National Ecosystems Monitoring Network
Standard Operating Procedure 02
For
Botanical Survey

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NEMN Standard Operating Procedure 02 – Vegetation Survey

Prepared by

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1 Scope

1.1 National Emission reduction Commitments Directive, Article 9

EU Member States have committed to reducing emissions of air pollutants to meet targets set in Annex II to the National Emission reduction Commitments Directive (NEC Directive (EU) 2016/2284). Article 9 of the NEC Directive requires each country to develop a network of sites to monitor negative impacts on ecosystems of a group of five air pollutants (SO_2, NO_X, NMVOC, NH_3 and $PM_{2,5}$) that contributes to acidification, eutrophication, ozone damage and biodiversity loss. The network should be representative of habitat types in the country, with coverage across pollution gradients and co-ordinate with other monitoring schemes for efficiency. Member states report monitoring data to the EU every four years, as required under Article 10 of the Directive in a standard template. Annex V of the NECD also sets out a list of optional parameters the Member States may use in implementing the monitoring and reporting obligation.

1.2 National Ecosystems Monitoring Network (NEMN)

A National Ecosystems Monitoring Network (NEMN) is being developed in Ireland to monitor and report negative impacts of air pollution on ecosystems (acidification, eutrophication, ozone damage and biodiversity loss) under Articles 9 and 10 of the Directive (Kelleghan et al., 2021). Reporting is on four-yearly cycles, with the next reporting of monitoring sites and indicators in 2022 and data in 2023.

NEMN monitoring consists of a set of periodic and continuous surveys, listed in Table 1.

In the first reporting round (2018/2019), NEMN included forests (37) and lakes (4), but Annex I open terrestrial habitats were under-represented, with only two sites. In this next phase of the NEMN, sites from five open habitats of critical importance for nature conservation in Ireland have been selected for inclusion. Annex I habitats included are: 6210 calcareous grassland, 6410 *Molinia* meadow, 7110 raised bog, 7130 blanket bog and 4010 wet heath. Sites are located across a gradient of air pollution pressure. Ammonia concentration was chosen as the indicator of air pollution pressure, since ammonia is a direct stressor and contributes to nitrogen deposition.

- All sites will be monitored for air pollution impacts.
- At a subset of these sites (Level 2 sites), equipment will also be installed to monitor air pollution inputs.

Table 1: NEMN surveys, frequencies at Level I and Level II sites, and next report dates.

Survey	Level I sites	Level II sites	Report due
Plot placement	At plot placement		1-July 2022
Vegetation	4 years	4 years	1-July 2023
Soil sampling and analysis	4 years	4 years	1-July 2023
Moss sampling and analysis	4 years	4 years	1-July 2023
Other surveys to follow		Continuous	4-year cycle

In 2021, initial plot placements and surveys are only being conducted in Level I sites of selected open terrestrial habitats. Reporting of site locations and indicators is due 1-July 2022 and 4-yearly, while reporting of monitoring data follows one year later.

1.3 Standard Operating Procedure for Botanical Survey

Botanical survey is part of the National Ecosystems Monitoring Network. This document sets out a standard operating procedure (SOP02) for botanical survey which operates alongside the SOPs for establishing and maintaining the permanent plots (SOP01), soil sampling and analysis (SOP03), and moss survey (SOP04). A further SOP on data management may be added later as this is not fully covered in the current documents. Feedback is invited to improve the SOP, at https://nemn.ucd.ie/contact/

This draft SOP02 is for immediate use in 2021 summer surveys. The SOP is subject to review. The methods are applicable for open terrestrial habitats, not currently for forests.

1.4 Compatibility with other surveys

NPWS already conducts habitat monitoring surveys at many of the NEMN sites. The Grassland Monitoring Survey (O'Neill et al, 2013; Martin et al, 2018), Raised Bog Monitoring and Assessment Survey (Fernandez et al, 2014) and the Survey of Upland Habitats (Perrin et al, 2014) all include some NEMN sites. These surveys contribute to the EU Habitats Directive Article 17 reporting. Some sites also have monitoring related to local projects, with their own objectives.

The NEMN survey method is intended to match other survey methods where possible so that recording for one may be used for both, avoiding duplication of effort. Botanical surveyors will not need to make many changes to methods already used for NPWS surveys. Although details of NPWS methods may change in future surveys, it is unlikely they will change drastically.

