasticity, moderately shiny surfaces:	clay loam	CL	25–40
	• high plasticity, shiny surfaces:	clay	C	40–60
3.3	no grains to see and to feel, does not gnash between teeth			
	• low plasticity:	silty clay loam	SiCL	25–40
	• high plasticity, moderately shiny surfaces:	silty clay	SiC	40–60
	• high plasticity, shiny surfaces:	heavy clay	HC	> 60

Note: Field texture determination may depend on clay mineralogical composition. The above key works mainly for soils having illite, chlorite and/or vermiculite composition. Smectite clays are more plastic, and kaolinitic clays are stickier. Thus, clay content can be overestimated for the former, and underestimated for the latter.
Source: Adapted from Schlichting, Blume and Stahr, 1995.

[24] http://www.fao.org/3/a-a0541e.pdf

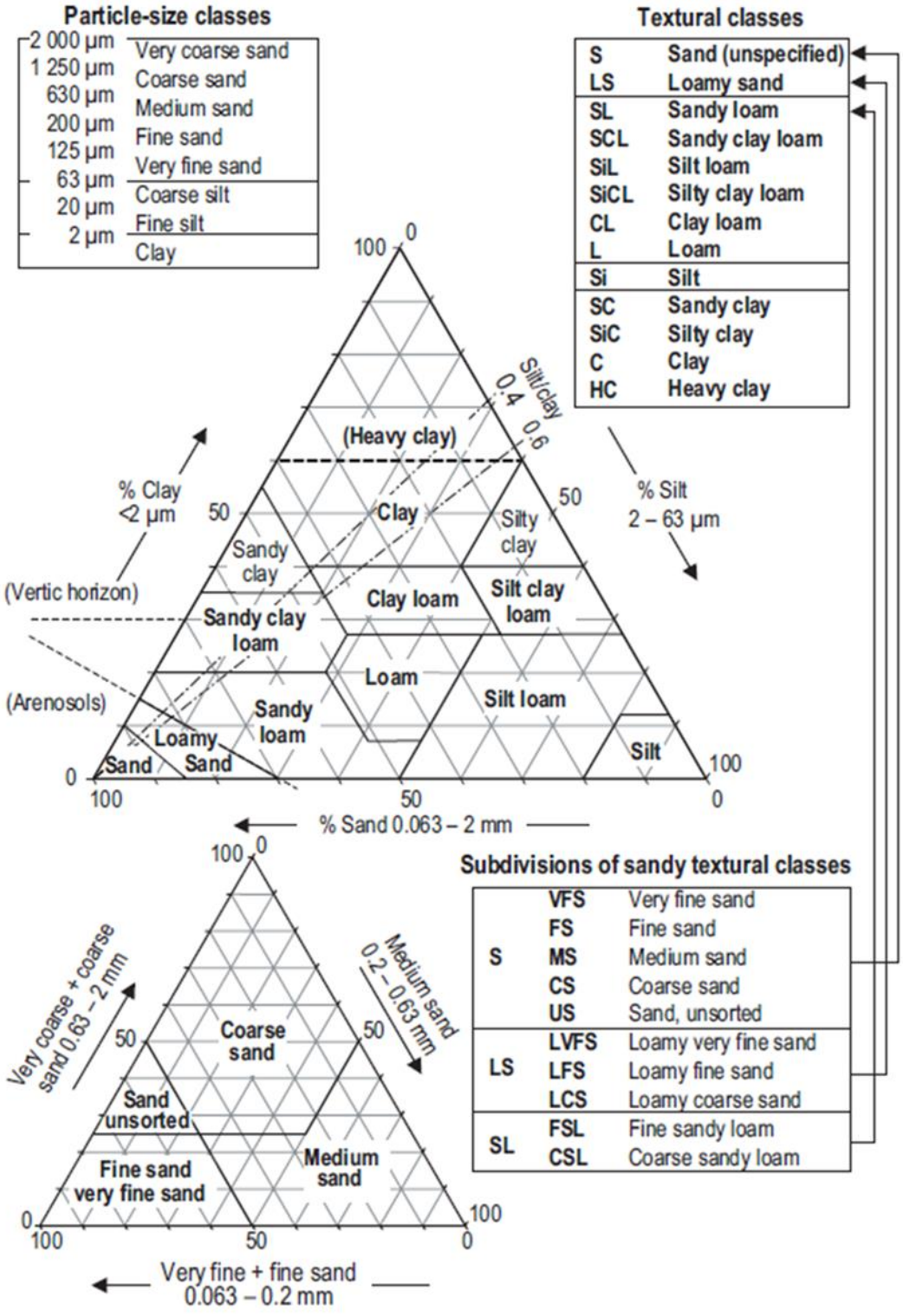


Figure 4: Relation of constituents of fine earth by size, defining textural classes and sand subclasses.

3. Terrestrial ecosystems: vegetation and soil

3.1 Vegetation

3.1.1 Reporting on parameters for acidification and eutrophication - vegetation

UK NECD sites reporting vegetation data include all sites from the ICP Forest Level II and ECN (Table 22). Some sites belong to multiple networks, with multiple site codes, e.g. Alice Holt (Table 23, Table 5).

Table 22: UK networks reporting vegetation for the NECD Article 9 data submission.

UK Network	Number of sites (active in 2017)	Data source / comments	Most recently available data reported	Data availability
ICP Forest Level II	5	ICP Forests database in Germany http://icp-forests.net/ Data is by request via the website (not received for this submission)	2015	Data available from ICP forests since 1994.
ECN	11	https://catalogue.ceh.ac.uk/ All data available under the terms of the Open Government Licence	2012	Data available from ECN since 1994.

Table 23: List of UK network sites monitoring vegetation and details (sites active in 2017, orange shading indicates site in more than one UK network).

Site Code	NECD ID	Site name	Network
ICP512*	NECD1	Alice Holt 2	ICP Forest Level II
T09			ECN
ICP919*	NECD3	Coalburn	ICP Forest Level II
ICP922*	NECD5	Llyn Brianne	ICP Forest Level II
ICP718*	NECD4	Rogate	ICP Forest Level II
ICP715*	NECD2	Thetford (Stanford 2)	ICP Forest Level II
T12	NECD7	Allt a' Mharcaidh/Cairngorms	ECN
T02	NECD8	Glensaugh	ECN
T03	NECD9	Hillsborough	ECN
T11	NECD11	Llyn Llydaw / Snowdon	ECN
T04	NECD6	Moorhouse / ECN Troutbeck	ECN
T05	NECD12	North Wyke	ECN
T10	NECD13	Porton Down	ECN
T06	NECD10	Rothamsted	ECN
T07	NECD14	Sourhope	ECN
T08	NECD15	Wytham Woods	ECN

* in ICP database, not received for this submission

It is noted that ECN data are reported on tree species only. There are other vegetation data available, however the template headings are not available for non-tree species.

Vegetation species protocol: Woodland vegetation data are collected at all of ECN's terrestrial sites using a standard protocol[25]. This survey is conducted when plots surveyed during the coarse-grain survey fall in woodland. Seedlings, diameter at breast height (dbh), height and species dominance are recorded within a surrounding 10m x 10m plot.

3.1.1 ICP protocol

The ICP protocol relevant for the worksheet[26] is copied here for information:

> The same trees should be sampled over the years and the trees must be numbered. For species with small crowns and small foliage mass, it is allowed to alternate between two sets of sample trees (minimum of 5 trees per set), if necessary, to avoid damage of the sample trees. Each set must correspond to the above conditions.
>
> In general, sampling must be carried out in such a way that all the orientations are represented in the set of sample trees. However, it is important that the sampled leaves or needles have developed in light; hence, south-facing branches are recommended and orientations in the canopy that are shaded should be avoided. If necessary, it is allowed to sample different orientations on each tree of the sample set. In special sites with evident influence of one orientation (e.g. steep slopes or strong dominant wind) only one orientation is sampled, which always have to be the same. In such cases, it is necessary to document the orientation.
>
> In general, the current year needles or leaves of evergreen species are most convenient for judging the actual nutritional state, but for a number of elements the comparison of element contents in older needles with that in current year needles is also of interest.
>
> The sampled leaves or needles must be taken from the upper third of the crown, but not from the very first whorls in the conifers; in stands where the different whorls can be clearly identified it is advisable to sample between the 7th and the 15th whorl.
>
> **All species:** It is necessary to take care that leaves or needles which are sampled are mature ones, especially for species which have several flushes per year (e.g., *Pinus halepensis*, *Pseudotsuga menziesii*, *Eucalyptus* spp., *Quercus* spp.). For *Larix* spp. and *Cedrus* spp. samples are taken of the short twigs of the previous year.
>
> **Deciduous species (including larch)**: Sampling is done on current year leaves or needles.
>
> **Evergreen species:** Sampling of both the current year needles or leaves and the second year needles or leaves (current+1) is (see Annex I):

[25] The UK Environmental Change Network Protocols for Standard Measurements at Terrestrial Sites: Protocol on Vegetation to monitor change in semi-natural vegetation, permanent grass and cereals. http://www.ecn.ac.uk/measurements/terrestrial/v

[26] ICP Forests Manual: Part XII Sampling and Analysis of Needles and Leaves version 05/2016 (updated 09/2017)

Quantity of material to be sampled: The recommended minimum quantities are:
- 10-20 grams of fresh needles or leaves (resulting in 5-10 grams of dry material) for each

Sampled age class for mandatory analysis;
- 20-30 grams of fresh needles or leaves for both mandatory and optional analysis. Each country may decide to sample a larger quantity of leaf material, according to the needs of its own analytical methods, or in order to conserve samples for future analysis. It is recommended to store dried, ground samples for the future use.

