NATURAL CAPITAL AND ECOSYSTEM ASSESSMENT

ENGLAND ECOSYSTEM SURVEY
SOIL SURVEY FIELD MANUAL

Version 2.0 Draft for comment

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1 Introduction

1.1 About this manual

This manual comprises of four sections:

- Introduction
- Preparation for the survey
- Fieldwork
- Management of soil samples after collection

The introduction gives an overview of the purpose of the soil monitoring, survey design at the plot level, and health and safety. Further sections are instructions to follow during the surveys. Please read them in full when reading for the first time. Ask questions through your survey coordinator if anything is not clear or you have any comments. Additional information is provided in appendices.

1.2 The soil monitoring part of the England Ecosystem Survey

The soil monitoring programme is part of the England Ecosystem Survey (EES) developed by Natural England. The aim is to gather nationally representative data about soils in England. The survey will support the reporting on the state of England's soils and allows for monitoring changes over time. This data will be co-located with field observations for vegetation, habitats, and landscapes which also will be collected as a part of EES. Data will be gathered within main units called 'monads' (1km^2 squares).

The soil survey includes taking soil samples for laboratory analysis of physical, chemical, and biological soil properties, among others:

- bulk density, texture, and moisture
- organic matter and carbon content
- nitrogen and phosphorus content
- microbial, nematode, mesofauna, and earthworm diversity.

Soil structure is visually assessed, and earthworms are counted and collected for species identification.

One survey cycle will take 5 years. Each year a representative selection of monads will be surveyed. The same monads will be revisited after 5 years.

For further information about EES refer to EES Vegetation and Landscapes Field Manual.

1.3 Types of soil survey in the England Ecosystem Survey

There will be two types of soil survey:

- soil sampling and assessment survey
- soil classification survey.

The soil sampling and assessment survey is described in this manual.

The purpose of the soil sampling and assessment survey is to collect soil samples for laboratory analysis and carry out field assessments, such as visual evaluation of soil structure (VESS), representative of each soil plot.

The soil sampling and assessment survey (further referred to as: soil survey) in the first year of the cycle will be done in spring, autumn of 2023 and winter 2023/24. The vegetation, landscapes, and other parts of environment will be surveyed separately during summer and autumn. The methodology for the vegetation and landscape surveys is described in the EES Vegetation and Landscapes Field Manual.

The purpose of the soil classification survey is to provide essential background information about the soil type present in each soil plot. Knowledge of the soil type is needed for grouping of similar soils for analysis of results and reporting. These surveys will not be repeated. The soil classification survey is **not** described in this manual.

1.4 Survey design within the monad and the soil plot

Each monad is surveyed in pre-selected locations within potentially suitable land. The sample unit for the soil survey is a soil plot. Soil plot is a square measuring 16m by 16m. There are two to six soil plots per monad.

In the centre of each soil plot there is a 2m by 2m vegetation plot. The soil sampling points are distributed around the vegetation plot. The sampling points are $1m^2$ areas of disturbance where different soil samples are taken. Sampling points are placed 2m apart. Four sampling points are sampled every five years (Figure 1).

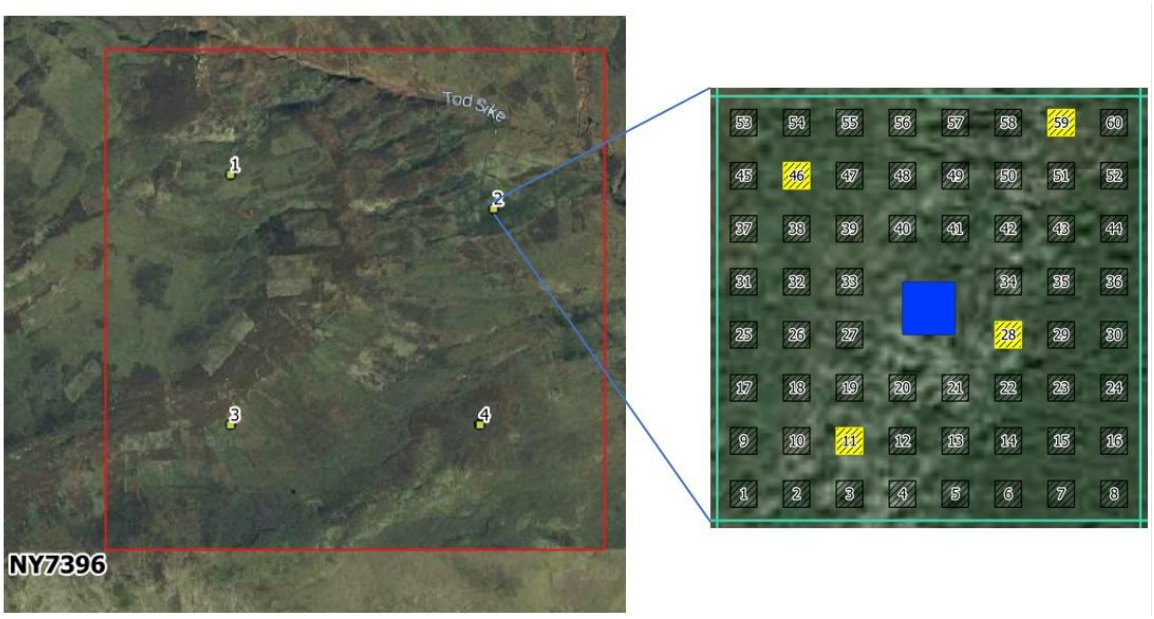


Figure 1: Example of a monad (1km by 1km, left) and a 16m by 16m soil plot, with four soil sampling points (yellow squares) and a vegetation plot (2m by 2m, blue) in its centre.

The sampling point locations within the soil plot are the same in each plot throughout the five-year cycle. In the example shown in Figure 1 these are sampling points no. 11, 28, 46, and 59. They are used in the first year of the survey cycle. In rare situations where a sampling point is unsuitable for the survey an alternative is chosen according to a set procedure.

The co-location of soil sampling points and vegetation plot provides valuable information about the relationship between the plants and the soil. The vegetation plot and a 1.5m buffer zone around it remain undisturbed by the survey.

1.5 Health and safety

It is an employer's duty to protect the health, safety and welfare of their employees and other people who might be affected by their work activities. Employers must do whatever is reasonably practicable to achieve this[1].

It is responsibility of your employer to:

- Assess risks – review the work activities that could cause injury or illness and take action to eliminate the hazard, or if that is not possible, control the risk. There may be other risks present on site than those outlined in this manual.
- Provide information about risks – give you information about the risks and how you are protected; instruct and train you on how to deal with the risks.
- Consult you on health and safety issues.

[1] https://www.hse.gov.uk/workers/employers.htm Accessed on 03/08/2023.

- Provide health and safety information – inform you about the health and safety law.

Your organisation must have robust health and safety procedures. These include use of site-specific risk assessments and up-to-date biosecurity measures. You must also have completed mandatory training, including:

- manual handling (provided by your organisation)
- detection of underground utilities and use of radio detection equipment (provided by your organisation)
- unexploded ordnance (UXO) awareness (arranged by Fera Science)
- EES soil sampling and assessment survey training delivered by Natural England.

Surveying involves navigating over open countryside carrying heavy equipment and it can take place during periods of poor weather conditions and poor visibility. You must consider any medical or other conditions that may results in different levels of risk for you and your colleagues. These risks will not be the same on all sites – this is why site-specific risks assessments are needed.

1.6 Biosecurity procedures

The EES soil survey is considered a high-risk activity because of the many different sites visited and likelihood of spread of harmful species between them. This could happen due to transfer of soil, plant material, and other debris. Cross-contamination between the plots can also influence the results of laboratory soil analysis. DNA-based methods used to assess soil biodiversity are especially sensitive to this.

To mitigate the biosecurity and cross-contamination risks, you must consistently follow biosecurity procedures described in sections: 3.15, 3.16, and 3.17.

The biosecurity disinfectant for the tools that have contact with soil samples is Propellar (propan-2-ol). Its vapours and fumes are flammable. The Safe4 disinfectant cleaner is used at **1:10** dilution a default disinfectant for use on other equipment and clothing. The Safe4 concentrate used to make up the solution is corrosive and can damage eyes. You must ensure that you have appropriate COSHH risk assessments prepared and that you adhere to them. You must use appropriate PPE, storage and handling methods for the chemicals used.

There may be sites where disease orders require you to use a different disinfectant than Safe4. It is your responsibility to follow local APHA and landowner's requirements.

1.7 Dynamic risk assessment

If there is a hazard which was not assessed as a risk, you must do a dynamic risk assessment and decide whether and how to continue the work.

Everyone who works on this survey has both the authority and responsibility to stop any task that could expose themselves or someone else to injury or harm.

1.8 Accidents and near misses

If you experience an accident or a near miss, you must report it as required by your organisation. You must also report it to Fera, who will report to Natural England.

If you are a NE surveyor, you must complete an **'**OHS1' form (found in the 'Health and Safety' section of the intranet) and either email it to healthandsafety@naturalengland.org.uk or call 0300 060 0100.

2 Preparation for the survey

The main steps of the preparation before the survey are:

1. Review of the Surveyor Information Pack and the Surveyor's Report for the site provided on SharePoint right before you go.
    a. Check for any recent updates, particularly concerning access details or new maps provided by the landowner.
    b. Check the modification date next to each document title to identify if any changes have occurred since your last review and reassess accordingly for any new information.
2. Contact landowner to arrange access and obtain additional information about the site. Document all your communications with landowners in the Communications Form for a given monad (example: Communications Form.xlsx) on SharePoint.
3. Determine if non-standard biosecurity measures are required, e.g. use of a different disinfectant or a different concentration due to a disease outbreak.
4. Review the generic risk assessment and prepare a site-specific version addressing hazards that may be present and fitness of surveyors involved.
5. Prepare the equipment, PPE, clothing, and consumables (for list of equipment see Appendix 1).

2.1 Review of the Surveyor Information Pack and the Surveyors' Report

1. Download the information so that you can refer to it on site when offline.
2. Review information about designations (e.g. is the site a SSSI), risks to historic artefacts (archaeology) and habitat regulations assessment (HRA). Take a note of mitigation required and restrictions. Details provided in section 2.6 below.

3. Review the ‘Surveyor summary spreadsheet’ within each monad folder. Scheduled monuments, proximity to scheduled monuments, historic environment features and agri-envionment options (which protect historic environment features) will be recorded here and advice will be provided as to where soil surveying is prohibited (Note: this information is not recorded on the Survey Planning Map or in Field Maps, we are working to include it there).
4. Review information in the Surveyor’s Report for information provided by surveyors who visited the site previously.
5. Site location, potential access routes, hazards (e.g. steep slopes).
6. Review the UXO report to learn about risks on site and mitigation required.
7. Examine the utilities reports for each plot and identify plots with nearby mapped utilities and their respective types.

2.2 Arranging access and obtaining additional information

All landowners and tenants within each monad will have received a letter from Natural England requesting permission for their land to be surveyed as part of the EES. The following land information is available:

- land parcels in the monads
- owner details
- where we have permission to access.

There will often be multiple landowners across a monad. The Surveyors’ Report provides contact details for everyone associated with the monad, together with any conditions or restrictions on access. The Surveyors’ Report will contain a map of the land parcels and the owner identity. You must comply with all conditions and restrictions listed there.

You must not enter or collect data on land for which you do not have access permission.

It is the responsibility of the lead surveyor to contact the landowners and occupiers to agree a date and time for the survey.

You must arrange access at least **10 working days** before the planned survey.

There may be many different people to contact, and you may not get through to landowners and occupiers on your first attempt.

Follow-up via call or email in the week running up to your first planned day in the field to reminder the site contact(s) about your visit.

When contacting landowners, land managers or tenants, explain to them that this work is being carried out by or on behalf of Natural England, as part of the England Ecosystem Survey.

- Confirm that the landowner has already given permission for the survey to take place.
- When visiting a college or school, review the access notes in the surveyor report to determine the designated times for accessing the plot, such as outside regular school hours. Additionally, confirm whether a "letter of assurance" (also known as a "letter of introduction") is required, and ensure you possess it during your visit. If needed, you can obtain this letter from Natural England.
- Refer to the initial access letter and landowners' Frequently Asked Questions (FAQ) documents to answer any questions landowners and tenants may have. Access permissions, a letter, consent form, and FAQs are available in the Surveyor Library: Access permissions and FAQs.
- Explain you will come back to them if you cannot answer any queries immediately, follow these up with colleagues and provide an answer as soon as possible via an agreed channel, e.g. phone call or email.
- Inform the site contact that they might be contacted again for the soil classification survey and vegetation survey later in the year.
- Ensure clarity in communicating your purpose of taking soil samples using hand tools, that the access is on foot using manual trolleys. Keep in mind that farmers or landowners might not recall or fully read the initial information provided.
- Some landowners may be interested in details of the area of disturbance through walking, use of trolley and sampling; tools used for sampling, corer diameter, depth of sampling etc. Please be prepared to provide such detail if required.