Plot size

The 2 x 2m quadrat size used here is the same as used in NPWS monitoring of grasslands through the Grasslands Monitoring Survey and in the Survey of Uplands Habitats for wet heath and blanket bog. While the raised bog surveys use larger quadrats, the 2 x 2m NEMN quadrat could be recorded at the same time and place as larger quadrats on raised bogs, as long as trampling is minimised. Some permanent quadrats have already been established on raised bogs, and grassland surveys have returned to the same grid references, without permanent markers. Where these are on NEMN sites and match the criteria for plot placement in SOP1, it is recommended these locations are adopted for NEMN permanent plots, because the historical data is useful and continuity is maintained for the habitat monitoring surveys. NEMN monitoring generally requires more quadrats per site than existing surveys.

Recording vegetation data

An exhaustive search of a quadrat for all species, followed by a visual cover estimate for each one, is a common method across existing NPWS surveys. The NEMN requires cover estimates on a percentage scale, as is used for the Survey of Upland Habitats (see Section 4.4). Domin data can be transformed into percentages, but it is preferable to record percentage cover directly, even though the accuracy of estimates is inevitably limited.

Recording plot characteristics

Data fields needed by the NEMN for characterising a plot largely overlap with existing surveys. Data fields such as slope, aspect and soil type are common but need minor adjustment, so the format is consistent among habitats. Therefore, these are also specified in this SOP and SOP01.

2 Objectives

- Floristic data provide an excellent basis for assessing habitat condition. Plant and lichen species indicate environmental conditions, and the current biodiversity value of the habitat.
- Presence / absence records for all species (*via* exhaustive search of a quadrat) are a robust indicator of conditions over the preceding period.
- Cover values are also very valuable, providing indicators of habitat type and current conditions (e.g. forb/total cover ratio).
- Bryophyte and lichen species vary considerably in their sensitivity to acidity and/or N pollution, so it is important to identify these groups to species level.
- All habitats will be surveyed using five 2 x 2m quadrats per site, to enable integrated analysis. For bogs, a 4 x 4 quadrat will also be recorded (see Section 3.2.1).

3 Positioning

3.1 Sampling design at site level

SOP01 details sampling design at survey and site level for open terrestrial habitats. A total of 375 permanent plots in open terrestrial habitats are specified for the survey. It is proposed to survey only seven of the 60 sites in the first year so that the protocol can be refined if necessary.

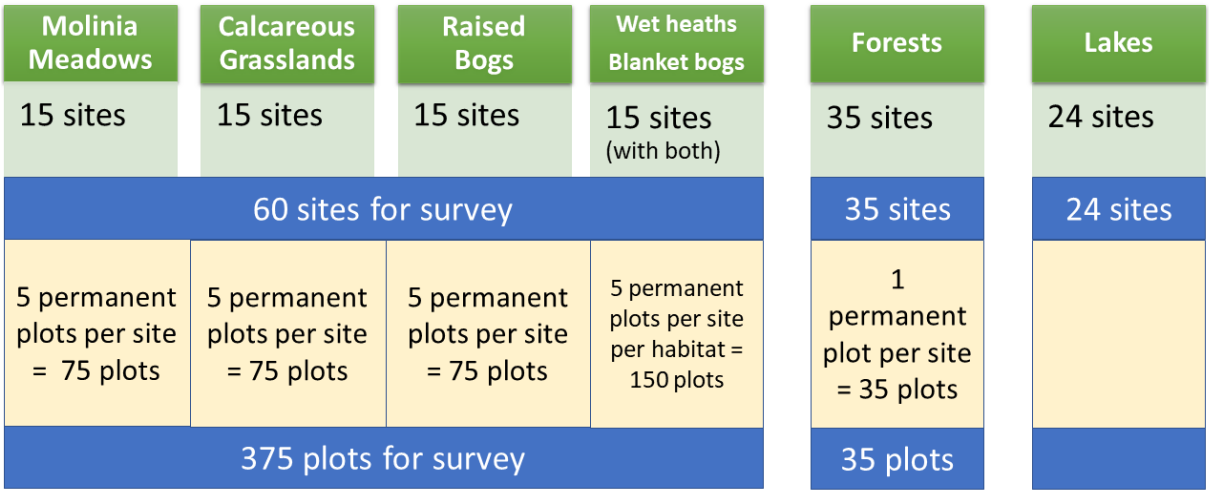

Figure 1: Range of habitats represented in the National Ecosystems Monitoring Network (NEMN), showing numbers of sites and plots. This SOP for botanical survey does not cover Forests or Lakes.