Type of sample: A. Samples for the measurement of dry mass of 100 leaves or 1000 needles

Drying temperature: 105 °C

Type of sample: B1. Leaves / needles drying before grinding

Drying temperature: ≤ 70 °C

Analytical determination procedures recommended for the analysis of foliage (ordered by element and frequency used in the ring tests).

Parameter = N (Nitrogen)

Determination = element analyser

Comments: To avoid homogeneity problems a minimum sample weight of > 100mg should be used

3.2 Terrestrial ecosystems soil

UK NECD sites reporting soil data include all sites from the ICP Forest Level II, ECN and LTMN for this worksheet (Table 12). Some sites belong to multiple networks, with multiple site codes, e.g. Alice Holt (Table 12). In addition, soil data from ICP forest soil survey "BIOSOIL" sites, where the surveyed plots are located within a 5 km radius of the UK NECD sites, are also reported.

Table 24: UK networks reporting soil data for the NECD Article 9 data submission.

UK Network	Number of sites (active in 2017)	Data source / comments	Most recently available data reported	Data availability
ICP Forest Level II	5	ICP Forests database in Germany http://icp-forests.net/ Data is by request via the website (not received for this submission except ICP512 – provided by Forest Research)	2017	Data available from ICP forests form 1996-2017 incl.
ICP Forest BioSoil	10 co-located sites (3 with ICP/ECN/LTMN, 7 with air quality sites)	ICP Forests database in Germany http://icp-forests.net/ Data is by request via the website	2006	Forests soil survey "BIOSOIL" undertaken in 2006 on a 16km grid across the UK focused in woodland. Data is not included in this submission for NECD94: (ICPBio184) NECD92: (ICPBio187) as not in ICP database to date.
ECN	11	https://catalogue.ceh.ac.uk/ All data available under the terms of the Open Government Licence	2015	Data available from ECN from 1996-2017 incl
LTMN	37	http://publications.naturalengland.org.uk/ All data available under the terms of the Open Government Licence	2016	Data available from LTMN from 2009-2016 incl

Table 25: List of UK network sites monitoring soils and details (sites active in 2017).

Site Code	NECD ID	Site name	Network
ICP512	NECD1	Alice Holt 2	ICP Forest Level II
T09			ECN
ICP919*	NECD3	Coalburn	ICP Forest Level II
ICP922*	NECD5	Llyn Brianne	ICP Forest Level II
ICP718*	NECD4	Rogate	ICP Forest Level II
ICPBio22			ICP Forest BIOSOIL
ICP715*	NECD2	Thetford (Stanford 2)	ICP Forest Level II
T12	NECD7	Allt a' Mharcaidh/Cairngorms	ECN
T02	NECD8	Glensaugh	ECN
T03	NECD9	Hillsborough	ECN
T11	NECD11	Llyn Llydaw / Snowdon	ECN
T04	NECD6	Moorhouse / ECN Troutbeck	ECN
T05	NECD12	North Wyke	ECN
T10	NECD13	Porton Down	ECN
T06	NECD10	Rothamsted	ECN
T07	NECD14	Sourhope	ECN
T08	NECD15	Wytham Woods	ECN
ICPBio41			ICP Forest BIOSOIL
LTMN34	NECD16	Dark Peak (River Etherow)	LTMN
LTMN28	NECD17	The Lizard (Goonhilly)	LTMN
LTMN4	NECD18	East Dartmoor Woods & Heaths (Yarner Wood)	LTMN
LTMN5	NECD19	Lullington Heath	LTMN
LTMN19	NECD20	Ainsdale Dunes & Sands NNR	LTMN
LTMN13	NECD21	Bure Marshes	LTMN
LTMN10	NECD22	Fenn's Moss	LTMN
LTMN1	NECD23	Ingleborough NNR	LTMN
LTMN6	NECD24	Monks Wood NNR	LTMN
LTMN15	NECD25	Stiperstones NNR	LTMN
LTMN25	NECD26	Lower Derwent Valley (Thorganby)	LTMN
LTMN8	NECD27	Thursley Common	LTMN
LTMN3	NECD28	Wardlow Hay Cop	LTMN
LTMN14	NECD29	Burnham Beeches NNR	LTMN
LTMN33	NECD30	May Moss NNR	LTMN
LTMN37	NECD31	Braunton Burrows	LTMN
LTMN27	NECD32	Chippenham Fen	LTMN
LTMN22	NECD33	Chobham Common	LTMN
LTMN35	NECD34	Cross Fell	LTMN
LTMN12	NECD35	Dersingham Bog	LTMN
LTMN21	NECD36	Downton Gorge	LTMN
LTMN31	NECD37	Ennerdale	LTMN
LTMN17	NECD38	Epping Forest	LTMN
LTMN9	NECD39	Finglandrigg Woods	LTMN
LTMN18	NECD40	Kielderhead	LTMN
ICPBio108			ICP Forest BIOSOIL
LTMN20	NECD41	Lindisfarne	LTMN
LTMN26	NECD42	Ludham & Potter Heigham Marshes	LTMN
LTMN16	NECD43	Malham Tarn	LTMN
LTMN2	NECD44	Martin Down	LTMN
LTMN24	NECD45	Mottey Meadows	LTMN

Site Code	NECD ID	Site name	Network
LTMN7	NECD46	North Solent	LTMN
LTMN30	NECD47	North Walney	LTMN
LTMN11	NECD48	Old Winchester Hill	LTMN
LTMN32	NECD49	Roudsea Mosses	LTMN
LTMN23	NECD50	Saltfleetby-Theddlethorpe Dunes	LTMN
LTMN36	NECD51	Woodwalton Fen	LTMN
LTMN29	NECD52	Wyre Forest	LTMN
ICPBio63	NECD57	Afon Hafren (Severn)	ICP Forest BIOSOIL
ICPBio117	NECD97	Carradale	ICP Forest BIOSOIL
ICPBio94	NECD79	High Muffles	ICP Forest BIOSOIL
ICPBio139	NECD53	Polloch / Allt na Coire nan Con	ICP Forest BIOSOIL
ICPBio47	NECD89	Tycanol Wood	ICP Forest BIOSOIL

* in ICP database, not received for this submission

3.2.1 Protocol, data availability and source

ICP Forest Level II: Monitoring under the Level II/ Biosoil program is fully compliant with the ICP forests manual unless otherwise stated. QA/QC procedures are strictly followed, and the analytical laboratory of Forest Research participates in all ICP forest ring tests. Data is validated by the UK before being submitted annually (1 year in arears), to the Programme Co-ordinating Centre of ICP Forests (http://icp-forests.net/). QA procedures are carried out before the data is uploaded to the ICP forests database. Requests for access to this data are made via a web portal at www.icpforest.net,

ICP Forest Biosoil: In addition to the full scale ICP forest monitoring program (Level II), a further ICP forests soil survey "BIOSOIL" was undertaken in 2006 on a 16km grid across the UK focused in woodland. This resulted in 167 additional soil-sampling points. Requests for access to this data are made via a web portal at www.icpforest.net.

ECN: In the UK, the ECN soil Properties protocol[27] is sub-divided as follows:

- Soil survey and classification (SB)[28]. Initial survey at 1:10 000 or 1:25 000 scales
- Five-yearly monitoring (SF). Samples from cores analysed for major ions
- 20-yearly monitoring (SC). Samples from soil pits analysed for major ions, heavy metals and physical properties.

LTMN: ECN protocols are adopted by all LTMN sites.

[27] http://www.ecn.ac.uk/measurements/terrestrial/s

[28] Avery BW (1980). Soil Classification for England and Wales (Higher Categories). Soil Survey Technical Monograph No. 14. Harpenden

4. Terrestrial ecosystem liquid

4.1 Parameters for acidification and eutrophication: Atmospheric Deposition

Atmospheric wet deposition measurements made at UKEAP Precip-net and ECN network sites reporting in the NECD Article 9 data submission are summarised in Table 26. Further details on the sites and measurements are provided in Table 27. Some sites belong to multiple networks, with multiple site codes and duplicated measurements, e.g. Glensaugh.

Table 26: UK networks reporting atmospheric wet deposition data for the NECD Article 9 data submission.