Ask the essential questions listed below:

- Are any areas that should be avoided, for example because of dangerous ground or features or unpredictable livestock.
- How can you access the survey plots, and where suitable parking place is?
- If it will be necessary to access someone else's land or access any locked gates and can they open them for you.
- Have fertilisers, manures, sewage sludge, other organic wastes, other agrochemicals recently been applied? You may need to call other contacts to obtain this information, e.g. the tenant farmer.

    - If such materials have recently been applied, follow up the question asking for details: type and name of the product, date of application.
    - Follow your company's risk assessment and consult your survey manager if in doubt of what you should do.
    - Schedule the survey as far after the application as possible if this can be accommodated.
- Are there underground utilities other than those known from the utilities report present within or near the alternative plot options grid.
- If there is any other important information about their land that you need to know beforehand; any additional precautions to be followed, e.g. additional biosecurity measures.
- If you suspect the land may be flooded or covered in snow, check this too as such conditions make the site non-surveyable. You will need to postpone the survey if such conditions occur. Note that water table will be high and surface water may be present in peatlands and it may not prevent sampling.
- Whether it is acceptable to use permanent markers to mark the corners of plots to aid relocation (only if you have been asked by the survey coordinator and provided with the markers to use).

Record all interactions with landowners in the Communications Form. Include information about plot abandonment, access refusal reasons (if applicable), hazards, dangerous animals, and substances applied to land. This data aids other surveyors in future surveys.

Landowners and tenants do not need to be present for the survey but can meet you if they so wish. See current guidance on working during the Covid-19 coronavirus outbreaks.

If permission to sample is revoked on-site, promptly document essential details, including:

- The stage at which you were asked to leave.
- Any prior communication leading to the request to stop.
- The reasons provided for revoking your permission to sample.

Capture all the information in the 'Communications Form' and email the form to **englandecosystemsurvey@naturalengland.org.uk**.

2.3 Survey Coordination

The soil sampling and assessment surveys were conducted between March 2023 and July 2023. he surveys for the 2023 sample will enter its second phase in September 2023. Simultaneously, vegetation and landscape assessments are

scheduled from May to November 2023, while soil classification surveys are set for June 2023 to March 2024.

To ensure efficient coordination among surveyors, please follow these steps:

- Inform the Fera coordinator in a timely manner about which monads you are planning to survey to keep the survey tracker up to date.
- Adapt your communication and questions when arranging access to the land, ensuring you are aware of recent contacts with the landowner or manager and whether other teams have surveyed or are planning to survey the same monad soon. If needed, contact surveyors who surveyed the land before.
- Confirm whether the default plot or an alternative plot option has been surveyed before, as the survey must take place in the same plot option as previous surveys.

Additional information on your responsibilities as a surveyor and where to find relevant details will be provided below.

2.3.1 How to use the Survey Planner

- Locate the planner Excel Sheet in the Surveyor Library (Figure 2): [EES External Surveyors Site - Surveyor library - All Documents (sharepoint.com)](#).

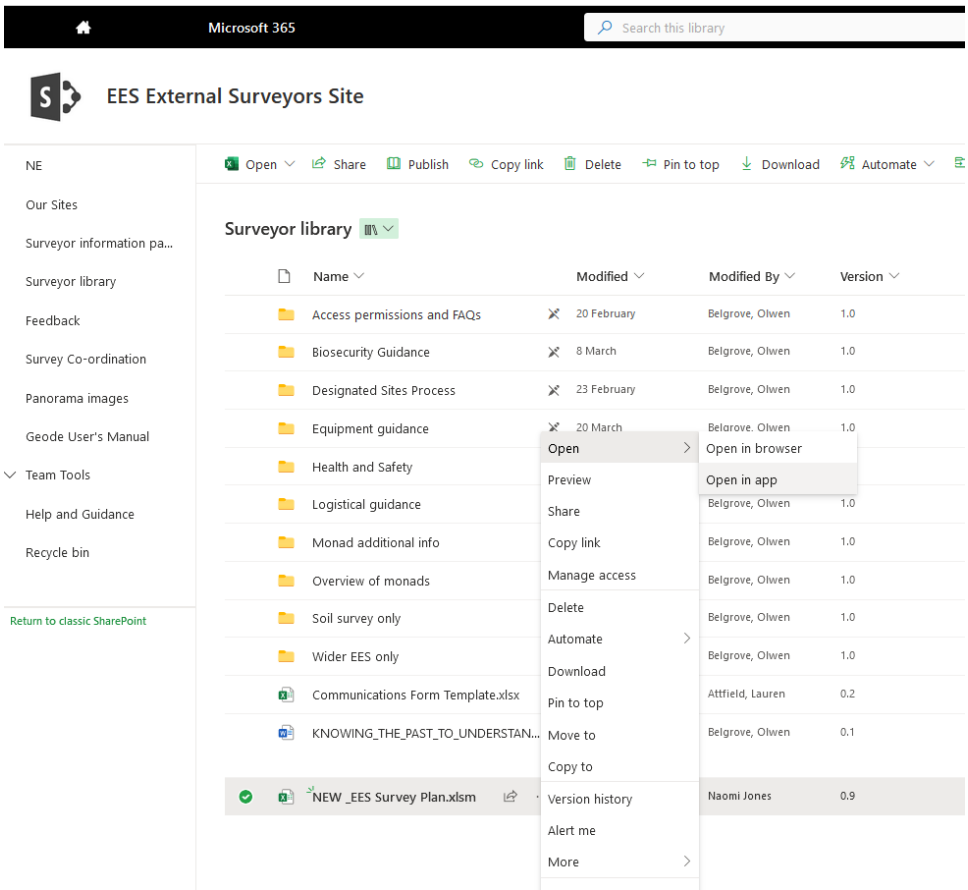


Figure 2: Overview of 'Surveyor library' with NEW_EES Survey Plan.xlsm highlighted.

- Right click on the NEW_EES Survey Plan.xlsm sheet → go to OPEN and → then OPEN IN APP (see image above). (If you just click on the survey plan without the “open in app” option, it will open in browser, which is ok, but this will take you to the last tab open, rather than the “SHEETS” tab as detailed below.
- Once open (in app), the survey planner should immediately open to the SHEETS tab(Figure 3).

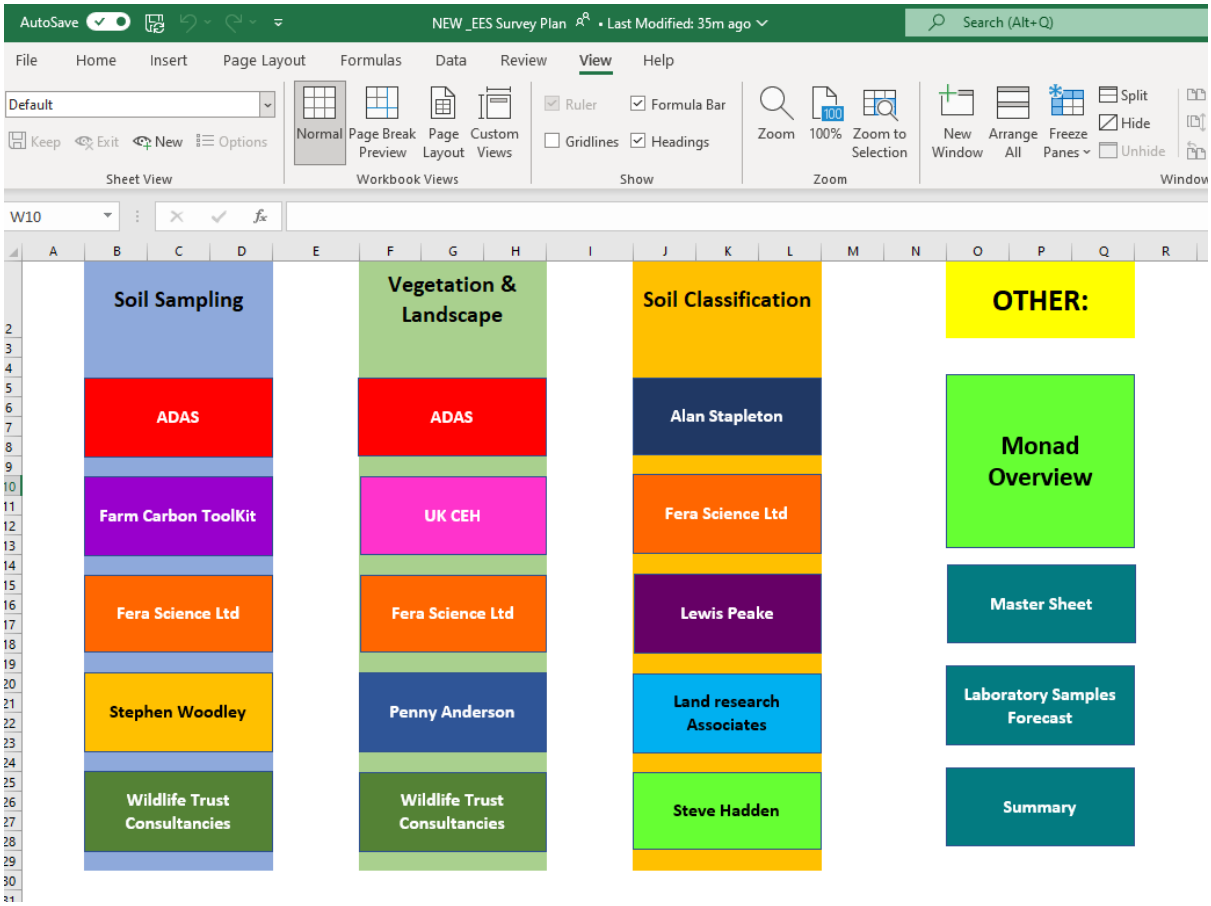
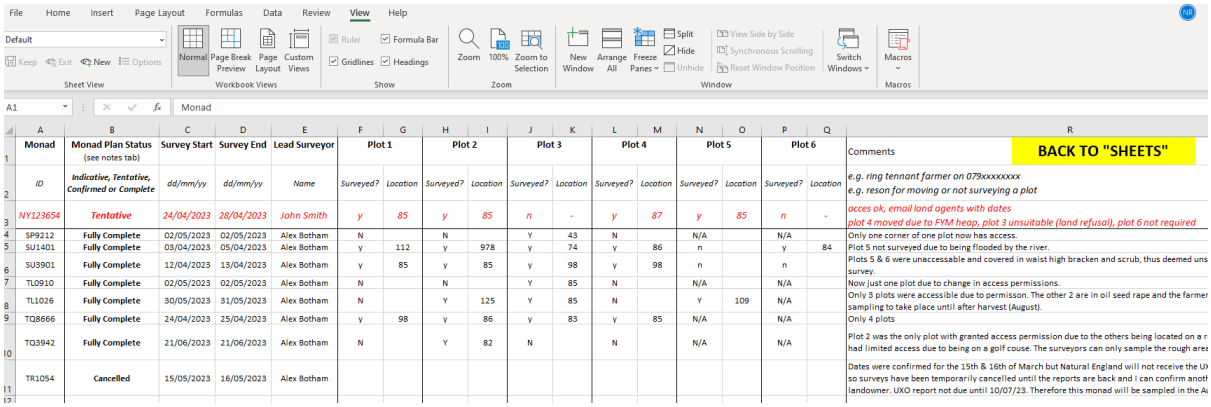


Figure 3: ‘Sheets tab’ in the survey planner.

You can then click on your Organisation, within the correct subtopics of Soils, Vegetation or Classification. This will take you to your individual survey sheet. The “Back to Sheets” in Yellow will again take you to the ‘SHEETS Tab’ (Figure 4).