3.2 Sampling layout at plot level

The plot layout described is for open (non-forested) terrestrial habitats. Forest sites in the NEMN have a different layout and do not currently include a botanical survey.

3.2.1 Open terrestrial habitats

See the Plot Placement SOP (SOP01) for details of plot layouts. For grassland and heathland habitats, the botanical survey is based on a 2m x 2m permanent quadrat. The plot also includes concentric rings for soil and moss sampling (Figure 2). A 1m zone around the quadrat is not sampled for anything as it may be trampled by botanical surveyors.

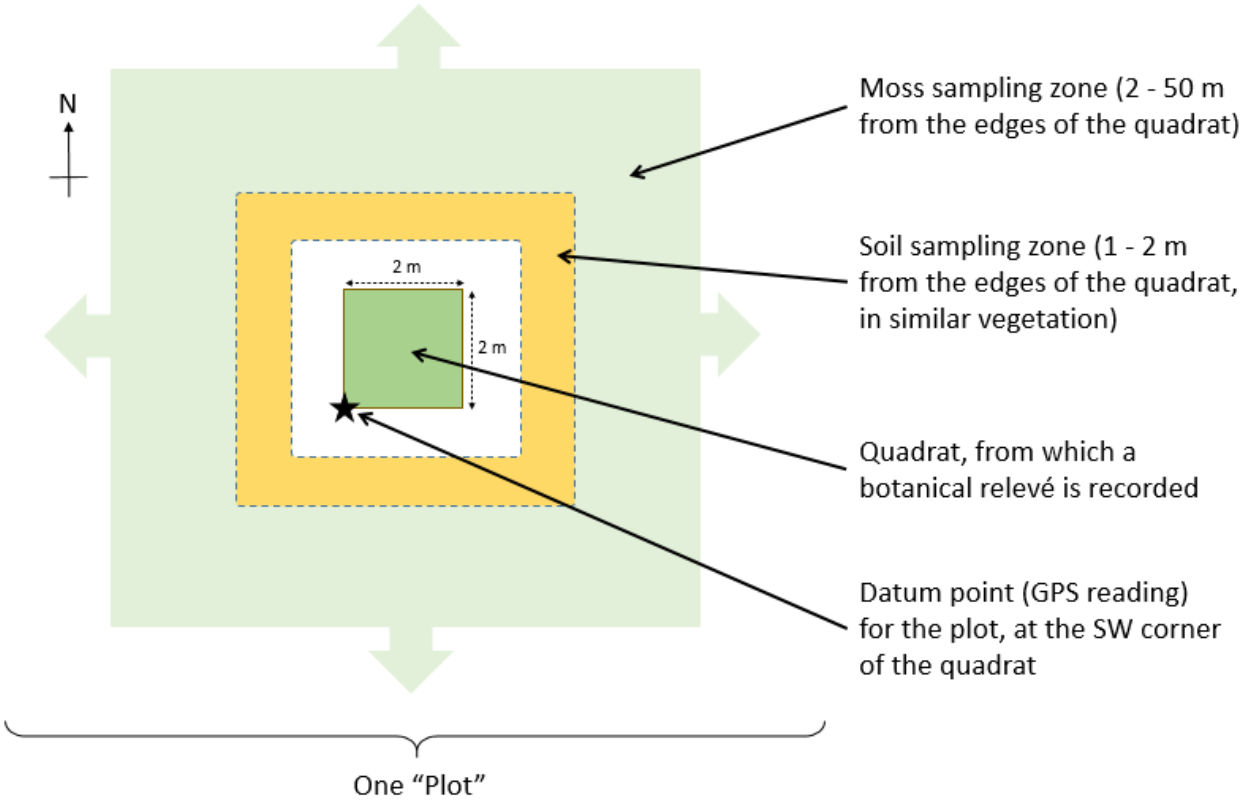

Figure 2. Plot layout (grasslands and heaths). Soil sampling occurs in a zone concentric with the quadrat, between approximately 1 m and 2 m away, in comparable vegetation areas.