UK Network	Number of sites (active in 2017)	Data source / comments	Most recently available data reported	Data availability
UKEAP Precip-net	Bulk deposition = 41	https://uk-air.defra.gov.uk/ All data are publically accessible online.	2017 aggregated annual data	Continuous weekly records from 1973 to 2001. 2-weekly records from 2002 to present.
	Daily wet only collector (DWOC) = 2: Auchencorth Chilbolton (both have co-located bulk precipitation measurements)	https://uk-air.defra.gov.uk/ All data are publically accessible online.	2017 aggregated annual data.	Auchencorth (DWOC: 2009 – present) Auchencorth (Bulk: 2012 – present) Chilbolton (DWOC/Bulk: 2016 – present) Harwell (DWOC/Bulk: 2009 – 2015)
ECN	Bulk deposition = 11 - 4 sites co-located with Precip-net site; - 2 sites located within 0.5 km of a nearby Precip-net site)	https://catalogue.ceh.ac.uk/ ECN dataset available under the terms of the Open Government Licence.	2015 Weekly data matching to collection frequency.	Continuous weekly records from 1992 to 2017 Continuous 2-weekly records from 2018 to present

Table 27: List of UK network sites measuring atmospheric wet deposition and details (sites active in 2017).

Site Code	Site name	Network	Collection Period / Type	Comments
UKA00635	Ainsdale Dunes & Sands	Precip-net	2-weekly / bulk	New site: started Jan 2017
T09	Alice Holt	ECN	2-weekly / bulk	
UKA00086	Allt a'Mharcaidh	Precip-net	2-weekly / bulk	
T12	Cairngorms	ECN	2-weekly / bulk	At a lower altitude location than allt a'Mharcaidh
UKA00451	Auchencorth Moss	Precip-net	2-weekly / bulk Daily / wet-only collector	Both reported
UKA00239	Balquhidder 2	Precip-net	2-weekly / bulk	
UKA00114	Bannisdale	Precip-net	2-weekly / bulk	
UKA00383	Beaghs Burn	Precip-net	2-weekly / bulk	
UKA00641	Bure Marshes AWS	Precip-net	2-weekly / bulk	New site: started Jan 2017
UKA00614	Chilbolton Observatory	Precip-net	2-weekly / bulk Daily / wet-only collector	Both reported
UKA00382	Crai Reservoir	Precip-net	2-weekly / bulk	
T01	Drayton	ECN	2-weekly / bulk	Closed in 2017
UKA00550	Driby 2	Precip-net	2-weekly / bulk	
UKA00130	Eskdalemuir	Precip-net	2-weekly / bulk	
UKA00642	Fenn's, Whixall & Bettisfield Mosses NNR	Precip-net	2-weekly / bulk	New site: started Jan 2017
UKA00103	Flatford Mill	Precip-net	2-weekly / bulk	
UKA00607	Forsinard RSPB	Precip-net	2-weekly / bulk	
UKA00348	Glensaugh	Precip-net	2-weekly / bulk	
T02	Glensaugh	ECN	2-weekly / bulk	Co-located with Precip-net Glensaugh
UKA00056	Goonhilly	Precip-net	2-weekly / bulk	
UKA00169	High Muffles	Precip-net	2-weekly / bulk	
UKA00293	Hillsborough Forest	Precip-net	2-weekly / bulk	
T03	Hillsborough	ECN	2-weekly / bulk	~400m East of Precip-net Hillsborough Forest
UKA00637	Ingleborough	Precip-net	2-weekly / bulk	New site: started Jan 2017
UKA00268	Llyn Llydaw	Precip-net	2-weekly / bulk	
T11	Snowdon	ECN	2-weekly / bulk	Co-located with Precip-net Llyn Llydaw
UKA00107	Loch Dee	Precip-net	2-weekly / bulk	
UKA00166	Lough Navar	Precip-net	2-weekly / bulk	
UKA00152	Lullington Heath	Precip-net	2-weekly / bulk	
UKA00639	Monks Wood	Precip-net	2-weekly / bulk	
UKA00357	Moorhouse	Precip-net	2-weekly / bulk	
T04	Moorhouse	ECN	2-weekly / bulk	Co-located with Precip-net Moorhouse
T05	North Wyke	ECN	2-weekly / bulk	
UKA00504	Percy's Cross	Precip-net	2-weekly / bulk	
T10	Porton Down		2-weekly / bulk	
UKA00180	Polloch	Precip-net	2-weekly / bulk	
UKA00110	Preston Montford	Precip-net	2-weekly / bulk	
UKA00173	Pumlumon	Precip-net	2-weekly / bulk	
UKA00391	River Etherow	Precip-net	2-weekly / bulk	
UKA00275	Rothamsted	Precip-net	2-weekly / bulk	
T06	ECN Rothamsted	ECN	2-weekly / bulk	Co-located with Precip-net Rothamsted

Site Code	Site name	Network	Collection Period / Type	Comments
UKA00640	Stiperstones	Precip-net	2-weekly / bulk	
UKA00317	Stoke Ferry	Precip-net	2-weekly / bulk	
UKA00162	Strathvaich	Precip-net	2-weekly / bulk	
T07	Sourhope	ECN	2-weekly / bulk	
UKA00112	Thorganby	Precip-net	2-weekly / bulk	
UKA00588	Thursley Common	Precip-net	2-weekly / bulk	
UKA00113	Tycanol Wood	Precip-net	2-weekly / bulk	
UKA00119	Wardlow Hay Cop	Precip-net	2-weekly / bulk	
UKA00123	Whiteadder	Precip-net	2-weekly / bulk	
T08	Wytham Woods	ECN	2-weekly / bulk	
UKA00168	Yarner Wood	Precip-net	2-weekly / bulk	
UKA00505	Ystradffin	Precip-net	2-weekly / bulk	

4.1.1 UK Bulk deposition method used in Precip-net and ECN

The Warren-Spring design of bulk rain collector[29] (Figure 5) is used in the Precip-net and ECN networks to collect precipitation and measure the wet deposition of both acidifying and eutrophying chemical species.

A conical polyethylene collector is connected to a 3 L polypropylene bottle. The collector is supported and held in place by a stainless steel mount. Two funnel sizes are available, each with a 63° cone; the smaller has a diameter of 115 mm, whilst the larger has a diameter of 152 mm. The size of funnel used is matched to rainfall amounts at sites.

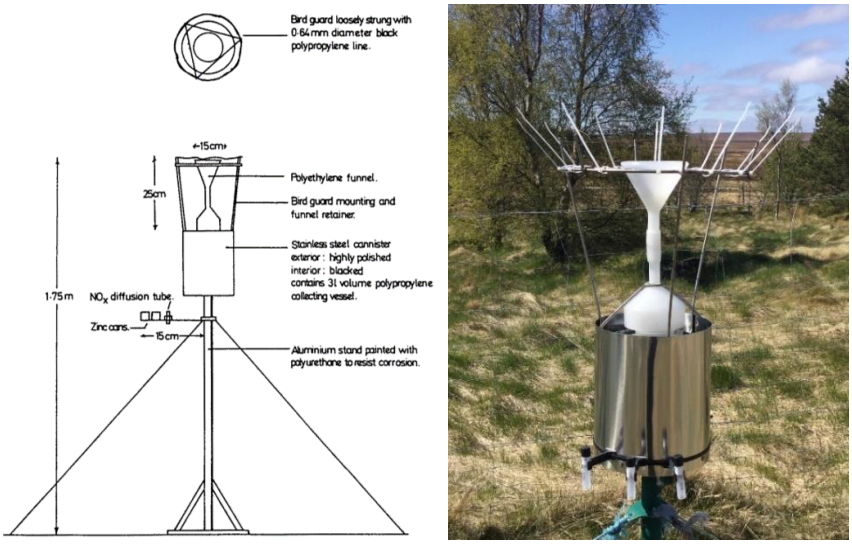


Figure 5: Warren-Spring design Bulk rain collector adopted by UK networks for rainwater collection to determine bulk wet deposition. (reproduced from Longhurst et al. 1987)[30]

[29] Hall, D. J.: 1986, The Precipitation Collector for Use in the Secondary National Acid Deposition Network, Stevenage: Warren Spring Laboratory, LR 56I (AP).

[30] Longhurst L.W.S., Gee D.R., Lee D.S. & Green S.E. The establishment of an urban acid deposition monitoring network. The Environmentalist, Volume 7, Number 4,299-307. 1987.

At the end of each sampling period, the sample bottles are removed and a clean one installed. The funnels are carefully cleaned with deionized water, dried with clean paper towels and a clean debris filter is inserted. Samples are collected fortnightly by the local site operator, returned to a coordination centre, processed and sent to a central chemical laboratory for analysis. For precipitation chemistry, the standard procedures are in line with EMEP Protocols[31] and World Meteorological Organisation Global Atmospheric Watch Programme (WMOGAWP) protocols. The upper surface of the collector is 1.75 m above the ground. A removable polypropylene mesh filter (~1 mm mesh Teflon) is placed at the base of the funnel to prevent coarse debris from falling into the collecting bottle. The collection bottle is protected from direct sunlight by being placed inside a highly polished canister, separated by a gap of 25 mm through which there is free passage of air. This serves to keep the collected rain sample dark and cool.