Monad	Monad Plan Status (see notes tab)	Survey Start	Survey End	Lead Surveyor	Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6		Comments	BACK TO "SHEETS"
ID	*Indicative, Tentative, Confirmed or Complete*	*dd/mm/yy*	*dd/mm/yy*	*Name*	*Surveyed?*	*Location*	*Surveyed?*	*Location*	*Surveyed?*	*Location*	*Surveyed?*	*Location*	*Surveyed?*	*Location*	*Surveyed?*	*Location*	*e.g. ring tennant farmer on 079xxxxxxxx* *e.g. reson for moving or not surveying a plot*	
NY123654	***Tentative***	*24/04/2023*	*28/04/2023*	*John Smith*	*y*	*85*	*y*	*85*	*n*	*-*	*y*	*87*	*y*	*85*	*n*	*-*	*acces ok, email land agents with dates* *plot 4 moved due to FYM heap, plot 3 unsuitable (land refusal), plot 6 not required*	
SP9212	**Fully Complete**	02/05/2023	02/05/2023	Alex Botham	N		N		Y	43	N		N/A		N/A		Only one corner of one plot now has access.	
SU1401	**Fully Complete**	03/04/2023	05/04/2023	Alex Botham	y	112	y	978	y	74	y	86	n		y	84	Plot 5 not surveyed due to being flooded by the river.	
SU3901	**Fully Complete**	12/04/2023	13/04/2023	Alex Botham	y	85	y	85	y	98	y	98	n		n		Plots 5 & 6 were unaccessable and covered in waist high bracken and scrub, thus deemed uns survey.	
TL0910	**Fully Complete**	02/05/2023	02/05/2023	Alex Botham	N		N		Y	85	N		N/A		N/A		Now just one plot due to change in access permissions.	
TL1026	**Fully Complete**	30/05/2023	31/05/2023	Alex Botham	N		Y	125	Y	85	N		Y	109	N/A		Only 3 plots were accessible due to permisson. The other 2 are in oil seed rape and the farmer sampling to take place until after harvest (August).	
TQ8666	**Fully Complete**	24/04/2023	25/04/2023	Alex Botham	y	98	y	86	y	83	y	85	N/A		N/A		Only 4 plots	
TQ3942	**Fully Complete**	21/06/2023	21/06/2023	Alex Botham	N		Y	82	N		N		N/A		N/A		Plot 2 was the only plot with granted access permission due to the others being located on a r had limited access due to being on a golf couse. The surveyors can only sample the rough area	
TR1054	**Cancelled**	15/05/2023	16/05/2023	Alex Botham													Dates were confirmed for the 15th & 16th of March but Natural England will not receive the UX so surveys have been temporarily cancelled until the reports are back and I can confirm anoth landowner. UXO report not due until 10/07/23. Therefore this monad will be sampled in the A	

Figure 4: 'Sheets tab' in the survey planner.

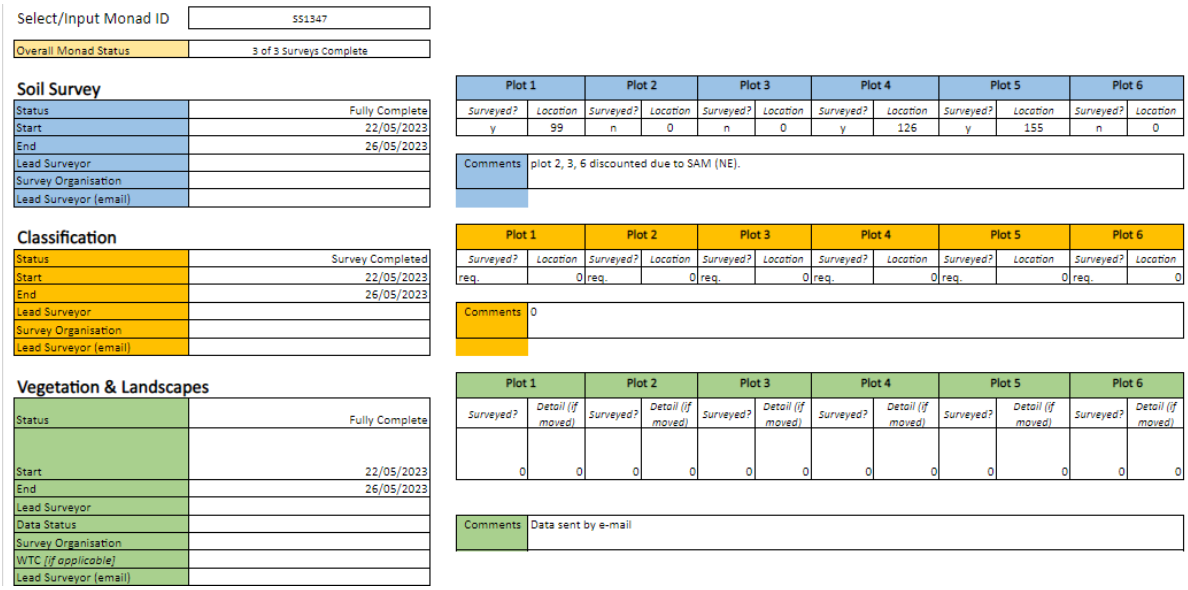
Update all the columns to the best of your ability, using drop down options where possible. Add as much information into the notes section as possible. Include detailed information in the notes section for future survey teams.

You can also navigate within the spreadsheet through the colour coded organisational tabs:

Update the sheets regularly, at least weekly, as they are crucial for planning work, quality control, and receiving lab samples.

One useful feature within this planner is the MONAD OVERVIEW TAB in the tab 'SHEETS':

If you input/select the Monad ID, the system will automatically fill in the corresponding information about the monad (. This information includes details about surveyed plots and any comments made by surveyors from other teams, along with their email addresses if you want to contact them for more information. If you need support, please email: **EES_2023@fera.co.uk**



Select/Input Monad ID	SS1347
Overall Monad Status	3 of 3 Surveys Complete

Soil Survey

Status	Fully Complete
Start	22/05/2023
End	26/05/2023
Lead Surveyor	
Survey Organisation	
Lead Surveyor (email)	

Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6	
Surveyed?	*Location*	*Surveyed?*	*Location*	*Surveyed?*	*Location*	*Surveyed?*	*Location*	*Surveyed?*	*Location*	*Surveyed?*	*Location*
y	99	n	0	n	0	y	126	y	155	n	0

Comments	plot 2, 3, 6 discounted due to SAM (NE).

Classification

Status	Survey Completed
Start	22/05/2023
End	26/05/2023
Lead Surveyor	
Survey Organisation	
Lead Surveyor (email)	

Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6	
Surveyed?	*Location*	*Surveyed?*	*Location*	*Surveyed?*	*Location*	*Surveyed?*	*Location*	*Surveyed?*	*Location*	*Surveyed?*	*Location*
req.	0	req.	0	req.	0	req.	0	req.	0	req.	0

Comments	0

Vegetation & Landscapes

Status	Fully Complete
Start	22/05/2023
End	26/05/2023
Lead Surveyor	
Data Status	
Survey Organisation	
WTC *[if applicable]*	
Lead Surveyor (email)	

Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6	
Surveyed?	*Detail (if moved)*	*Surveyed?*	*Detail (if moved)*	*Surveyed?*	*Detail (if moved)*	*Surveyed?*	*Detail (if moved)*	*Surveyed?*	*Detail (if moved)*	*Surveyed?*	*Detail (if moved)*
0	0	0	0	0	0	0	0	0	0	0	0

Comments	Data sent by e-mail

Figure 5: 'Monad summary for Soil Sampling & Assessment (blue), Soil Classification (yellow) and Landscape & Vegetation (green) survey.

2.3.2 Finding out whether default or one of alternative plot options has been surveyed

- Consult the EES Survey Plan. This will provide information on whether the site has been surveyed before or if there are any planned surveys.
    - In the tab 'Monad_Summary' an overview of all three surveys (soil sampling and assessment, soil classification and Vegetation and Landscape survey) can be found (Figure 5).
    - Soil Classification survey: Information about the soil plot where the survey was conducted can be found under the 'Location' section on each plot (Figure 5).
    - Landscape and Vegetation survey: If the soil plot was moved during the survey, you can find the information about the new location in the 'Detail (if moved)' section (Figure 5).
- Review the Surveyor Planning Map on arcgis.com and Field Maps which displays the plots with field records submitted.
    - A yellow dot indicates that the soil plot has been surveyed by the soil classification team, and forms have been submitted before the soil sampling and assessment survey takes place (Figure 6).
    - A dark blue dot indicates that the soil plot has been surveyed by the vegetation team, and forms have been submitted before the soil sampling and assessment survey takes place (Figure 6).

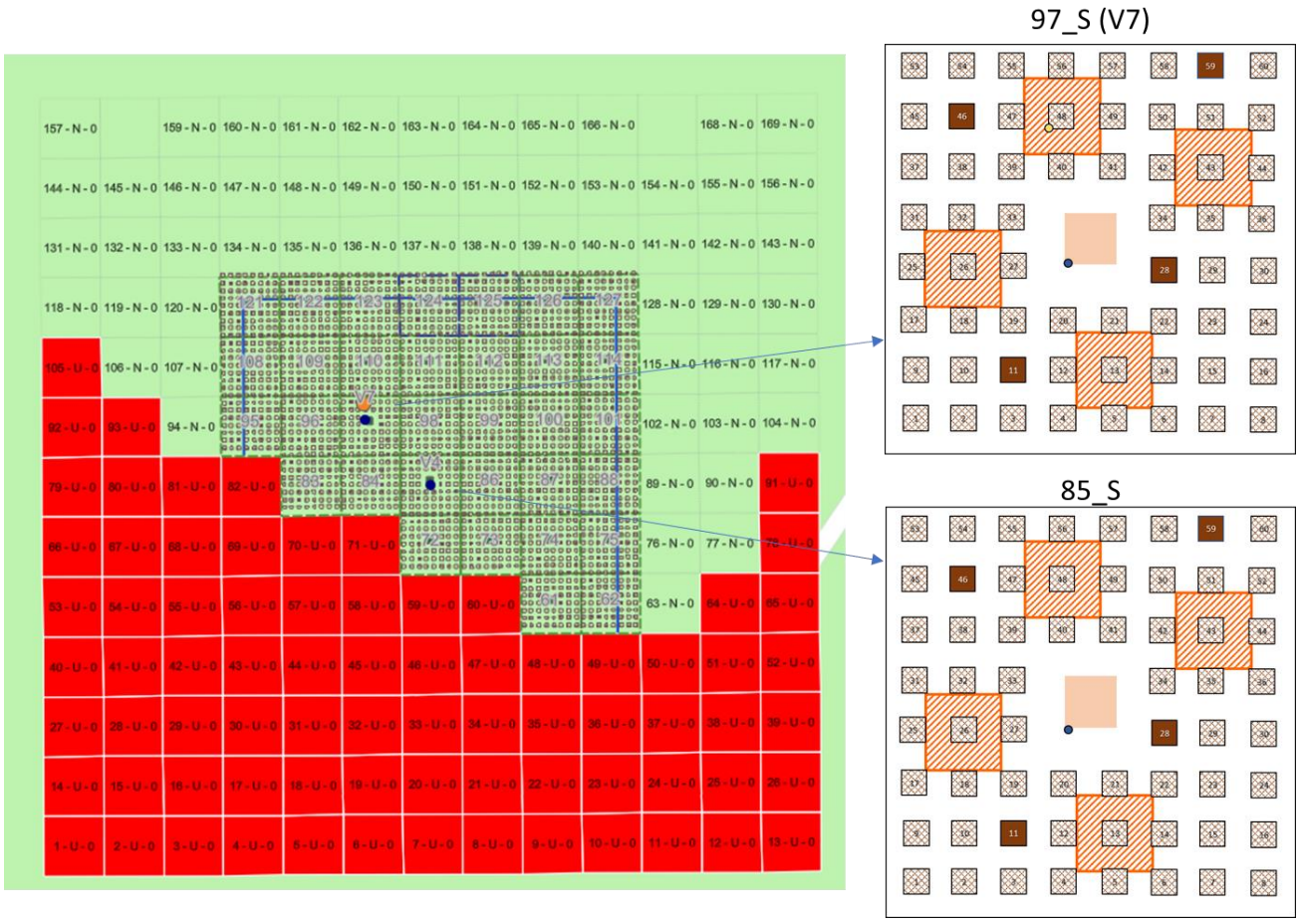


Figure 6: Left: View in Field Maps of grid of alternative plot options for one of the plots within a monad with soil classification completed for plot option 97 (highlighted with yellow dot) and Vegetation survey completed for default plot no 85 and alternative plot 97 (highlighted with blue dot). Right top: A plot featuring a completed soil classification point, highlighted by a yellow dot, and a completed vegetation survey point, marked with a blue dot. Right bottom: Default plot 85 with a completed vegetation survey point, highlighted with a blue dot. Both images on the right depict default sampling points as brown squares and alternative sampling points as squares with a crosshatched grid. Additionally, four options for soil classification survey, each covering an area of 3m by 3m, are represented by squares with an orange hatch pattern. Note: In the default plot no 85 was suitable for the vegetation survey but NOT for the soil survey therefore plot no 97 was also surveyed and this one should be used for soil sampling and assessment.