For bog plots, both a 2 x 2 m quadrat and a 4 x 4 m quadrat must be recorded (Figure 3). The 2 x 2 m quadrat is searched first, and cover values estimated. Then the remainder of the 4 x 4 m quadrat is searched for additional species, and cover values re-estimated for the 4 x 4 m area. The zones for soil and moss sampling are centred on the 4 x 4 m quadrat.

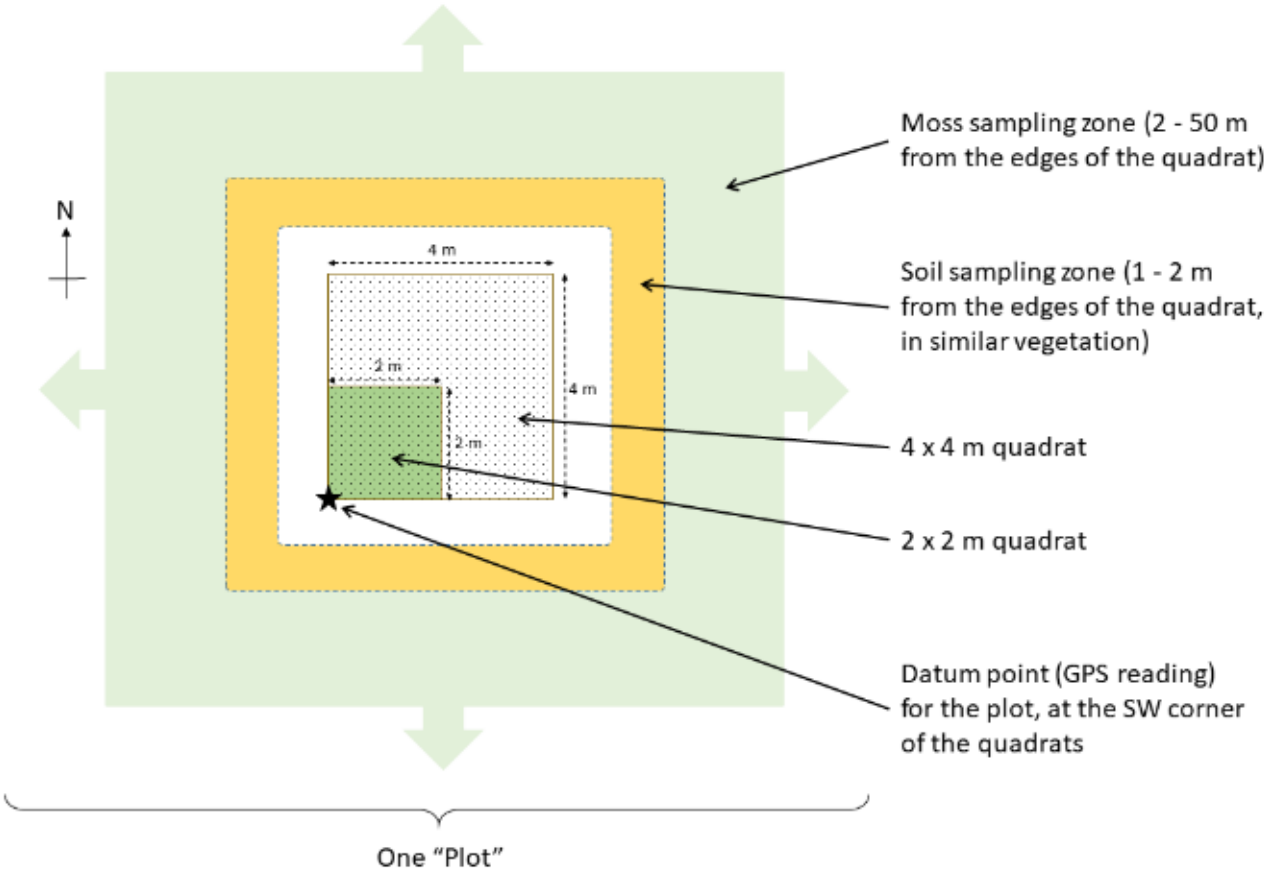

Figure 3. Plot layout (bogs), showing nested 2 x 2 and 4 x 4 m quadrats.