Bird deterrents are also deployed on the top of the funnels to try to minimise contamination from bird droppings. A ring of loosely strung “bird wire” (or polypropylene line) surrounds the funnel, to prevent droppings from birds sitting on the top of the collector entering the sample. In addition, cable ties are also secured to the top ring of the stainless steel mount, each radiating outwards away from the collector to deter birds from perching on the wire (Figure 5). At some problematic sites, the bird deterrents are supplemented by setting up alternative, decoy bird perches some distance from the collector.

Table 28 Analytical methods and limits of detection for Precip-Net

Parameter_id	Analytical technique	Detection Limit
Ca	Ion chromatography	0.02
Cl	Ion chromatography	0.01
cond	Conductivity meter	2
H+	Calculated from pH	0
K	Ion chromatography	0.02
Mg	Ion chromatography	0.01
Na	Ion chromatography	0.02
NH4-N	Ion chromatography	0.01
NO3-N	Ion chromatography	0.01
pH	pH meter	2
PO4-P	Ion chromatography	0.01
	By weight	0
SO4-S	Ion chromatography	0.01
SO4-S(NM)	Calculated from sea salt ratio	0

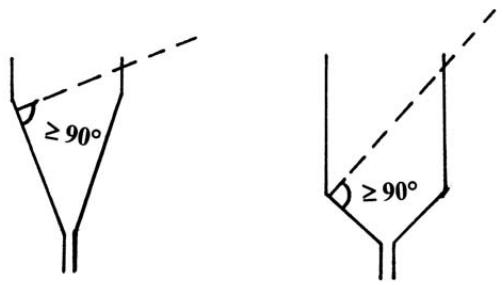
[31] https://projects.nilu.no//ccc/manual/index.html

4.1.2 UK method vs ICP (WMO) bulk method

For bulk wet deposition measurements, the ICP protocol recommends the use of a type of bulk precipitation collector described by the World Meteorological Organisation (WMO) that fulfils minimum requirements for correct precipitation quantity measurements[32]. The two methods are compared in

Table 29.

Table 29: A comparison of bulk precipitation collector design recommended by ICP (based on World Meteorological Organisation) versus the Warren-Spring bulk collector design used in the UK.

Features	ICP (WMO manual)	UK Warren-Spring (W-S) design	Comments
Shape of Collection funnel	Recommends that the upper part of the collector should be very sharp and should go down vertically in the form of a cylinder. Vertical part of the collector should be deep enough to avoid any ejection or loss by wind of the incoming precipitation	Collector is conical	Rainfall volume in W-S design comparable to standard met office rain gauge. Loss of precipitation due to splashing is considered to be insignificant
Shape of Collection funnel		63^0 cone	
Sampling height	Recommend that the rim of the collector should be 1.0-1.5 m above	Upper surface of the collector is 1.75 m above the ground	comparable
Bird deterrent	The upper exterior part of the collector could be surrounded by a so-called "bird wire" or "bird ring"	same	comparable
Sieves and filters	A polyethylene net (mesh width 1 mm) sieve or other inert sieves (aquaristic filter fleece) should be placed at the top of the neck of the collector	removable polypropylene mesh filter (~1 mm mesh Teflon)	comparable
Sampling frequency	Recommends weekly to minimise artefacts due to evaporation or algal growth.	2-weekly in Precip-net (Extensive tests have shown good agreement between weekly and 2-weekly collections)	comparable

[32] ICP Forests Manual. Part XIV: Sampling and Analysis of Deposition. Version 05/2016 (updated 03/2018).

4.1.3 Daily wet-only method used in Precip-net

At Auchencorth Moss and Chilbolton, daily wet only collections (DWOC) are also made with a wet-only sampler, in parallel to the 2-weekly bulk rain collections (Table 27). Daily wet only samples are analysed for the same ions as the 2-weekly bulk rain samples: Na, NH_4-N, K, Mg, Ca, Cl, NO_3-N, SO_4-S, PO_4-P. In the daily samples, fluoride (F^-) is measured additionally. Wet-only collectors (Figure 6) open automatically at the onset of precipitation by the use of a sensor, and close at the end after rain has stopped, thus avoiding the collection of particles and gases during dry periods.

Figure 6: Daily wet only collector at Auchencorth, with the Warren-Spring bulk precipitation collector in the background.

Data availability: Precip-net: Data from the UKEAP Precip-net are submitted annually to the Department for Environment, Food & Rural Affairs (Defra) UK-AIR database (https://uk-air.defra.gov.uk/), in a format consistent with other UK Authority air quality networks and relevant reporting requirements. Ratified calendar year data are published in June the year following collection. **ECN**: ECN data are stored in a central database and are freely available through a variety of data access methods. ECN is a multi-agency programme sponsored by a consortium of UK government departments, research institutes and environmental agencies. These organisations contribute to the programme through funding either site monitoring and/or network co-ordination activities. The network is coordinated by the Centre for Ecology & Hydrology. The ECN sites are also part of the long-term, site-based environmental monitoring and research (LTER) programme (http://www.lter-europe.net/lter-europe/infrastructure/networks#lter-united-kingdom).

4.2 Soil acidity and eutrophication

Soil solution collection and analysis provides data on chemical content of elements and ions in soil liquid phase. The methods are described in the ICP Forests Manual Part X. Recommended frequency of assessment is every 10 years. Soil solution data are also reported by the ECN sites. Variables measured include pH, conductivity, alkalinity, aluminium, calcium, chloride, ammonium, nitrate nitrogen, phosphate phosphorous, potassium, sulphate sulphur, sodium, total nitrogen and total dissolved phosphorous. These data are collected by suction samplers at all of ECN's terrestrial sites using a standard protocol[33]. They represent continuous fortnightly records from 1992 to 2015.

LTMN has adopted the same soil solution protocol as LTMN however the data are not available for this data submission.

[33] http://www.ecn.ac.uk/measurements/terrestrial/ss

5. O_3-air quality-carbon flux

Air pollutants of interest for reporting in the NECD Article 9 reporting template are ozone (O_3), nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and ammonia (NH_3). The ICP Forests manual on Monitoring of Air Quality[34] states that ambient air quality at one site can be estimated by modelling or by interpolation of monitoring data from a nearby site. For ozone, sampling is carried out on a 2-week basis and covers the period of 1 April – 30 September. For the other pollutants, the minimum sampling frequency is 4 weeks or monthly and should cover all 12 months of the year.

The following recommendations are laid out in the ICP Forests manual[1]:

- Passive sampling can be used to achieve low-cost measurements at remote sites,
- Passive samplers should be combined with real time measurements for validation purposes,
- Individual countries are free in their choice of passive samplers, as long as criteria for quality assurance are met,
- All samples, or at least all samplers measuring the same variable, are analysed at the same laboratory per country,
- The lab should use and document well-defined sample handling and analytical procedures, according to either national and/or European standards for good laboratory practices (e.g. EN 13528 part 3[35]).
- To participate in intercomparison tests of different types of passive samplers.
- Reference methods as described in Directive 2008/50 CE of the European Parliament and Council of 21 May 2008 on Ambient Air Quality and Cleaner Air for Europe and European Normative standards,
- Instrument run at an EMEP site in accordance to the EMEP Manual (EMEP/CCC/Report 1/15,NILU, Norway).

5.1 Quality assurance and Quality Control

ICP Forests recommends the following data checks on passive samplers, summarised in Table 30 to Table 32 below**:**

Table 30: Upper and Lower plausibility limits for passive monitoring of air quality

Pollutant (units)	Lower limit	Upper limit
O_3 (µg m^{-3})	5	100
NH_3 (µg m^{-3})	0.2	40
NO_2 (µg m^{-3})	0.2	30
SO_2 (µg m^{-3})	0.2	40

[34] ICP Forests manual Part XV Monitoring of Air Quality. Version 05/2016.

[35] EN 13528 part 3. Ambient air quality - Diffusive samplers for the determination of concentrations of gases and vapours – Guide for selection, use and maintenance. CEN, Brussels, 2003.

Table 31: Data completeness and measurement period

Pollutant	Data completeness for measurement period
O_3	80% April - September
NH_3	80% whole year
NO_2	80% whole year
SO_2	80% whole year

Table 32: Data Quality Objectives (DQO)

Pollutant	Type of measurement	DQO
All pollutants	Field measurement	Data completeness ≥ 80%
All pollutants	Passive samplers co-located with active monitors	Data within ± 30% of reference value
All pollutants	Intercomparison for passive samplers	Data within ± 30% of reference value
All pollutants	Coefficient of variation among replicates	≤ 10%

5.2 Atmospheric concentrations: Ozone (O_3)

5.2.1 Site-based measurements

Continuous atmospheric ozone (O_3) measurement data are available at nine AURN network sites in the UK network (Table 33). Further details on the network sites and measurements are provided in Table 34.