- If a plot has been surveyed before, the plot which you will need to survey will be marked with a yellow and/or blue dot. However, this information may not be available if other surveys are ongoing simultaneously or if the data has not been uploaded yet. In such cases, it's necessary to directly contact the other surveyors to confirm the plot options to be surveyed. The information of which teams are out can be found in the EES Survey Plan.
- Additionally, include any new information about site access obtained from your site access contacts, as well as any hazards present on the site, in the

Communications Form. Email the completed form to:englandecosystemsurvey@naturalengland.org.uk

2.4 Review and preparation of site-specific version of the risk assessment

1. Make a note of the nearest emergency department (A&E dept), including name, distance from, route to.
2. Plan route to site and note any potential hazards and obstacles including livestock, farm buildings, watercourses, mineshafts, spoil heaps, boggy areas, cliffs.
3. Check what biosecurity measures will be required, e.g. when crossing land holding boundaries.
4. Check current restrictions due to disease outbreaks: link to APHA's interactive map.
5. Check for any issues flagged up in the Surveyors' Report.
6. Check if chemicals or other potentially hazardous materials were recently applied to land. If so, carry out a risk assessment and decide if it is safe to continue the survey. Contact your survey manger if in doubt.
7. Check local mobile coverage: Mobile Phone Coverage 2023 - UK Mobile Phone Network Signal Coverage Comparison. Compare 5G, 4G and 3G on Vodafone, EE, O2, 3, Tesco, Virgin and more. (ukmobilecoverage.co.uk).
8. Include any additional hazards and how to control them in the site-specific risk assessment.
9. Make colleagues and buddy aware of any medical conditions or allergies, bring any necessary medication such as insulin, epi-pens.
10. Check the weather forecast and postpone survey if necessary.
11. Do a personal risk assessment if you have any relevant medical conditions or are pregnant.

2.5 Preparation of equipment and consumables

1. Bring an OS map for remote sites to be able to navigate back to the vehicle in case of electronic device failure.
2. Make sure the mobile phone is fully charged.
3. Check that you have Spot-X tracker and spare lithium batteries. On remote sites and sites with poor mobile coverage it provides means to communicate with a

designated person in your office and calling emergency services. The arranging of the monitoring system for remote sites is a responsibility of your employer.

4. Prepare appropriate clothing for the time of the year and location.
5. Periodically check contents of the first aid kit, replenish stock of items if used recently, replace out of date items with new ones.
6. Perform vehicle checks: e.g. condition of tyres and pressure, engine oil, screenwash, fuel levels.
7. Plan how you will carry the equipment. Place all required tools in clean toolboxes or, if backpacks are used, in clean plastic bags before placing them in the backpacks.
8. Ensure you have frozen ice packs available on the first day of the survey. Use cool box provided to transport frozen ice packs so that you have them available after first day of collection.
9. Prepare disinfectant required for the site. Use Safe4 disinfectant at **1:10** dilution, if no specific requirements are given by the survey coordinator or the site contact. Follow COSHH risk assessments and wear appropriate PPE when using chemicals.
10. Fill up the water container, check stock of Propellar and paper towels.
11. Check well in advance of the surveys that you can access maps in Field Maps and download required offline areas.
12. Check for updates to Survey123 form when online and if an update is available download the latest survey form before starting the survey.

2.6 Mitigation for protected sites

To avoid damage to Sites of Scientific Interest or other protected areas during the survey, follow these steps (Supporting documentation can be found in the Surveyor Library on SharePoint).

To mitigate potentially adverse effects of the surveys you must [as much as possible this process will be simplified in the final version of the manual]:

- Review the Habitats Regulations Assessment (HRA) rapid screening documents for the sites you are going to.
- Check the access notes in the Surveyor's Report for comments from Natural England's local area teams.
- Review Natural England's Designated Sites View for detailed information on protected species and features. Check the Surveyor Report and the Surveyor Planning Map on AGOL for designation and access requirements. For further

guidance, the rapid Habitat Risk Assessments can be found in the Designated Sites Process.

- Limit vehicular access and parking ideally to surfaced tracks and hard standing areas within the SSSI; prefer walking for other access.
- Remove all materials and equipment used, including any food remains.
- Minimize damage to the vegetation and soil; avoid cutting or removing vegetation for access.
- Be cautious not to disturb wildlife, especially ground nesting birds, and move away quickly if causing any disturbance.
- Prevent any release of organisms on site, including plant seed and micro-organisms carried from other sites on boots, clothing, bags and equipment.
- Follow general biosecurity measures and any site-specific measures mentioned in the Surveyor's Report and communicated by the access permissions contact for the site.

The proposed soil survey is unlikely to have a significant effect on any protected site and therefore require no strategic or site-based appropriate assessment by Natural England as the competent authority.

Natural England will use the rapid HRA screening tool to assess lower risk projects and determine if there are any significant impacts on SAC's/SPA's or Ramsar sites expected from the EES. This preliminary screening will be carried out by Natural England in advance of the survey.

2.7 Support during surveys

During the survey, comprehensive support is readily accessible to address any inquiries or concerns you may encounter. Please do not hesitate to reach out to us should you require any clarification or guidance.

- Natural England has a team member on duty every working day to help with **urgent queries**. Contact is available through a WhatsApp group that has been set up by Verda Fazlic from Fera. You should have received an e-mail with a communications flow and a link/QR Code to join the group. In case you have not, please see both here.
    - https://chat.whatsapp.com/DcY8mTY0UQM1x28Ae5owmv
- Person on duty in the WhatsApp chat will also provide a phone number which can be used if preferred or more convenient.
- You can also email the shared mailbox EES_2023@fera.co.uk you will receive response within **a few days**.

3 Fieldwork

Please plan your work so that you have sufficient time to complete the sampling in the plots you intend to visit. It is critical for your safety and well-being that you have enough time to take rest and carry out the tasks with care. If this cannot be reconciled with the time allowed for the surveys by your organisation, please speak with your line manager to find a solution.

.

Allow sufficient time for preparation before the surveys and additional tasks, such as cleaning and disinfection of clothing and equipment, and sample management. If in doubt of how much time it would take to prepare for and carry out the surveys, please consult your line manager and more experienced colleagues. Fera and Natural England can also provide support.

There is flexibility in completing a monad within the survey cycle if needed, if the work is completed within the survey period. Your Fera survey coordinator will agree with your survey manager the cut-off date by when the surveys must be complete.

3.1 Summary workflow

3.1.1 On site before start of sampling and assessment activities

1. Turn on GNSS receiver upon arrival (see Appendix 2 for instructions).
2. Locate the vegetation and soil plots, assess their suitability, and choose suitable alternative locations if needed.
3. Locate and assess suitability of soil sampling points within the suitable soil plot.

3.1.2 In each sampling point within the plot (suggested division of work)

1. Record GPS coordinates of SW corner of the sampling point in Field Maps (Surveyor 1).
2. Record monad, soil plot number, plot option number, in Field Maps (Surveyor 1).
3. Take picture of 1m x 1m square sampling point before sampling (Surveyor 1).
4. Count and sample earthworms, measure soil temperature (Surveyor 2).
5. Carry out VESS (Surveyor 2).
6. Take Z core (Surveyor 1).
7. Take ABC core (Surveyor 1).
8. Take rArB core (Surveyor 1).

9. Take sample M (Surveyor 1).
10. Replace soil in pits, close coring holes using the spade (Surveyor 2).
11. Take photograph of the point after sampling (Surveyor 1).
12. Move equipment to the next point (Surveyor 1).

3.1.3 After finishing work at the last point in the plot

1. If moving to another plot clean sampling equipment according to the biosecurity procedures.
2. If the plot is in another landholding also clean boots, trolley wheels and other equipment.
3. At the vehicle place M, Z, W, rA, rB samples in insulated boxes with ice packs and samples A, B, C in non-insulated boxes.
4. Carry out the end of the day clean-up procedure.
5. Add any new information about access and hazards present on site to the Communications Form on SharePoint.

3.2 Locating the plots

3.2.1 General information about navigation and locating plots

EES uses high accuracy GNSS (Global Navigation Satellite System) receivers and field data collection apps on an iPad to navigate and locate the sampling plots and points. The GNSS receiver that is used in the surveys is Geode GNS3M with additional positioning correction subscriptions.

Use the Geode for navigation and recording the position of south-west corners of the sampling points. The iPad's internal GPS is not sufficiently accurate. Refer to Appendix 3 of the manual for instructions on using the Geode and ensure Field Maps is set to use the Geode instead of the integrated provider. You can access the guidance document at this link: Appendix 3 GNSS Receiver Guidance.pdf.

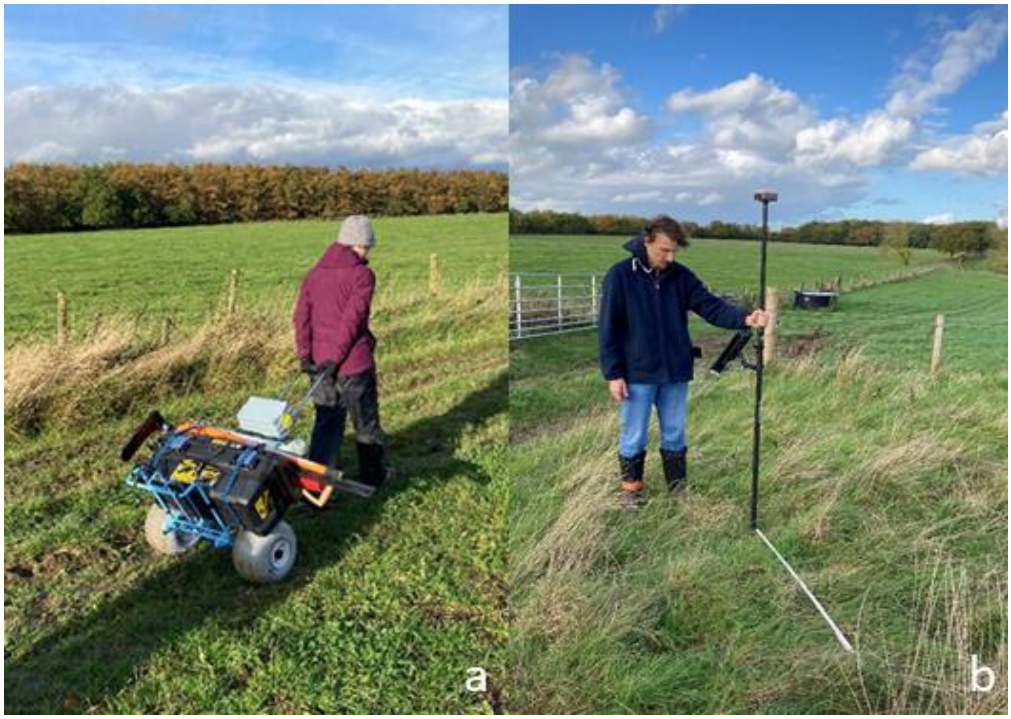


Figure 7: a) Transport of tools on a lowland site using a beach trolley b) locating the SW corner of sampling point using the GNSS receiver and an iPad mounted on a survey pole.

It is important to keep ground disturbance to a minimum. Walking across the soil plot should be minimised to only what is necessary to access this year's sampling points (Figure 7).

When conducting soil surveys in arable fields, prioritize minimizing crop damage by adhering to the following guidelines:

- Walk along the field's perimeter whenever possible.
- Be mindful of flattening the crop and try to keep equipment on nearby tram lines if possible.
- Avoid leaving equipment scattered in the field.

The central 2m by 2m vegetation square is excluded from the soil survey and must not be walked across.

Switch on the GNSS receiver as soon as arriving on site and use it for general navigation. This allows for the convergence of Atlas corrections to take place and be maintained between reaching the plot. This takes between 15 and 40 minutes and the receiver must be on and upright all the time to enable this and to maintain high accuracy positioning thereafter.

Use the GNSS receiver mounted on the survey pole. The survey pole is to be extended to its full length (2m) to ensure best reception of satellite signal (for full app and receiver use instructions please refer to Appendix 2, Figure 7).

3.2.2 Geodes and iPads

For the latest Geode troubleshooting guidance, refer to “Geode troubleshooting” document in the Surveyor’s Library’s “Equipment Guidance”.

Under typical conditions in open ground, the Geode should offer accuracy better than 50-60cm. However, in areas with steep hills and tall obstacles nearby, achieving this level of accuracy might not be possible. In such cases, accuracies of around 1m are acceptable, and based on experience, achieving accuracies of approximately 1.2m is feasible even in problematic areas.

3.3 Assessing suitability of the plots

3.3.1 Desk study completed by Natural England

Natural England identified potential suitable 16m by 16m soil plot locations in a pre-survey desk study by looking at the following:

- Land where soil cannot be sampled due to designations, such as scheduled Ancient Monuments. Ceck the ‘monad summary spreadsheet’ available in each monad folder for historic environment risk level, and areas where soil surveying is prohibited.
- Land where sampling would be unsafe, such as landfills, quarries. Please note that we have not excluded plots that are located on steep slopes or in inaccessible areas as this was not possible in our current set up of the process. It is your responsibility to assess whether safe access and surveying is possible with regards to topography..
- Presence of known underground and overhead utilities (does not replace the need to follow the HSE and HSG47 guidance).
- UXO risk zones that require additional mitigation.
- Presence of significant non-uniformities within the plot, such as trees, tracks, paths, different habitats, different soil types (see criteria for assessment of plot suitability in the field, section 3.3.2).