3.3 Observation frequency

NECD Article 9 reporting, for which the NEMN provides data, is on a 4-year cycle, so botanical surveys on the same frequency would be ideal. Four-yearly monitoring is appropriate for detecting effects of air pollution, since these are often gradual. Habitats Directive Article 17 reporting is on a 6-year cycle and botanical surveys on this frequency can still usefully contribute to the NEMN.

Botanical surveys of one habitat should preferably occur in the same year to avoid inter-annual variation from weather. All sites of a habitat should be surveyed between 1st June and 31st August, and if possible each site should be visited at the approximately the same time of year in every survey.

4 Field Sampling

4.1 Workflow

The plot placement tasks (SOP01) must be completed first, then the botanical survey, and then the soil and moss sampling, preferably on the same day.

4.2 Field data entry

Data entry in the field will be, where possible, straight into Turboveg (Hennekens, 2001) software on a portable computer device, using the current species list from the National Biodiversity Data Centre. Turboveg is already standard in many NPWS botanical surveys. It incorporates standardised plot data headings, such as vegetation height in a 'Header' table and the species list in a second table, 'Species'. Data fields can be limited to the correct format, including drop-down menus, when required. Notes can be added, for example to record details of samples taken for identification. Paper records may be used in the field but must be digitised before submission. Photographs should be submitted with the file name identifying the plot number and date.

In bogs, where the habitat surveys require 4 x 4 m quadrats, surveyors should record the NEMN 2 x 2m quadrat separately. In grasslands and heaths, where the quadrats are all 2 x 2m the same form may be used in the field to simultaneously record for NEMN and habitat surveys.

If it was not possible to complete the survey for any reason, a record should still be created. There is a data field to record that the survey was not completed, and reasons should be given in the 'Remarks' field. SOP01 gives more detail on actions to be taken in different situations.

4.3 Plot Header Data

The plot header data characterises the plot, and includes all data relevant to the botanical survey except the species list. Information about the plot which normally stays the same, such as slope and aspect, are recorded in the plot record (see SOP01). Dynamic plot information, which may change between surveys, is recorded in the plot header data (Table 2). Some fields are new but many exactly match GMS fields. Please feed back any conflicts in data fields to https://nemn.ucd.ie/home/contact/.

- For grassland habitats, recording methods should be based on ISGS and GMS (O'Neill et al, 2013; Martin et al, 2018).
- Take an overhead **photo** of the vegetation within the quadrat, at high resolution if possible. It is useful if the photo includes corner markers and/or string delineating the plot.
- Nitrogen pollution particularly affects small-growing species, so vegetation height is a key measurement. Following the ISGS (O'Neill et al., 2013), we suggest vegetation height is estimated on the basis of the **median height of vegetation**, omitting flower heads and small clumps of taller species. Measuring tapes/sticks should be used to aid in the estimation. Estimation should be standardised among surveyors at the beginning of the survey.
- Total cover of **species groups** (e.g. shrubs), and **non-vegetation cover**, should be estimated for the classes specified in Table 2. It is particularly important to record cover values for **total bryophytes** and **total lichens** since many (but not all) species in these groups are sensitive to air pollution. See Section 4.4 for more on cover estimation.
- Biomass measurements may be requested in later surveys, but are not included at this stage.
- Header and Species data entered through Turboveg should be collated using the Google form *plot_veg*, available from nemn.ucd.ie/documentation, and submitted as a .csv file.

Table 2: Plot header data fields for NEMN botanical surveying.

Field	Example	Comments
NEMN_SITE_CODE	N001	Comes with site list
NEMN_PLOT_NR	001	Submit *NEMN_plot* from nemn.ucd.ie/documentation
DATE	yyyymmdd	
COVERSCALE	% cover	Shouldn't change but needs to be included.