Table 33: UK networks reporting atmospheric O3 data for the NECD Article 9 data submission.

UK Network	Method / Number of sites (active in 2017)	Data source / comments	Most recently available data reported	Data availability
AURN	EU reference method: BS EN14625: 2005 (O3) UV absorption	https://uk-air.defra.gov.uk/ All data are publically accessible online.	2017 aggregated annual data	Continuous hourly average data records from 1990 to present.

Table 34: List of UK network sites measuring atmospheric O3 and details.

Site Code	Site name	Network	Measurement frequency
UKA00171	Bush	AURN	Automatic continuous, hourly averaged data
UKA00323	Chilbolton	AURN	same
UKA00012	Eskdalemuir	AURN	same
UKA00168	High Muffles	AURN	same
UKA00152	Ladybower	AURN	same
UKA00614	Lerwick	AURN	same
UKA00451	Lullington Heath	AURN	same
UKA00130	Lough Navar	AURN	same
UKA00169	Narberth	AURN	same
UKA00166	Sibton	AURN	same
UKA00162	Strathvaich	AURN	same
UKA00128	Yarner Wood	AURN	same

Data availability and source: AURN: Automatic measurement Data from AURN are submitted annually to the Department for Environment, Food & Rural Affairs (Defra) UK-AIR database (https://uk-air.defra.gov.uk/), in a format consistent with other UK Authority air quality networks and relevant reporting requirements. Ratified calendar year data are published in June the year following collection.

5.2.2 Modelled concentrations

Since ozone is monitored at only a few sites in the UK network, modelled ozone data for UK sites are also reported, to complement the measurement data. Ozone data is derived from modelled gridded data using the most recent version of the EMEP4UK atmospheric

chemistry transport model at 5×5 km^2 resolution[36], based on daily mean calculated across the whole year (per grid cell). Since the modelled UK ozone concentration data is reported in units of ppb, the data was converted to µg m^{-3} using a conversion factor of 1.9957[37]. Ozone flux (accumulated uptake through the stomatal pores on the leaf surface), expressed as Phytotoxic Ozone Dose above a threshold flux of Y (POD_Y; $_{mmol}/m^2$), was also modelled for the UK using EMEP4UK model. The methodology is described in detail in Sharps et al. (2019)[38].

5.2.3 POD_y and exceedance flux-based critical levels: O_3

Ozone fluxes and critical level exceedances have been modelled and mapped for the years 2014, 2015 and 2016. Data from all three years are submitted. PODy is calculated over a stated accumulation period within a year, so it represents the PODy within a year, but not the whole year. Hourly ozone data is used to calculate the flux. Outside the stated accumulation period, the hourly flux is assumed to be zero. PODy was reported in preference to critical level, as it is the UNECE preferred metric.

Report on ozone fluxes (PODy; $mmol/m^2$) and exceedance of a flux-based critical level ($mmol/m^2$ projected leaf area) depends on the MAES ecosystem classification for each site (Table 35). A key uncertainty is the vegetation type present at the sites in the NECD monitoring network. The same grid squares might have values calculated for specific crops, forest habitats and semi-natural vegetation. If the NECD monitoring site within a grid square is a forest, the calculated ozone flux and critical level exceedance will be different than for grasslands or crops.

[36] Vieno M., Dore A.J, Stevenson D.S, Doherty R., Heal M.R, Reis S., Hallsworth S., Tarrason L., Wind P., Fowler D., Simpson D. & Sutton MA.. 2010. Modelling surface ozone during the 2003 heat-wave in the UK**.** Atmospheric Chemistry and Physics. 10, 7963-7978, doi: 10.5194/acp-10-7963-2010, 2010.

[37] https://uk-air.defra.gov.uk/assets/documents/reports/cat06/0502160851_Conversion_Factors_Between_ppb_and.pdf

[38] Sharps K., Harmens H., Sawicka K., Vieno M., Steadman C. & Hayes F. NECD Reporting 2019 - Quantifying and mapping exceedances of ozone flux-based critical levels for vegetation in the UK (2014 – 2016). CEH Report March 2019.

Table 35: Reporting on ozone fluxes (PODy) and exceedance of flux-based critical level

Vegetation at site	PODy and exceedance of flux-based critical level	Accumulation period used
Cropland	Report for species: wheat (*Triticum aestivum*) and potato (*Solanum tuberosum*);each species in different row. Note: due to uncertainty of PODy for oil seed rape and lack of exceedance data, we would be inclined not to report this data (methodology not included in Modelling and Mapping Manual of LRTAP Convention either).	POD_6 (Wheat), accumulation period based on a growing season of 42 days. POD_6 (Potato), accumulation period based on a growing season of 70 days.
Forest	Report for species: common beech/silver birch, (*Fagus sylvatica/Betula pendula*), representing managed broadleaf woodland, and Norway spruce (*Picea abies*), representing managed coniferous woodland. Note: should a forest site not be covered by any of the above two managed woodland types but represent an unmanaged beech woodland, then the values for this rare woodland type should be included, representing the species 'common beech (*Fagus sylvatica*)'	POD_1 (Common beech/Silver birch), accumulation period based on a growing season of 192 days. POD_1 (Norway spruce), accumulation period based on a growing season of 192 days.
Grassland	Report for flower number of semi-natural grassland (no specification of species).	Accumulation period based on a growing season of 90 days.

5.3 Atmospheric concentration of pollutants (eutrophication, acidification)

5.3.1 Ammonia, NH_3

Atmospheric ammonia (NH_3) measurements from all UKEAP NAMN network sites and two UKEAP EMEP supersites for reporting in the NECD Article 9 data submission are summarised in Table 36. Further details on the network sites and measurements are provided in Table 37.

Table 36: UK networks reporting atmospheric NH3 data for the NECD Article 9 data submission.

UK Network	Method	Number of sites (2017)	Data source / comments	Most recently available data reported	Data availability
UKEAP NAMN	Passive method: ALPHA samplers[39]	52	https://uk-air.defra.gov.uk/	2017 aggregated annual data	Continuous monthly records since 2000.
	Active method: Diffusion denuder (DELTA)[40] samplers	29	https://uk-air.defra.gov.uk/ .	2017 aggregated annual data	Continuous monthly records since 1996.
UKEAP EMEP Supersites	Continuous wet chemistry – MARGA[41]	2	https://uk-air.defra.gov.uk/	2017 aggregated annual data	Continuous hourly records since 2006.

Table 37: List of UK network sites measuring atmospheric NH3 and details (sites active in 2017)

Site Code	Site name	Network	Measurement frequency	Comments
UKA00635	Ainsdale Dunes & Sands NNR	NAMN, ALPHA	Monthly	
UKA00410	Alice Holt 2	NAMN, ALPHA	Monthly	
UKA00086	Allt a' Mharcaidh	NAMN, ALPHA	Monthly	
UKA00451	Auchencorth Moss	NAMN, ALPHA + DELTA	Monthly	Co-location
		EMEP: MARGA	Continuous, hourly average	
UKA00395	Auchincruive	NAMN, ALPHA	Monthly	
UKA00334	Bedingfield	NAMN, ALPHA	Monthly	

[39] Tang, Y. S., Cape, J. N., and Sutton, M. A.: Development and types of passive samplers for monitoring atmospheric NO_2 and NH_3 concentrations, Scientific World J., 1, 513–529, https://doi.org/10.1100/tsw.2001.82, 2001.

[40] Sutton, M. A., Tang, Y. S., Miners, B., Fowler, D. : A new diffusion denuder system for long-term, regional monitoring of atmospheric ammonia and ammonium, Water, Air and Soil Pollution, Focus, 1, Part 5/6, 145-156, 2001.

[41] Conolly, C., Davies, M., Knight, D., Vincent, K., Sanocka, A., Lingard,J., Richie, S., Donovan, B., Collings, A., Braban, C., Tang, Y. S., Stephens, A., Twigg, M., Jones, M., Simmons, I., Coyle, C., Kentisbeer, J., Leeson, S., van Dijk, N., Nemitz, E., Langford, B., Bealey, W., Leaver, D., Poskitt, J., Carter, H., Thacker, S., Patel, M., Keenan, P., Pereira, G., Lawlor, A., Warwick, A., Farrand, P., and Sutton, M. A.: UK Eutrophying and Acidifying Atmospheric Pollutants (UKEAP) Annual Report 2015, 2016.