The desk study did not include assessment of suitability for the vegetation surveys.

The desk study assessment of plot suitability does not guarantee that the default plot is safe and suitable for the survey. You must confirm the suitability of the plot according to the procedure described in section 3.3.5 before you start the survey.

The map in the field data collection app shows grids of alternative plot location options within a monad. There will be between two and six grids in each monad. In each grid, each plot option is numbered (1-169). The central plot of the grid, no. 85, is the default location (Figure). Each plot option number has a suffix indicating results of the desk study assessment, for example 61_SX (Figure 8).

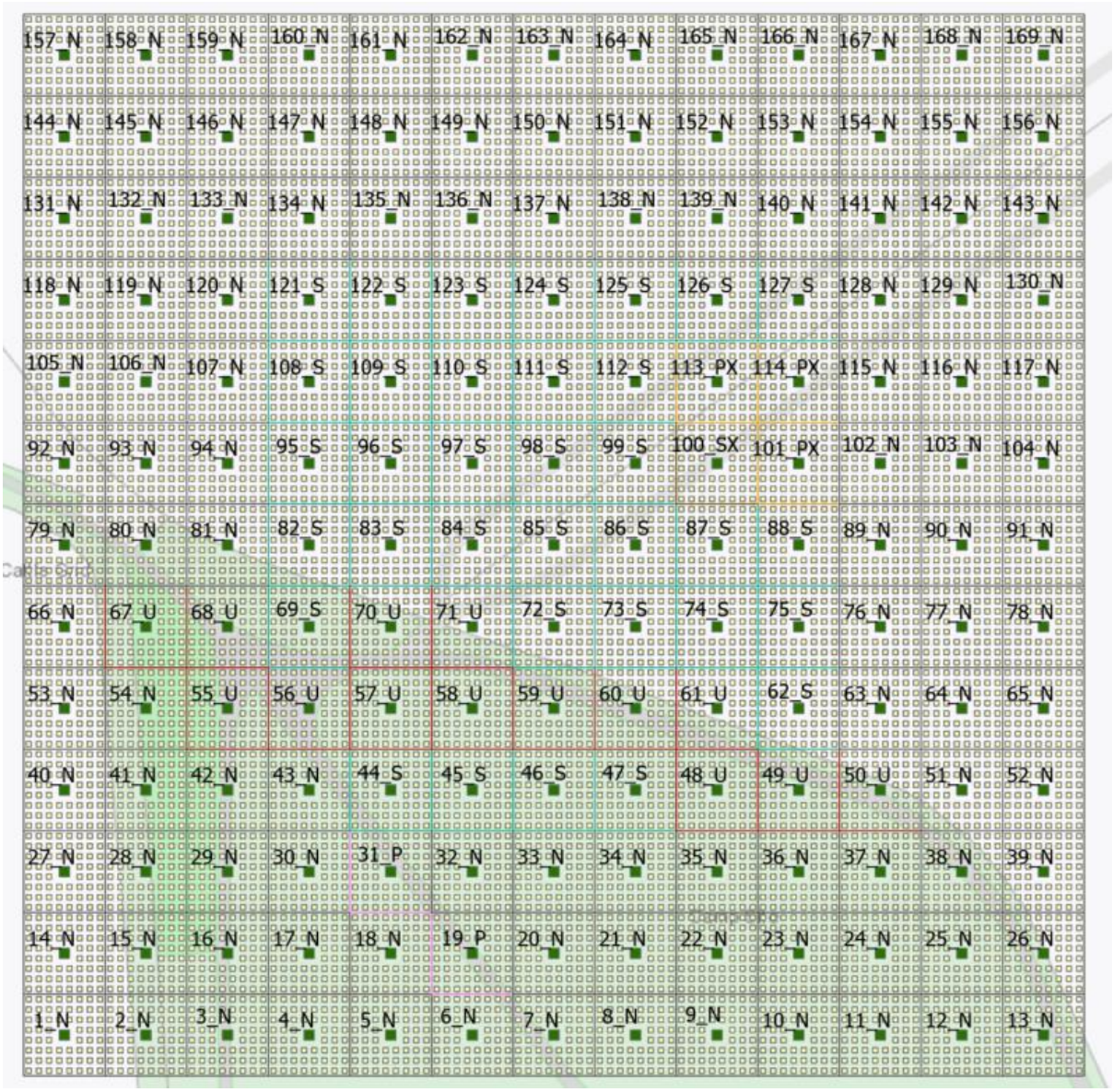


Figure 8: Example of the grid of alternative plot location options numbered from 1-169.

The suffixes used to denote suitability of plots for the soil survey are defined as:

S – plot deemed as suitable for the soil survey, carry out field checks on field-identifiable features to verify.

P – plot deemed potentially suitable for the soil survey, outside of hard constraints, but review of aerial imagery and other data was inconclusive. Carry out field checks on field-identifiable features to verify.

U – plot deemed unsuitable for the soil survey, either due to hard constraints or non-homogeneity. Must not be surveyed.

N – suitability for the soil survey not assessed, the plot was not assessed as enough suitable plots close to default location were found during the desk study. Automated

intersection with hard-constraint layers did not show the plot to be unsuitable. Carry out field checks on field-identifiable features to verify.

X – additional suffix indicating UXO risk higher than low. To ensure safety when dealing with potential unexploded ordnance (UXO) risks higher than low, conducting soil surveys requires the presence of a non-intrusive UXO survey by a qualified explosive ordnance clearance (EOC) engineer. Before sampling, the engineer must check the sampling points. Follow these steps to arrange for their supervision:

- Notify survey coordinator of the survey date.
- The survey coordinator will inform Natural England about the survey date.
- Natural England will the instruct the EOC engineer to provide non-intrusive UXO survey and supervision during the soil survey.
- The survey coordinator will provide you with the engineer's contact details. This will allow you to easily arrange a meeting with the engineer at the designated site.
- You are responsible for promptly informing the EOC engineer if there are any changes to the survey schedule.

In the current setup, the plot alternatives are categorized based on suitability as determined in the desk study. The available options for selection are limited to those identified as either **suitable ('S')** or **potentially suitable ('P')** during the desk study. These selected plots are the ones that have designated sampling points within them (as shown in Figure 9). If none of the enabled options are deemed suitable during the survey, the survey cannot be conducted in that plot.

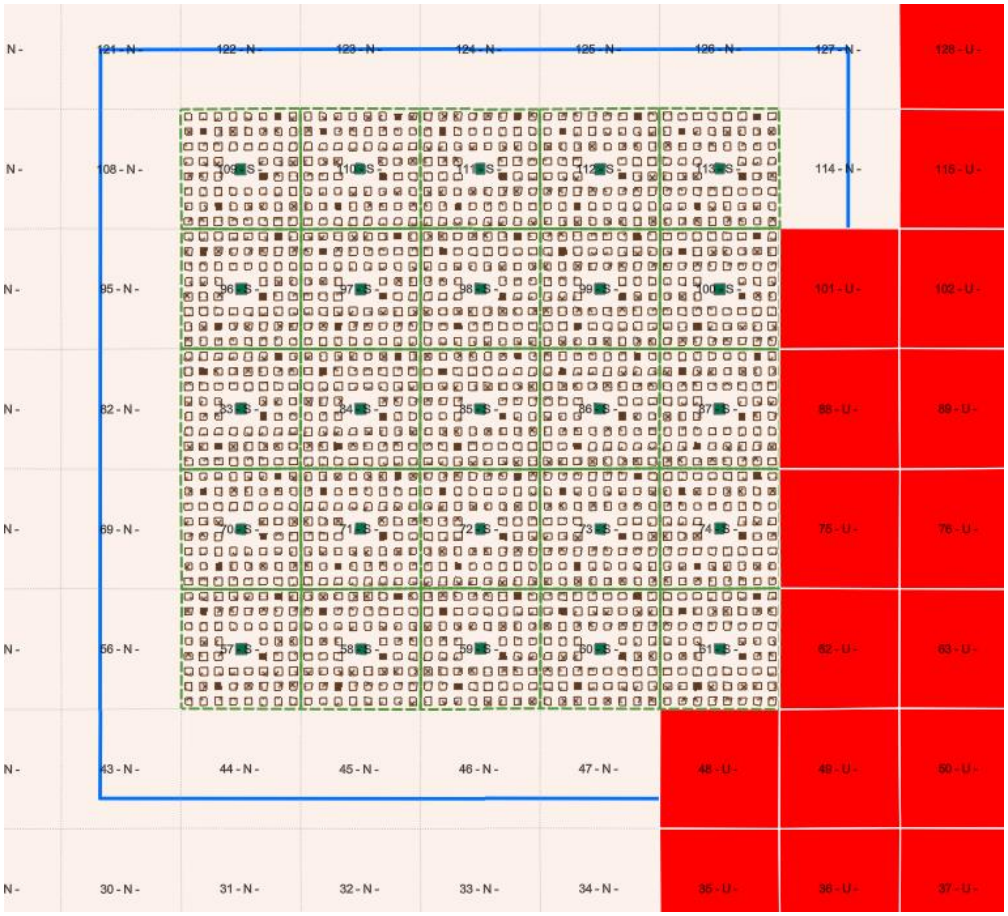


Figure 9: Plot alternatives overview in Field Maps app, note that ‘N’ plots do not have sampling points in them and currently cannot be used.

3.3.2 Assessing suitability of survey plots on site

Every soil survey plot must have a suitable vegetation plot in its centre. The soil plot is not surveyed if the vegetation plot is unsuitable. There are locations where vegetation plots can be surveyed without having soil plots associated with them. In such a case an additional vegetation plot with suitable soil plot around needs to be identified.

If the soil survey takes place before the vegetation survey, you first need to assess the vegetation plot for its suitability. Default locations of vegetation plots are selected at random and not assessed before the survey for their suitability. This means it is possible for the default vegetation plots to be in unsuitable areas, such as on roads, small water bodies, access tracks, and others.

If the vegetation survey has already taken place, you need to carry out the soil survey in the location identified as suitable for the soil survey by the vegetation surveyors. You still need to do the safety checks, on-site checks for underground utilities are not carried out by the vegetation surveyors.

It is rare that you will have to abandon a soil plot because you identified it as unsuitable after the vegetation survey was carried out. This is because suitability for the soil survey is checked during the desk study and during the vegetation survey.

3.3.2.1 Different scenarios for moving plots

This section gives an overview of different scenarios of relationship between the vegetation and soil surveys. Further sections give detailed criteria and the detailed process to follow when assessing plot suitability.

3.3.2.1.1 DEFAULT SCENARIO

The **veg plot** automatically generated by the 1ha square is suitable. The 16 by 16m soil plot centred around that veg plot is also suitable. No plots are relocated. The **square veg plot** and **soil veg plot** are identical.

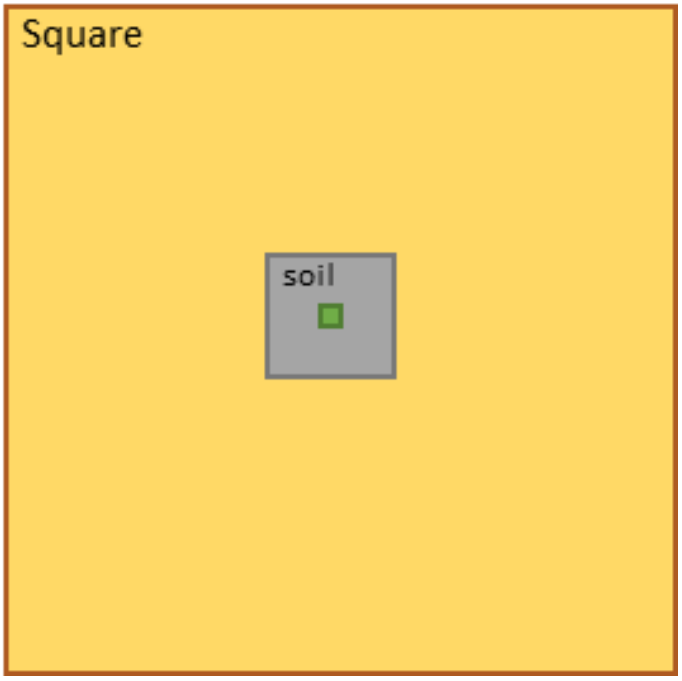


Figure 10: Defaults scenario: Soil plot (grey) and vegetation plot (green) are automatically generated and suitable for survey.