QUAD_DIMS	2 x 2	Length of quadrat side, m
AUT_NAME	A.N. Other	Name of surveyor
QUAD_PHOTO	Y/N	Reminder to take a photo of the vegetation in the quadrat
X_COORD	587654	ITM grid reference (metres)
Y_COORD	492145	ITM grid reference (metres)
COV_TOTAL	150.50	Percentage cover in layers, matching the layers used in species recording. COV_TOTAL is the sum of cover values for all the plant and lichen layers.
COV_TREES	000.00	
COV_SHRUBS	005.00	
COV_FORBS	060.00	
COV_GRAMINOIDS	065.00	
COV_MOSSES	015.00	
COV_LICHEN	000.50	
COV_ALGAE	000.00	
COV_LITTER	005.00	
COV_WATER	000.00	
COV_ROCK	000.00	
COV_DUNG	000.00	
BARE_SOIL	000.00	
HEIGHT_MEDIAN	020	Median vegetation, cm
HAB_CHANGE	0	Has the habitat in the plot changed significantly from the original habitat it was chosen for? 1: yes, 0: no (See SOP01 for more details)
HAB_NOW	PB3	Fossitt code (see https://bit.ly/3h6GBfK) for current habitat type. Complete this whether or not the habitat has changed.
COMPLETED	1	Was the survey successfully completed today? If not, explain in 'Remarks'. 1: yes, 0: no (See SOP01 for more details)
FLAG	0	Is action required from anything added in Remarks? 1: yes, 0: no
REMARKS	text	Brief explanations from other fields where needed. Details of samples taken for identification.

4.3.1 Equipment

The equipment needed to locate and mark plots is covered in SOP01. No extra equipment is needed for the botanical survey beyond that normally used for NPWS habitat surveys: maps, hand lens, camera, handheld

computer and/or pre-printed forms for data entry, identification guides, and paper envelopes for unidentified samples.

4.4 Species recording

- All vascular plant, bryophyte and lichen species found in a thorough search of the quadrat should be recorded to species level, unless commonly recorded as an aggregate e.g. *Euphrasia* sp., *Rubus fruticosus* agg..
- The aim is to identify most bryophytes in the field, but specimens may be taken for later identification when needed. Lichen identification may need to be from collated specimens at the end of the season. Specimens should be collected in labelled paper envelopes, air dried on return to base each evening, and stored carefully to avoid crushing or mould, e.g. in a plastic food storage container containing silica gel.
- Visual cover estimates are sufficient, using a **percentage scale**, e.g. [0.1, 0.3, 0.5, 0.7, 1, 3, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100%]. Total cover for all species will usually exceed 100%, because of overlapping layers. Non-vegetation cover (litter, water, rock, dung, bare soil) should not be recorded if it is beneath vegetation.
- Where **specimens and/or photographs** are needed for later identification, they need to be labelled uniquely and the details recorded with the quadrat data in the 'Remarks' field.

TurboVeg species data may be **submitted as a .csv file** using the form plot_veg at https://nemn.ucd.ie/documentation

4.5 Quality assurance and quality control in the field

Quality assurance in the field includes:

- Use of a standard operating procedure
- Capture of field data in a suitable medium
- Consistent completion of the metadata record (date, disturbance, access, conditions) - see SOP01
- Clear and consistent labelling of individual sample containers
- Submission of the dataset in an approved form (.csv file)

5 Data management

5.1 Immediate processing

Data processing after field data collection should be the same as for existing NPWS botanical surveys.

- Data from the handheld computer should be transferred each day to more permanent storage.
- The data should be backed up regularly as part of standard good practice.
- Where samples were taken of species not identified at the time, the species name should be added once identified and the name of referee recorded in the notes.
- NEMN does not require these samples to be retained or sent in.

5.2 Further data processing

A separate SOP on data management will be developed.

5.3 Quality control

- A basic data check should be run within a few weeks of data collection, so that surveyors may remember if there are questions. Checking may be performed by the same surveyors or other staff. The data checker should look for missing data, unrealistic grid references, unrealistic dates, inconsistent site or plot identification, and unlikely species. Experience with data checking should inform development of formal plausibility checks.
- If data are altered (for example, a date was muddled and corrected) the change should be recorded. Frequent mistakes should be reported back so solutions can be agreed, for example altering the SOP or running staff training.
- Surveys should incorporate active measures to promote consistency, especially when estimating cover percentages, and vegetation height, which are inevitably subjective. In training, and at times throughout the season, staff should independently make estimates for the same plot, and then compare and discuss these estimates.

6 References

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