Site Code	Site name	Network	Measurement frequency	Comments
UKA00297	Bickerton HIll	NAMN, ALPHA	Monthly	
UKA00405	Brompton	NAMN, ALPHA	Monthly	
UKA00369	Brown Moss 2	NAMN, ALPHA	Monthly	
UKA00310	Bure Marshes AWS	NAMN, ALPHA	Monthly	
UKA00636	Burnham Beeches NNR	NAMN, ALPHA	Monthly	
UKA00128	Bush OTC	NAMN, ALPHA + DELTA	Monthly	
UKA00492	Caenby	NAMN, DELTA	Monthly	
UKA00321	Cardigan	NAMN, ALPHA	Monthly	
UKA00384	Carlisle	NAMN, ALPHA	Monthly	
UKA00389	Carradale	NAMN, DELTA	Monthly	
UKA00328	Castle Cary	NAMN, ALPHA	Monthly	
UKA00614	Chilbolton	NAMN	Monthly	Co-location
		EMEP: MARGA	Continuous, hourly average	
UKA00401	Coleraine	NAMN, ALPHA	Monthly	
UKA00325	Cwmystwyth	NAMN, DELTA	Monthly	
UKA00481	Detling	NAMN, DELTA	Monthly	
UKA00608	Drayton 3	NAMN, ALPHA	Monthly	
UKA00368	Dumfries/Grannoch	NAMN, ALPHA	Monthly	
UKA00308	Dunwich Heath	NAMN, ALPHA	Monthly	
UKA00130	Eskdalemuir	NAMN, DELTA	Monthly	
UKA00291	Fenn's Moss	NAMN, ALPHA	Monthly	
UKA00607	Forsinard RSPB	NAMN, DELTA	Monthly	
UKA00335	Fressingfield	NAMN, ALPHA	Monthly	
UKA00348	Glensaugh	NAMN, ALPHA + DELTA	Monthly	
UKA00426	Glenshee Hotel	NAMN, ALPHA	Monthly	
UKA00056	Goonhilly	NAMN, DELTA	Monthly	
UKA00169	High Muffles	NAMN, DELTA	Monthly	
UKA00293	Hillsborough	NAMN, DELTA	Monthly	
UKA00637	Ingleborough NNR	NAMN, ALPHA	Monthly	
UKA00457	Inverpolly	NAMN, ALPHA	Monthly	
UKA00171	Ladybower	NAMN, DELTA	Monthly	
UKA00290	Lagganlia	NAMN, ALPHA + DELTA	Monthly	
UKA00268	Llyn Llydaw	NAMN, ALPHA	Monthly	
UKA00270	Llynclys Common	NAMN, ALPHA + DELTA	Monthly	
UKA00411	Loch Awe	NAMN, ALPHA	Monthly	
UKA00370	London Cromwell Rd 2	NAMN, ALPHA	Monthly	
UKA00166	Lough Navar	NAMN, DELTA	Monthly	
UKA00152	Lullington Heath	NAMN, DELTA	Monthly	
UKA00397	Lyulphs Tower	NAMN, ALPHA	Monthly	
UKA00638	May Moss NNR	NAMN, ALPHA	Monthly	
UKA00639	Monks Wood NNR	NAMN, ALPHA	Monthly	
UKA00357	Moorhouse	NAMN, ALPHA + DELTA	Monthly	
UKA00356	Myerscough	NAMN, ALPHA	Monthly	
UKA00323	Narberth	NAMN, DELTA	Monthly	
UKA00269	North Wyke	NAMN, ALPHA	Monthly	
UKA00447	Oldmeldrum	NAMN, ALPHA	Monthly	
UKA00493	Plas Y Brenin	NAMN, DELTA	Monthly	
UKA00385	Pointon	NAMN, ALPHA	Monthly	
UKA00180	Polloch	NAMN, DELTA	Monthly	
UKA00487	Porton Down	NAMN, ALPHA	Monthly	
UKA00311	Redgrave & Lopham Fens	NAMN, ALPHA	Monthly	
UKA00391	River Etherow	NAMN, ALPHA	Monthly	
UKA00491	Rosemaund	NAMN, DELTA	Monthly	

Site Code	Site name	Network	Measurement frequency	Comments
UKA00275	Rothamsted	NAMN, ALPHA + DELTA	Monthly	
UKA00012	Sibton	NAMN, ALPHA	Monthly	
UKA00347	Sourhope	NAMN, ALPHA + DELTA	Monthly	
UKA00476	Stanford 2	NAMN, ALPHA	Monthly	
UKA00640	Stiperstones NNR	NAMN, ALPHA	Monthly	
UKA00317	Stoke Ferry	NAMN, ALPHA + DELTA	Monthly	
UKA00162	Strathvaich Dam	NAMN, DELTA	Monthly	
UKA00312	Sutton Bonington	NAMN, DELTA	Monthly	
UKA00296	Tadcaster	NAMN, ALPHA	Monthly	
UKA00112	Thorganby	NAMN, ALPHA	Monthly	
UKA00588	Thursley Common 2	NAMN, ALPHA	Monthly	
UKA00119	Wardlow Hay Cop 2	NAMN, ALPHA	Monthly	
UKA00278	Wytham Woods	NAMN, ALPHA	Monthly	
UKA00168	Yarner Wood	NAMN, DELTA	Monthly	

5.3.2 Methodology

NAMN: Atmospheric NH_3 gas monitoring in the NAMN network uses two different methods (Table 36). The first method is with an active diffusion denuder methodology using the CEH DELTA (Denuder for Long Term Atmospheric sampling) system. This provides monthly measurement of gaseous NH_3 and particulate NH_4^+, as well as monthly measurement of acid gases and aerosols for the Acid Gas and Aerosol Network. The second method is the CEH ALPHA passive method. Replicated (triplicate) measurements are made to allow QAQC of measurement precision[42]. Quality procedures for NAMN are described in detail in Tang & Sutton (2003)

EMEP: The MARGA (Measurement of Aerosol composition and Reactive Gases) instrument is a research grade instrument produced by Applikon-Metrohm B.V., N.L. The instrument has two sample boxes one box measures $PM_{2.5}$ and the other measures PM_{10}. The instrument provides continuous measurement of hourly mass concentration of water-soluble (inorganic) species and gases. This includes the particulate-phase (PM_{10} and $PM_{2.5}$) cation (K^+, Na^+, NH_4^+, Ca^{2+}, Mg^{2+}) and anion (Cl^-, NO_3^-, SO_4^{2-}) species and acid (SO_2, HCl, HONO, HNO_3) and alkali gases (NH_3).

Data availability NAMN and EMEP: Data from the UKEAP NAMN and EMEP sites are submitted annually to the Defra UK-AIR database (https://uk-air.defra.gov.uk/). Ratified calendar year data are published in June the year following collection.

5.3.2 Nitrogen Dioxide, NO_2

Atmospheric nitrogen dioxide (NO_2) measurements made at UKEAP NO_2-net, ECN and co-located AURN network sites for reporting in the NECD Article 9 data submission are summarised in Table 38.

NO_2-Net sites are used to provide a rural background for the UK modelling of NO_2 via the Modelling Ambient Air Quality contract for annual compliance mapping. This supplements information delivered on a separate Defra network, the Automatic Urban and Rural Network.

Palmes-type diffusion tubes with stainless steel grids mounted in low density polyethylene caps are used to collect the samples. The stainless steel grids are impregnated with an absorbent chemical (triethanolamine and acetone) which captures the NO_2 as the gas diffuses through the tube. The tubes are left in situ for 4 weeks then analysed.

[42] Tang, Y.S. & Sutton, M.A. (2003) in Quality management in the UK National Ammonia Monitoring Network. In: Proceedings of the International Conference "QA/QC in the field of Emission and Air Quality Measurements" 21 – 23 May 2003, Prague (CZ))

Table 38: UK networks reporting atmospheric NO2 data for the NECD Article 9 data submission.

UK Network	Method	Number of sites (2017)	Data source / comments	Most recently available data reported	Data availability
UKEAP NO_2-net	Palmes-type diffusion tube (7.1 cm long, open inlet)[43]	23	https://uk-air.defra.gov.uk/ All data are publically accessible online.	2017 aggregated annual data	Continuous 2-weekly records from 1991 to 20. 4-weekly records since 20xx
ECN	Palmes-type diffusion tube (7.1 cm long, open inlet)	11 - 4 sites co-located with NO_2-net sites; - 1 site located within 0.5 km of a nearby NO_2-net site.	https://catalogue.ceh.ac.uk/ All data available under the terms of the Open Government Licence.	2015 2-weekly data matching to collection frequency	Continuous 2-weekly records from 1993 to 2015 published.
AURN	EU reference method: BS EN14211: 2005 (NOx) chemiluminescence analyser	2	https://uk-air.defra.gov.uk/ All data are publically accessible online.	2017 aggregated annual data	Continuous data records since 1997
EMEP	EU reference method: BS EN14211: 2005 (NOx) chemiluminescence analyser	1 (Auchencorth)	Available from request: CEH	2017 aggregated annual data	Continuous data records since 2000

Data availability NO_2-net: Data from the UKEAP NO_2-net are submitted annually to the Department for Environment, Food & Rural Affairs (Defra) UK-AIR database (https://uk-air.defra.gov.uk/), in a format consistent with other UK Authority air quality networks and relevant reporting requirements. Ratified calendar year data are published in June the year following collection. **ECN** data are stored in a central database and are freely available through a variety of data access methods. ECN is coordinated by the Centre for Ecology & Hydrology and is a multi-agency programme sponsored by a consortium of UK government departments, research institutes and environmental agencies. The ECN sites are also part of the long-term, site-based environmental monitoring and research (LTER) programme (http://www.lter-europe.net/lter-europe/infrastructure/networks#lter-united-kingdom).