NOTE: The 1ha 'square' is not used in soil surveys and is not shown on the soil survey maps. The square is an area within which broad habitat types are identified and their extent mapped in the vegetation surveys. Alternative soil plot options can be outside the square as their grid measures 208 by 208m and comprises 169 options (13 by 13 soil plots).

3.3.2.1.2 ALTERNATIVE SCENARIO 1

The veg plot automatically generated by the 1ha square is unsuitable. One of the four alternative options (1st west; 2nd – north; 3rd – east; 4th – south) is suitable for both vegetation and soil surveys. The veg plot and 16m by 16m soil plot are both

relocated to a suitable alternative point. The **square veg plot** and **soil veg plot** are identical.

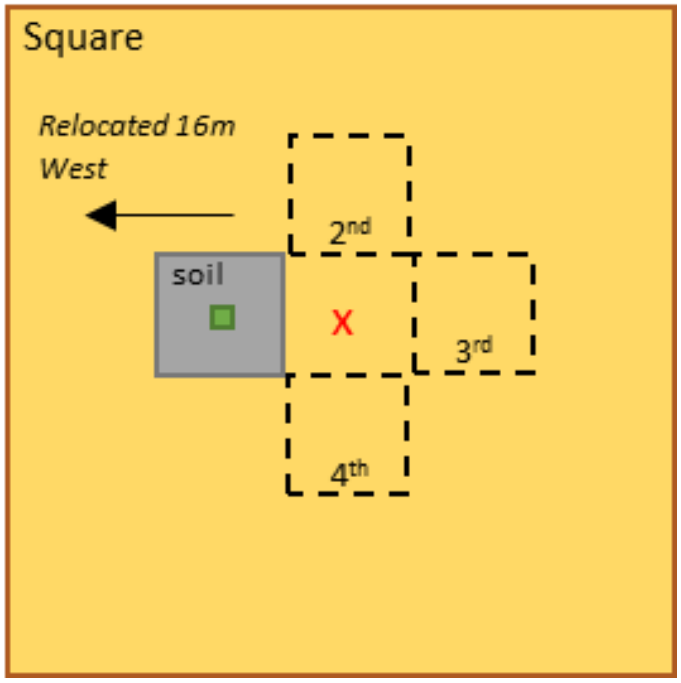


Figure 11: Alternative scenario 2: Default soil plot (grey) and vegetation plot (green) are not suitable (red X) and relocated 16m West to one of the four alternative options.

Examples: a road, linear feature or pond prevents placement of the vegetation plot and soil plot.

3.3.2.1.3 ALTERNATIVE SCENARIO 2

The **veg plot** automatically generated by the 1ha square is suitable. The 16x16m soil plot is unsuitable. The **veg plot** is surveyed. The 16x16m soil plot is moved as described in 3.3.5. The **square veg plot** and **soil veg plot** are not identical and are surveyed separately, leading to **two** 2m by 2m vegetation plots.

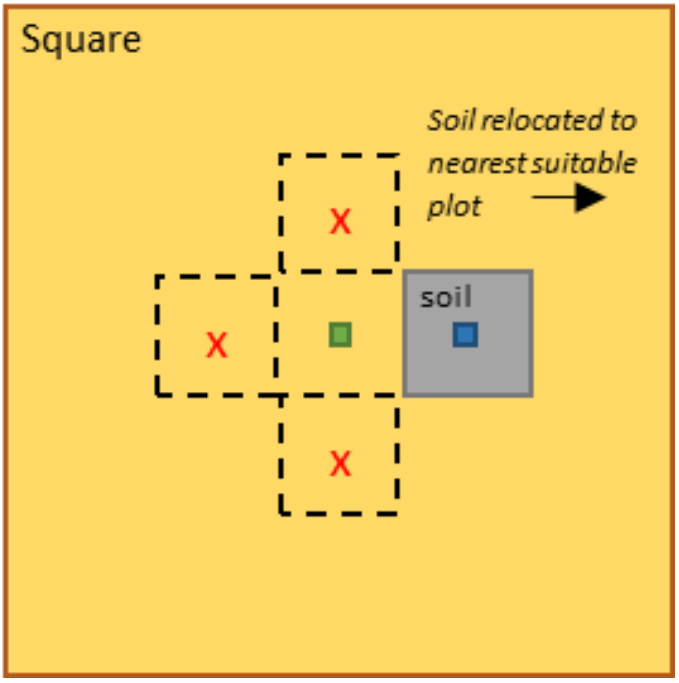
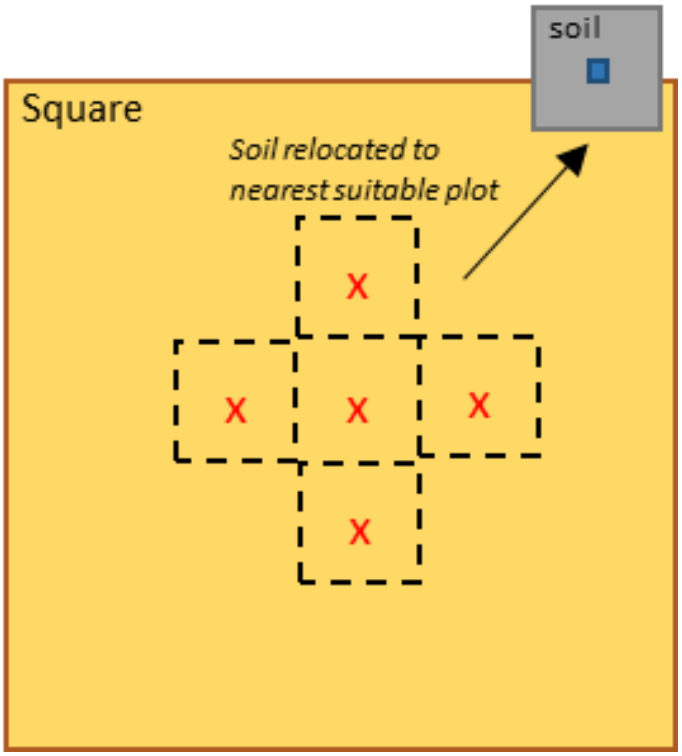


Figure 12: Alternative scenario 3: Default soil plot not suitable, vegetation plot (green) is suitable. Soil plot (grey) with suitable vegetation plot (blue) moved to nearest suitable plot options. Plots that are not suitable marked with red X.

Examples: part of the 16 by 16m plot is within the buffer of an underground utility; there is insufficient future soil sampling space due to shallow, rocky soil.

3.3.2.1.4 ALTERNATIVE SCENARIO 3

The veg plot automatically generated by the 1ha square is unsuitable, as are the four alternative options. The 16 by 16m soil plot is also not suitable (a soil plot to be suitable must have suitable veg plot in it). The **veg plot is abandoned**. The soil plot is moved as described in 3.3.5. The **soil veg plot** is surveyed. **Note, the alternative plot could be within or outside the 1ha square.**



Examples: a large pond or rock exposure prevents vegetation or soil sampling.

3.3.3 Criteria for suitability of a vegetation plot

A 2m by 2m vegetation plot is unsuitable if it is in a:

- woodland or a linear feature, such as a hedgerow or riparian vegetation
- river or lake, coastal lagoon, marine habitat
- on a sealed surface, constructed or unvegetated track or path, in a built-up area.
- curtilage (an area of land attached to a building, forming one enclosure with it, and with a use linked to the building e.g., garden).

Should the plot be located on a vegetated track or path and the vegetation is representative of the surrounding habitat, it can be a representative vegetation plot.

3.3.4 Criteria for suitability of a soil plot

A soil plot is unsuitable if:

- The vegetation plot in its centre is unsuitable.
- The plot is crossed by underground utilities or overhead power lines.
- The plot is within a prohibited area identified on the monad summary spreadsheet.

- There is no or very limited soil present on a large part of the plot that would make soil sampling very difficult such as exposed rock, scree slopes.
- A significant part of the plot has got a different macro or microtopography such as vertical exposures, half ridge and furrow and half not.
- There are significant differences in slope or aspect in parts of the plot giving rise to differing soil characteristics such as part of the plot is on a slope and part is level.
    - Exception: spatial variation at a plot scale characteristic of the surrounding area such as eroded revegetated blanket bog.
- There is significantly different land use or land management in parts of the plot such as grassland and arable within soils plot. A plot is also unsuitable if crossed by a field boundary, even if management on both sides of the boundary appears to be the same).
- The plot is an unusual landform otherwise not present in the surrounding area, such as a single mound or hollow.
- Part of the plot is subject to localised erosion, compaction or superficial damage which otherwise is not a regular, unavoidable feature of a larger area such as erosion rills, vehicle tracking, scrapes, gullies.
    - If a regular tramline passes the plot, that is acceptable. If multiple tramlines pass the plot, e.g. the plot is near the edge of a field where tramlines converge and farm machines turn, then the plot is **not** suitable. If a sampling point is on a tramline, a sampling point next to it can be chose (this is explained further in the manual).
- Part of the plot is noticeably wetter or drier.
- There are man-made structures in the plot, such as:
    - a path
    - track
    - materials storage (manure, soil, hay)
    - soil stripping
    - electricity pylon
    - drainage ditch (except frequent moorland grips)
    - path of animal crossing through the field
        - Mole hills and rabbit burrows do not automatically make a plot unsuitable if they are a general feature of the field/habitat, but if your sampling point lands directly on one you can move the coring location along the diagonal to avoid it (within the sampling

point) or choose an alternative sampling point (one of adjacent and within the plot).

    - feeding stations where animals gather etc.
- Part of the plot appears to be influenced by localised pollution or nutrient enrichment.
- The plot includes two different habitats, stands etc, unless it is a typical feature of the surrounding area, a pattern occurring at a plot scale which would be impractical to avoid.
- There are indications of different soil types present in one plot.
- Is in a woodland.
- Single tree(s) are present in the plot or at plot boundary.
- Large shrubs are present in the plot. Small shrubs, such as heather that are in keeping with the surrounding habitats and would not interfere with sampling are permitted.
- Large animal burrows are present (rabbit warrens, badger setts etc.)
    - A sampling point is suitable if only the occasional burrows such as, mole hills, are present.
    - Check the plot and surroundings for signs of badger activity. Follow guidance given in Appendix 3 for signs of badgers. Choose a plot buffered by at least one more plot from a plot where badgers sett is suspected.

A soil plot that is currently unsuitable may become suitable later in the same survey campaign if:

- Plot is flooded (except peatland sites where water table is high and some surface water is usually present, the access to the plot must be safe).
- Potentially dangerous animals, such as bulls, cows with young calves, are present within the plot (enquire with farmer/landowner).
- Fertilisers, manures, waste materials or pesticides have been applied within last month.

3.3.5 Assessing plot suitability – vegetation plot not surveyed before

The procedure for assessing plot suitability when soil surveys take place before the vegetation and landscape surveys is as follows:

1. Navigate to the edge of the vegetation plot in the default plot location (plot no. 85). Do not walk on the vegetation plot.

2. Assess suitability of the vegetation plot according to the criteria given in 3.3.3. Mark it with flags at this stage if necessary.
3. If the vegetation plot is unsuitable, do not proceed with assessment of the soil plot but:
    a. Assess alternative options for the vegetation plot in the order of: W, N, E, S (plots no. 84, 98, 86, 72). Choose the first suitable option and proceed with no. 4 below.
    b. If none of the options is suitable, then assess the closest in-between options in this order: SW, NW, NE, SE (plots no. 71, 97, 99, 73).
    c. If none of the above are suitable, continue assessment of further alternative plot options one grid segment further from the default plot in clockwise order starting from plot no. 59, 58, 57, 70 and so on.
4. Once suitable vegetation plot is identified. Assess suitability of the soil plot by looking around and applying criteria given in section 3.3.4 above.
5. If the soil plot appears suitable after this quick check, mark the vegetation plot with flags. Walk outside the soil plot it along its perimeter, keep assessing its suitability, and mark the corners with the flags.
6. Check the suitability of the soil plot again, now looking at the marked extent of the soil plot.
7. If the soil plot is suitable, open new EES soil survey form in the Survey123 app. Record the monad, plot number and plot option number. There is one Survey123 form per plot to record data for each of the sampling points (this takes place during the sampling). Take the photograph of the plot. The photograph is to be taken from the north, looking south, when standing on the northern side of the plot, outside of it. Capture the entire plot.
8. If the soil plot is not suitable, go back to point 3.
9. Proceed with locating and checking the four sampling points as described in section 3.4 below.

[note, instruction to record plots with only vegetation plots suitable has been removed as it is no longer required]

3.3.6 Assessing plot suitability – plot surveyed before in vegetation or/and soil classification survey

1. Go to soil plot that was identified as suitable by the previous surveyors, walk around it to confirm its suitability and mark its corners with flags.