AURN: The NO_2 monitoring data for the UK is delivered through the Automatic Urban and Rural Monitoring Network (AURN), which provides hourly measurements of concentrations of NO_X and NO using the chemiluminescence reference measurement method laid out in the Air Quality Directive. NO_2 concentrations are calculated within the reference method by subtracting the concentration of NO from the concentration of NO_X. Data are submitted annually to the Defra UK-AIR database (https://uk-air.defra.gov.uk/). **EMEP:** The NO_2 monitoring data for the Auchencorth EMEP supersites is delivered through the Centre for

[43] NO_2 Network Field Intercomparison, 2003-2005. AEAT/ENV/R/2311 Issue 1. October 2006

Ecology & Hydrology, which provides hourly measurements of concentrations of NO_x and NO using a blue light- conversion chemiluminescence analyser.

Table 39: List of UK network sites measuring atmospheric NO2 and details (sites active in 2017).

Site Code	Site name	Network	Measurement frequency	Comments
T09	Alice Holt	ECN	weekly	
UKA00086	Allt a' Mharcaidh	NO_2-net	4-weekly	
UKA00451	Auchencorth	EMEP	Continuous, hourly average	Check with Christine
UKA00128	Bush	AURN	continuous	
T12	Cairngorms	ECN	weekly	At a lower altitude location than allt a'Mharcaidh
UKA00239	Balquhidder	NO_2-net	4-weekly	
UKA00114	Bannisdale	NO_2-net	4-weekly	
UKA00614	Chilbolton	NO_2-net	4-weekly	
		AURN	Continuous, hourly average	
UKA00130	Eskdalemuir	NO_2-net	4-weekly	
UKA00130	Eskdalemuir	AURN	continuous	
UKA00103	Flatford Mill	NO_2-net	4-weekly	
UKA00607	Forsinard RSPB	NO_2-net	4-weekly	
UKA00348	Glensaugh	NO_2-net	4-weekly	
T02	Glensaugh	ECN	weekly	Co-located with NO_2-net Glensaugh
UKA00056	Goonhilly	NO_2-net	4-weekly	
UKA00169	High Muffles	NO_2-net	4-weekly	
UKA00169	High Muffles	AURN	Continuous, hourly average	
UKA00293	Hillsborough Forest	NO_2-net	4-weekly	
T03	Hillsborough	ECN	weekly	~400m East of NO_2-net Hillsborough Forest
UKA00171	Ladybower	AURN	Continuous, hourly average	
UKA00268	Llyn Llydaw	NO_2-net	4-weekly	
T11	Snowdon	ECN	weekly	Co-located with NO_2-net Llyn Llydaw
UKA00107	Loch Dee	NO_2-net	4-weekly	
UKA00166	Lough Navar	NO_2-net	4-weekly	
UKA00323	Narberth	AURN	Continuous, hourly average	
UKA00152	Lullington Heath	AURN	Continuous, hourly average	
UKA00357	Moorhouse	NO_2-net	4-weekly	
T04	Moorhouse	ECN	weekly	Co-located with NO_2-net Moorhouse
T05	North Wyke	ECN	weekly	
UKA00504	Percy's Cross	NO_2-net	4-weekly	
UKA00180	Polloch	NO_2-net	4-weekly	
T10	Porton Down		weekly	
UKA00173	Pumlumon	NO_2-net	4-weekly	
T06	ECN Rothamsted	ECN	weekly	Co-located with NO_2-net Rothamsted
T07	Sourhope	ECN	weekly	
UKA00162	Strathvaich	NO_2-net	4-weekly	
UKA00113	Tycanol Wood	NO_2-net	4-weekly	
UKA00550	Ulceby Cross (Driby2)	NO_2-net	4-weekly	
UKA00123	Whiteadder	NO_2-net	4-weekly	
T08	Wytham Woods	ECN	weekly	
UKA00168	Yarner Wood	NO_2-net	4-weekly	
UKA00168	Yarner Wood	AURN	Continuous, hourly average	

5.3.3 Sulphur Dioxide, SO_2

Atmospheric sulphur dioxide (SO_2) measurements made at all UKEAP AGANet and at AURN automatic network sites that are co-located with UK NECD sites are summarised in Table 40. Further details on the network sites and measurements are provided in Table 41.

Table 40: UK networks reporting atmospheric SO2 data for the NECD Article 9 data submission.

UK Network	Method	Number of sites (2017)	Data source	Most recently available data reported	Data availability
UKEAP AGANet	Active method: DELTA[44]	27	https://uk-air.defra.gov.uk/ All data are publically accessible online.	2017 aggregated annual data	Continuous monthly records since 1999.
AURN	EU reference method: BS EN14212: 2005 (SO_2) UV-Fluorescence monitors		https://uk-air.defra.gov.uk/ All data are publically accessible online.	2017 aggregated annual data	Continuous hourly average data records were undertaken from the latter half of the 20th century, varying by site.
UKEAP EMEP Supersites	Continuous wet chemistry – MARGA	2	https://uk-air.defra.gov.uk/ All data are publically accessible online.	2017 aggregated annual data	Auchencorth: continuous hourly data since June 2006 Harwell: continuous hourly from 2009 – 2015 Chilbolton: continuous hourly data since 2016

[44] Tang, Y. S; Braban, CF.; Dragosits, U; Simmons, I; Leaver, D; van Dijk, N; Poskitt, J; Thacker, S; Patel, M; Carter, H; Pereira, M. G; Keenan, PO.; Lawlor, A; Connolly, C; Vincent, K; Heal, MR.; Sutton, Mark A.. 2018 Acid gases and aerosol measurements in the UK (1999–2015): regional distributions and trends. Atmospheric Chemistry and Physics, 18 (22). 16293-16324. https://doi.org/10.5194/acp-18-16293-2018

Table 41: List of UK network sites measuring atmospheric SO2 and details (sites active in 2017).

Site Code	Site name	Network, method	Measurement frequency	Comments
UKA00451	Auchencorth Moss	AGANet, DELTA	Monthly	co-located measurement
		EMEP, MARGA	Continuous, hourly	
		EMEP, UV-Fluorescence	Continuous, hourly	
UKA00128	Bush OTC	AGANet, DELTA	Monthly	
UKA00492	Caenby	AGANet, DELTA	Monthly	
UKA00389	Carradale	AGANet, DELTA	Monthly	
UKA00614	Chilbolton	AGANet, DELTA	Monthly	Co-located measurement
		EMEP, MARGA	Continuous, hourly	
		AURN, UV-Fluorescence	Continuous, hourly	
UKA00325	Cwmystwyth	AGANet, DELTA	Monthly	
UKA00481	Detling	AGANet, DELTA	Monthly	
UKA00130	Eskdalemuir	AGANet, DELTA	Monthly	
UKA00607	Forsinard RSPB	AGANet, DELTA	Monthly	
UKA00348	Glensaugh	AGANet, DELTA	Monthly	
UKA00056	Goonhilly	AGANet, DELTA	Monthly	
UKA00169	High Muffles	AGANet, DELTA	Monthly	
UKA00293	Hillsborough	AGANet, DELTA	Monthly	
UKA00171	Ladybower	AGANet, DELTA	Monthly	Co-located measurement
		AURN, UV-Fluorescence	Continuous, hourly	
UKA00290	Lagganlia	AGANet, DELTA	Monthly	
UKA00166	Lough Navar	AGANet, DELTA	Monthly	
UKA00152	Lullington Heath	AGANet, DELTA	Monthly	Co-located measurement
		AURN, UV-Fluorescence	Continuous, hourly	
UKA00357	Moorhouse	AGANet, DELTA	Monthly	
UKA00323	Narberth	AGANet, DELTA	Monthly	Co-located measurement
		AURN, UV-Fluorescence	Continuous, hourly	
UKA00493	Plas Y Brenin	AGANet, DELTA	Monthly	
UKA00180	Polloch	AGANet, DELTA	Monthly	
UKA00491	Rosemaund	AGANet, DELTA	Monthly	
UKA00275	Rothamsted	AGANet, DELTA	Monthly	
UKA00317	Stoke Ferry	AGANet, DELTA	Monthly	
UKA00162	Strathvaich Dam	AGANet, DELTA	Monthly	
UKA00312	Sutton Bonington	AGANet, DELTA	Monthly	
UKA00168	Yarner Wood	AGANet, DELTA	Monthly	

Data availability AGANet, AURN and EMEP: Data from the UKEAP NAMN and EMEP sites are submitted annually to the Department for Environment, Food & Rural Affairs (Defra) UK-AIR database (https://uk-air.defra.gov.uk/), in a format consistent with other UK Authority air quality networks and relevant reporting requirements. Ratified calendar year data are published in June the year following collection.

5.4 Carbon Flux

The carbon flux network records carbon balance for nine sites across the UK, with just four of these sites co-located with the UK NECD network. Since the recording frequency of 20Hz provides too much data for the template, yearly values, based on means across multiple years are submitted for the four co-located sites. Although the units were the same as stipulated in the template, the values were inversed for reporting, since the GHG Flux data reported Carbon uptake rather than balance.

Table 42: UK networks reporting atmospheric O3 data for the NECD Article 9 data submission.

UK Network	Method / Number of sites (active in 2017)	Data source / comments	Most recently available data reported	Data availability
GHG Flux	Carbon flux measurements = 4		Annual values based on means across multiple years	Continuous 20Hz data records since 2007
ICP Forest Level 2	Continuous CO_2 eddy flux monitoring = 1	Carbon fluxes (in t CO_2 ha^{-1} y^{-1}) and stocks (in t CO_2 ha^{-1}) associated with the main components of a 75-80 year-old deciduous oak plantation (yield class 6 m_3 $ha^{-1}y^{-1}$) on a surface water gley in Alice Holt Research Forest		Wilkinson *et al*. (2012) *Biogeosciences*, 9, 5373-5389

Table 43:.List of UK network sites measuring Carbon Flux and details (sites active in 2017).

Site Code	Site name	Network, method	Measurement frequency	Comments
UKGHGFN2	Auchencorth	GHG Flux	20 Hz	Co-located with other air quality measurements
UKGHGFN5	Easter Bush	GHG Flux	20 Hz	Located within 0.5 km of air quality measurements
UKGHGFN6	Forsinard	GHG Flux	20 Hz	Located within 0.5 km of air quality measurements
UKGHGFN8	Moorhouse	GHG Flux	20 Hz	Co-located with other air quality measurements
ICP512	Alice Holt	GHG Flux		See Forest Research for more details
ICP919	Coalburn	GHG Flux		See Forest Research for more details

Note: an arbitrary ID was assigned for each of these sites, in the absence of a network site code

6. Freshwater ecosystems

UK NECD sites reporting freshwater ecosystem data include all sites from the Uplands Waters Monitoring Network (UWMN, http://uwmn.defra.gov.uk/) and some sites from the Environmental Change Network (ECN) (Table 44, Table 45). The UK welcomes the NECD guidance that a combination of intensive site and broad-scale monitoring is beneficial. Data from intensive sites (UWMN and ECN) are provided in the current submission. In terms of broad-scale monitoring, the submission of broad-scale data to the site identification and data reporting template poses a challenge. Reporting on the freshwater environment adjacent to a few atmospheric monitoring sites is also not going to be nationally representative.

The possibility to include data already reported to the European Commission from Water Framework Directive (WFD) sites across the UK was investigated. The framework for delivering the WFD in the UK is through River Basin Management Planning. The UK is split into several River Basin Districts (RBDs), sub-divided into smaller management units (Water Bodies). The surface Water Bodies, in turn, may be rivers, lakes, estuary or coastal. Inputting WFD into the NECD template could be possible for future submissions but was not within the timeframe of the 2019 submission.

The two UK networks reporting freshwater ecosystem data are the UWMN and the ECN. UWMN follows ICP chemistry protocols but not biological protocols.

Table 44: UK networks reporting freshwater ecosystem data for the NECD Article 9 data submission.

UK Network	Number of sites reporting data (active in 2017)	Data source / comments	Most recently available data reported
UWMN	23	Biological data is currently stored on MS Access Database held at University College London(UCL), to be transferred to CEH database. Data currently available on request	2013- 2017
ECN	6	https://catalogue.ceh.ac.uk/ All data available under the terms of the Open Government Licence	2013- 2017

Table 45: List of UK network sites monitoring freshwater (sites active in 2017).

Site Code	NECD ID	Site name	Network
UWMN24	NECD56	Afon Gwy (Wye)	UWMN
UWMN17	NECD57	Afon Hafren (Severn)	UWMN
UWMN2	NECD7	Allt a' Mharcaidh/Cairngorms	UWMN
T12			ECN
UWMN19	NECD54	Beaghs Burn	UWMN
UWMN20	NECD59	Bencrom River	UWMN
UWMN21	NECD60	Blue Lough	UWMN
UWMN11	NECD61	Burnmoor Tarn	UWMN
UWMN22	NECD62	Coney Glen	UWMN
UWMN27	NECD63	Danby Beck	UWMN
UWMN9	NECD64	Dargall Lane	UWMN
UWMN8	NECD55	Dumfries/Loch Grannoch	UWMN
T02	NECD8	Glensaugh	ECN
UWMN16	NECD65	Llyn Cwm Mynach	UWMN
UWMN15	NECD66	Llyn Llagi	UWMN
UWMN5	NECD67	Loch Chon	UWMN
UWMN26	NECD68	Loch Coire Fionnaraich	UWMN
UWMN6	NECD69	Loch Tinker	UWMN
UWMN4	NECD70	Lochnagar	UWMN
T04	NECD6	Moorhouse / ECN Troutbeck	ECN
UWMN23	NECD71	Narrator Brook	UWMN
UWMN13	NECD72	Old Lodge	UWMN
UWMN3	NECD53	Polloch / Allt na Coire nan Con	UWMN
UWMN12	NECD16	River Etherow / Dark Peak	UWMN
T06	NECD10	Rothamsted	ECN
UWMN7	NECD73	Round Loch of Glenhead	UWMN
UWMN10	NECD74	Scoat Tarn	UWMN
T07	NECD14	Sourhope	ECN
T08	NECD15	Wytham Woods	ECN

6.1 Upland Waters Monitoring Network (UWMN)

The UWMN (formerly Acid Waters Monitoring Network, AWMN), was established in 1988 to provide long-term integrated (physical, chemical and biological) monitoring to assess the health, and physical, ecological and biogeochemical functioning of upland waters. The network is designed to track changes in surface water quality and freshwater biodiversity across all upland regions of the UK, not only those sensitive to acid deposition. Brief details of the methodologies for chemistry and biology are given below:

6.1.1 Chemistry:

- Most standard chemical determinands are measured, except labile aluminium concentration
- Chemistry data are annual means.
- Rainfall estimates are based on 1km resolution data.
- Chemistry data are uploaded annually to the UWMN Oracle database at CEH which is being prepared for publication after a change in management in April 2018.

6.1.2 Biology:

- Biological sampling and archiving with the most recent biological analysis in 2015
- Monitoring/sampling frequency: Streams = monthly; lakes = 3 monthly
- Annual Epilithic diatoms: 3 samples from fixed locations. 300 diatoms per sample counted to species level.
- Macroinvertebrates: 5 x1 minute kick-samples. All individuals collected and counted in laboratory.
- Aquatic macrophytes: Annual to 3-yearly: Shoreline survey and fixed transects
- Salmonids: Electrofishing of streams and lake outflows (3 x 50 survey stretches) – (Discontinued)
- Biological data is stored on a database held by University College London.

6.1.3 Meteorology

- Gridded estimates of daily and monthly areal rainfall for the United Kingdom (1890-2017) [CEH-GEAR] https://catalogue.ceh.ac.uk/documents/ee9ab43d-a4fe-4e73-afd5-cd4fc4c82556

6.2 ECN

Water chemistry data is recorded for ECN terrestrial sites where they are drained by streams. Water temperature data are collected at ECN's freshwater sites in accordance with the ECN Surface Water Chemistry & Quality protocol[45]: Surface water temperatures are recorded by hand-held thermometers at the freshwater chemistry sampling point when water samples are collected. The temporal range varies from site-to-site (earliest record from 1975, latest from 2012).

[45] http://www.ecn.ac.uk/measurements/freshwater/fwc-fwa.

6.3 Acidification and eutrophication species and indicators

Diatom inferred pH is determined using the C2 programme (Juggins et al., 2007[46]). It is based on the Weighted Averaging Partial Least Squares method, and uses the diatom-pH training set from the SWAP project (Stevenson et al., 1991[47]). This method was developed for reconstructing lake pH using diatoms in lake sediments, but directional trends in inferred pH based on diatom epilithon should provide an indication of any directional response to change in lake acidity. Macroinvertebrate metrics include the total number of taxa (mixed taxonomic levels) occurring in 5 one-minute kick samples, and Hills's N1 – the exponent of Shannon's Index and a measure of the number of abundant species in a sample (Hill, 1973[48]).

[46] Hill, M.O. 1973. Diversity and evenness: a unifying notation and its consequences. Ecology, 54, 427-431

[47] Stevenson, A.C., et al. 1991. The Surface Waters Acidification Project palaeolimnology programme: Modern diatom/lake-water chemistry data-set. ENSIS Ltd. London.

[48] Juggins, S. 2007. C2 Veriosn 1.5 User Guide. Software for ecological and palaeoecological data analysis and visualisation. Newcastle University, Newcastle upon Tyne, UK. 73pp.