6. In a rare situation that the soil plot is found to be unsuitable, do not proceed with the soil survey in this plot.
   Provide feedback to survey coordinator.

7. If the soil plot is suitable, proceed with locating and checking the four sampling points as described in section 3.4 below.

3.4 Locating sampling points

3.4.1 Default sampling points

The default sampling points to be used throughout the first five-year period of soil surveys for every plot are: **11, 28, 46 and 59 (**Figure 13**)**.

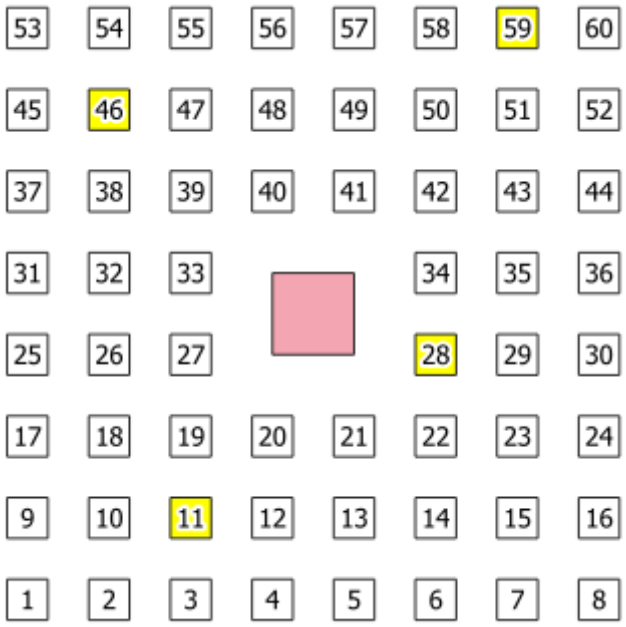


Figure 13: Default sampling points (11, 28, 46, 59) within the 16m by 16m soil plot highlighted in yellow

1. For all four sampling points in a suitable soil plot:
    a. Using the map in the Field Maps app navigate to the south-west corner of the sampling point (Figure 7).
    Approach the point from south or west to avoid trampling on the area to be sampled.
    b. When setting out the point with the survey pole, use circular spirit level on the pole to ensure it is in a vertical position when checking the position on the map in the app.
    c. Mark SW corner and remaining corners of the 1m by 1m sampling area. If the position accuracy is better than 10cm, use the GNSS receiver to mark the NE corner of the sampling point. Then use two tape measures to mark the other two corners of the sampling point by taking 1m distance from each of the already marked points. If the position accuracy is worse than 10cm, use compass directions and tape measure to mark the three other corners of the sampling point. Mark the point on the diagonal first, then, from this point, using two tape measures mark the remaining two corners by measuring 1m distance from the other two corners.

2. After marking all sampling points leave the GNSS receiver standing upright to maintain accuracy (use field trolley for support). Then in each sampling point:
    a. Check for underground services using a Cable Avoidance Tool (CAT) and a signal generator (Genny). Follow the guidance given in the Health & Safety Executive's Booklet HS(G)47,"Avoiding Danger from Underground Services".
    b. The check can be done by one person walking around the plot with signal generator in a distance of about 20 metres or more from the person with the scanner in the sampling point.
    c. If there is an indication of underground utilities crossing or being near any of the sampling points, then the whole plot is unsuitable. The action to take depends on whether the vegetation survey already took place within the plot:
        i. For sites where soil survey takes place before the vegetation surveys, establish the direction of the utility and find an alternative plot at least one plot away from the utility in a perpendicular direction.
        ii. For sites where the soil plot was identified as suitable during earlier vegetation surveys, do not seek alternative suitable soil plots in this location, follow instructions in no. 6 in the list in section 3.3.6 above.
3. Proceed with soil sampling and assessments in each sampling point.

3.4.2 What to do if a sampling point is not suitable

On rare occasions where a default sampling point is not suitable, choose next suitable alternative in the order of W, N, E, S, NW, NE, SE and SW. If none of the alternative sampling points is suitable, the entire plot is unsuitable.

Please record the reason why you abandoned the plot in the note section in Survey123 form.

3.5 Samples taken and assessments carried out in each sampling point

Table 1 lists the types of samples taken and assessments to be done during the soil survey.

Table 1: Soil samples and assessments taken in each sampling point within the plot

Sample or assessment type	Depth (cm)	Purpose of the sample
Z	0-8	Mesofauna soil sample – for Tullgren extraction followed by DNA extraction
A	0-15	Physicochemical soil analysis
B	15-30	
C	30-40	
rA	0-15	Sample for identification of mycorrhizal fungi from root tips present in the soil sample
rB	15-30	
M	0-15	Microbial, nematode diversity and fresh material analysis, e.g. aggregate stability
W-5min W-add	0-20	Earthworm samples, two composite samples per plot
Temp.	10	Soil temperature at the time of sampling
VESS	0-30	Visual Evaluation of Soil Structure
Peat depth	-	On peat soils (thickness of organic horizon, if more than 2cm thick)

Soil samples are collected in plastic bags. Earthworms are collected in plastic containers with vented lids and moist paper in them. Soils samples: M, Z, A, B, C, and earthworm samples: W-5min and W-add are composite samples. A composite sample is a sample comprised of four individual samples taken in each of the sampling points and added together in one bag.

Samples rA and rB are not composites samples. They are bagged individually in each sampling point.

Apart from samples and assessments, several types of metadata are collected. This includes the variants of methods used, photographs, and notes of any issues encountered during the survey. The metadata will be used to facilitate continuous improvement by providing feedback about performance of field methods both to the surveyors and Natural England, and to improve data analysis.

3.6 Taking good photographs

Using the iPad camera app instead of the in-app camera in Survey123 is recommended due to the limitations of the latter, specifically the lack of focus and exposure lock, resulting in suboptimal image quality. Additionally, taking photos

separately mitigates the risk of losing valuable data in the event of a Survey123 crash during form completion. To achieve this, the following settings should be adjusted accordingly:

- Switch off location access to the iPad camera app: **Settings →Privacy & Security→Location Services→Camera**
- Set to **‘Never’** (this will be irrelevant if you switch off Location Services completely but would be good to set it like that as a precaution against Camera app getting into conflict with the other apps using location services).
- Switch photo format to most compatible: **Settings (scroll down the left-hand side tab)→Camera→Formats set to ‘Most Compatible’**
- Ensure that the **'Preserve Settings'** option for Camera Mode is turned off and the **'Live Photo'** option is turned on. Disabling 'Preserve Settings' ensures that the Live Photo setting remains consistent the next time you open the Camera app.
- Please make sure that Survey123 has got access to photos, otherwise you will not be able to append them from the folder. To do this, on your iPad go to: **Settings (scroll down the left-hand side tab)→Survey123→Photos set to ‘All Photos’**

Before taking photographs, ensure the camera lens is clean and free from any debris. If you notice any sand grains or particles on the lens, rinse it with water to prevent potential scratches. After rinsing, gently wipe the lens dry using a clean paper towel. This will help maintain the lens's clarity and ensure high-quality photographs.

Use colour correction cards in photographs of sampling points, soil cores, and soil blocks. Maintain the cards in a clean condition to accurately represent true colours in the images. When cleaning, rinse off any soil debris first and then gently wipe with a clean paper towel. If the colour on the cards starts to rub off, request a replacement promptly.

When taking core and soil block photos, keep tablet horizontal and ensure the photographed surface is not shaded. Select focus point and keep tablet steady to avoid blurry photographs.

Ensure that no persons or equipment are present in the photographs. If a photo inadvertently includes people, promptly delete it (if necessary) and retake the shot. Photos of persons would be personal data that the survey does not collect.

3.6.1 Labelling of sample bags and sample containers

Affix barcode labels provided by the survey coordinator to all bags and container s that are used for soil samples and earthworm collection. You still will need to note down the:

- monad id
- plot number
- sample
- point number (for samples rA and rB)
- which corer (small or large) was used (only for samples rA and rB)
- date.

Use ‘x’ used as a separator, for example:

TG2200 x 1 x rA x 1

20/03/23

Take spare bags and marker pens into the field in case a bag needs replacing. When writing using provided markers, ensure the letters are legible and resistant to removal by writing slowly to allow thick coverage of the ink. Ensure the label of the bags and containers match the information recorded on the crib sheets and captured in survey123. Check the label is readable before packaging the samples.

3.7 Layout and beginning of sampling in each of the sampling points

3.7.1 Sampling layout

Soil samples are taken from fixed depth, in set order and using constant volume at specific points (Figure 14). Keep disturbance to the limited area around the sampling point.

When sampling:

- minimise treading on soil surface
- keep to one side of the sampling area in case repeat cores need to be taken.

Sample	Description
Z	Mesofauna (0-8cm)
ABC	Physiochemical (A = 0-15cm, B = 15-30cm, C = 30-40cm)
M	Microbes (0- 15cm)
rArB	Mycorrhiza (rA = 0-15cm, rB = 0-30cm)

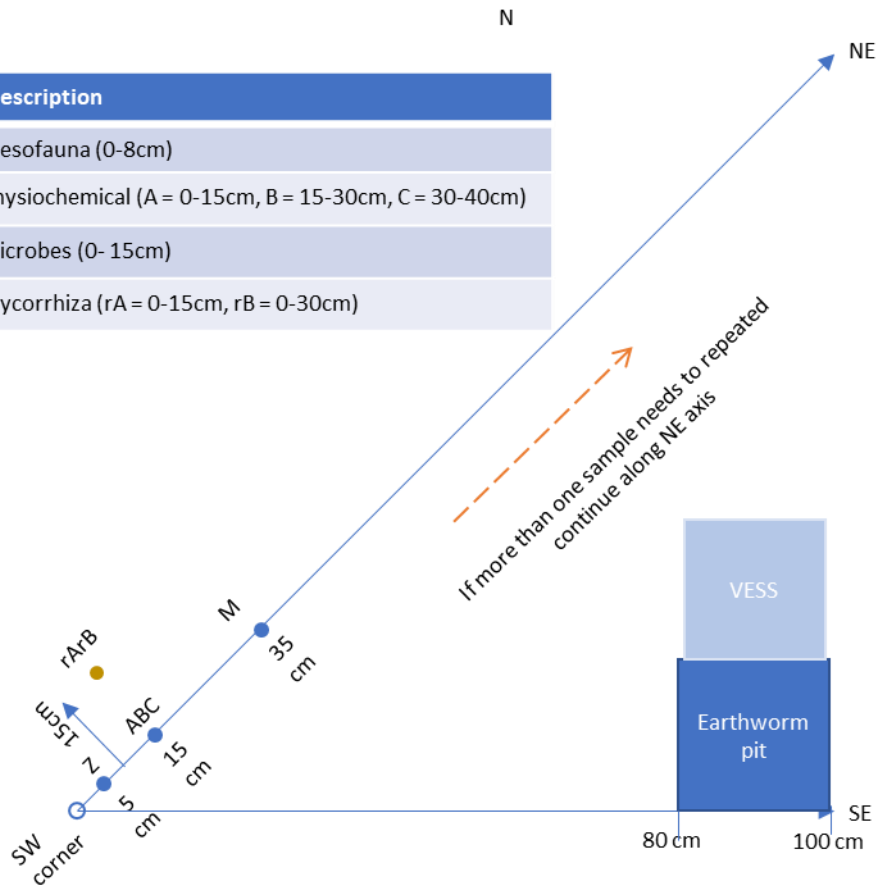


Figure 14: The diagram illustrates the arrangement of sample types at a single sampling point. Core samples (Z, ABC, M) are represented by blue circles, while rArB is denoted by a dark yellow circle. The earthworm pit (sample W) is indicated by a dark blue square, and the VESS block is marked with a light blue square. The distances from the SW corner of the sampling point are indicative minimum distances. In cases where earlier sampling causes disturbance, it may be necessary to place the sample further along the diagonal. For re-sampling, the minimum distance for moving the coring points along the diagonal is 5cm for sample Z and 15cm for samples ABC and M.

3.7.2 Beginning of sampling in a sampling point

1. Open the Survey123 form you created for the plot. **Please fill out every section of this form** excluding the additional information sections such as “other” which you can use as and when relevant. Make sure to check that default values are correct and do not need changing.

2. Take a photograph of the sampling point before sampling. The photograph is to be taken looking south, when standing north of the sampling point, from the height of about 1.5m, looking at the plot at an angle of about 45°. Place colour correction card just outside the 1m by 1m disturbance area with all three cards visible. All four corners of the sampling point need to be visible.

3. Proceed with sampling and assessments. Typical working arrangement is that one of the surveyors takes the core samples, whilst the other does the pit assessments (VESS) and collects the earthworm samples.

3.8 Cross-contamination and biosecurity measures within the plot

1. Clean used tools with spatula and wire brush to remove excess soil.
2. When moving between the sampling points keep soiled tools separately from clean tools by placing in a polythene bag. Take a clean bag before at the first sampling point to use it for this purpose.

Clean-up between the plots is described in sections 3.15, 3.16, and 3.17, after the sampling and assessment procedures.

3.9 Earthworm sampling and soil temperature

In the field, earthworms are only to be counted and collected for laboratory analysis. In the laboratory, the earthworms will be separated into 3 ecological groups: juveniles and adults. They will be counted and weighted to provide total earthworm number and biomass (fresh weight). Species of adult earthworms will be identified.

The EES soil survey aims to provide data that could be compared with the data collected by the Sustainable Farming Incentive (SFI) monitoring scheme. The SFI monitoring scheme method limits the search time for earthworms to 5 minutes after the block has been broken up along natural planes and fissures. To maintain compatibility with the SFI monitoring, the earthworm search is divided into two stages: the 5-minute sample (W-5min) and additional thorough search, (W-add) sample.

The SFI protocol limits search to the topsoil if the topsoil depth is less than depth of the block (20cm). In such cases the block is truncated. To collect data compatible with the SFI methods, if the block includes subsoil, the subsoil part is separated and included in the second stage of the earthworm search. The earthworms found in the subsoil part are added to the additional search numbers and the W-add sample.

The procedure is as follows:

1. Leave the north side of the earthworm sampling square untrampled and undisturbed, it will be used for VESS (Figure 14).
2. Prepare tarpaulin laying it on the surface the light-coloured side up.

3. Mark the 20 by 20 cm area to be excavated on the soil surface. Search for earthworm casts and middens. Identify the presence or absence of earthworm casts and count middens[2] within the marked area, record in the app.

4. Cut 20cm by 20cm by 20cm soil block using a spade (Figure 15). The hole is c. 2cm wider than the spade. Excavate without delay.

Figure 15: a) Width and length of square (20cm x 20cm) and b) depth of excavated block (20cm)

5. If the topsoil is less than 20 cm deep, trim off the subsoil and put it aside on the tarpaulin.

In mineral soils (with low organic matter content) the topsoil can be identified by a markedly lighter colour than the subsoil (Figure 16).

[2] Middens are small piles of earthworm casts, plant material, stones that cover entrance to permanent burrows of deep burrowing (anecic) earthworms. The second group of earthworms that you can find are topsoil-dwelling (endogeic) earthworms. The third group are surface-dwelling (epigeic) earthworms found on the soil surface in plant litter or just below it (<3cm deep).

Figure 16: A soil profile where topsoil depth is 30cm (scale in decimetres).

6. Trim any excess from the soil block that exceeds the depth of 20cm and return to pit (exclude from the search).
7. Insert the thermometer horizontally into the exposed side of the soil pit 10cm from the soil surface and leave there to take measurement later.
8. Before starting to pick up earthworms, break the soil block into fragments (peds) it naturally breaks into upon applying pressure. Shake it and pull apart if needed. Separate each fragment from enmeshing roots and them by hand along any exposed fracture planes or fissures.
9. Spread the fragments on the tarpaulin segregating them from small on one side through medium in the middle to large on the other side.
10. Moisten a sheet of paper tower with water and place in each sampling container.
11. Start with the first search for five minutes (done by one person), count and collect all the earthworms found in the 1 litre container labelled sample ‘W-5min’ with moist paper towel inside. Record the count for ‘W-add’ sample in the app as you progress. If 1 litre pots have not been supplied, use two of 0.5 litre pots.
12. Continue with the search. Restart counting earthworms and collect them in the ‘W-add’ container. Record the count in the app in the ‘W-add’ field.
13. If kept aside earlier, add the subsoil part from the block and include in the search. Break the soil blocks further and check root mat for earthworms.

14. Be sure to break up the block, the root matt, and grass tussocks. Use hand cultivator (rake) if helpful taking care not to damage earthworms.

15. Check that the correct containers are used. Scan the barcode of the labels on the containers using the app. This begins the process of sample tracking. Scanning is done at each sampling point.

16. Avoid keeping containers with earthworms in direct sunlight or high temperature. Place in the cooler bag immediately after collection.

17. Keep the containers cool right from the collection: use the insulated dry bag in the field, transfer to insulated box with ice packs when back at the vehicle. Use ice packs from the end of the day when samples were collected, not after a few days of storage.

18. Take temperature measurement and take the thermometer out of the soil.

19. Open the containers regularly (minimum every three days, when ice packs are replaced) for about 20 seconds after earthworms have been collected until they are posted to allow fresh air to enter the pots. Ensure you allow fresh air in just before you post the samples.

20. Replace ice packs first after 24 hours to cool the samples down quickly, then every 3 days, also replace them with freshly frozen ones (from the freezer, not from a cool box) just before postage, even if it the ice packs have been replaced the previous day.

3.10 Visual Evaluation of Soil Structure (VESS)

1. Deepen the untrampled (north) side of the earthworm pit to a depth of c. 35cm without pushing against the VESS block (Figure 14).

2. When deepening the pit observe soil structure, strength and colour. Examine the side of the pit once it is visible to that depth. Search for signs of a tillage (plough) pan and record the score in the app.

The scoring of the plough pan follows the Visual Soil Assessment[3] methodology and in which it is described as follows:

Good condition – no tillage pan with friable, clearly apparent structure and soil pores throughout the topsoil.

Moderate condition – moderately developed tillage pan in the lower topsoil showing clear zones of consolidation but including areas with weakly developed structure, cracks, fissures and a few macropores.

[3] For photo examples see the Field Guide: VSA field guide » Manaaki Whenua (landcareresearch.co.nz)

Very firm to hard – well-developed tillage pan in the lower topsoil, showing severe consolidation with no structure, no macropores and few or no cracks.

3. Cut sides of the block, then insert spade at the north side to excavate full intact block if soil conditions allow.
4. Carry out evaluation as directed in Appendix 4.
5. Take a clear photo of the block with tape measure with point ‘0’ at the soil surface level. Take the photo from above with iPad kept horizontally, avoid shading the block with your body. Use the ribbon staff tape, not the tape shown (Figure 17).
6. If VESS is not possible record reason in the app.

Figure 17: Examination of soil structure in a block excavated using a spade. a) visualisation how deep the spade should be inserted next to excavation hole of sample W b) excavated block c) showing depth of hole in relation to length of spade blade d) block loosened up to visualise soil structure before taking a photograph (detailed method in Appendix 4).

3.11 Soil samples collected using soil corers

3.11.1 Split core sampler –general principles

The corer used in the survey is a 2-inch (external diameter) modified split core sampler produced by Art's Manufacturing and Supply (AMS), Inc. The corers are driven down using slide hammers (Figure 18).

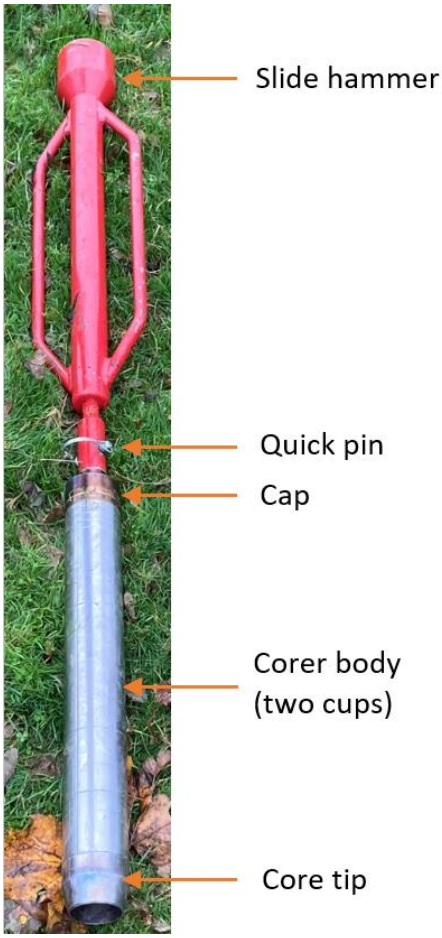


Figure 18: Corer connected to a slide hammer (heavier version of hammer shown)

Always clean equipment before starting at a new plot as described in the section 3.16.

Before assembling the corer, to ensure the parts fit together, clean the threads in cap and coring tip, and grooves in the cups of the corer with a wire brush (Figure 19).

Figure 19: Cleaning the threads inside the core tip with a wire brush to remove excess soil

When connecting the hammer and the corer, place both horizontally on the ground, align two parts of the coupling and join them with the quick-pin.

When using the hammer, lift it not to briskly, without hitting the top limiter, so as not to pull the corer up at each lift. Let the hammer drop by its own weight. Control its direction to maintain vertical alignment of the corer. You can use the hammer standing or kneeling (Figure 20). Repeat as many times as needed until the marker for the desired depth is level with the soil surface. When checking depth against the marker lean above the soil and look from the side.

Look from the side to read the depth correctly, not from the top

Figure 20: a) Soil sampler driving core into the soil using slide hammer (10kg hammer). Lighter version available for upland and remote sites where use of trolleys is not possible. b) corer inserted at full depth of 45cm (sample length) with hammer still attached.

If the soil surface is uneven or when working on a slope, use the median of the maximum and minimum height as reference point for how deep the corer should be inserted (Figure 21).

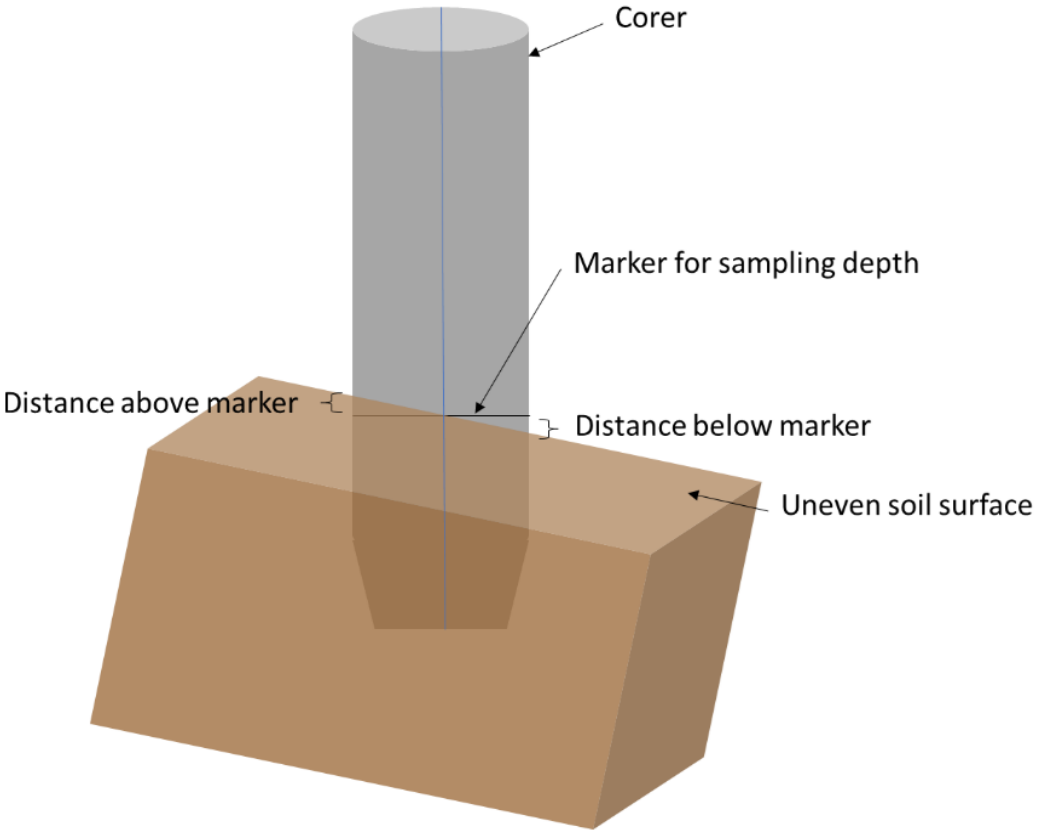


Figure 21: Diagram to show how the corer should be inserted when soil surface is uneven. Ensure that the distance above the marker equals the distance below the marker on soil corer.

In soils with surface litter, before samples A, B, C are taken, remove loose, (undecomposed) litter layer (L horizon). Record depth of the organic layer if deeper than 2cm including the F horizon (Figure 22).

Figure 22: Soil with a fermented litter horizon over a mineral horizon: a) loose litter removed from the surface b) F horizon with a piece of mineral horizon attached c) thickness of the F horizon.

The fermented litter horizon typically will overlay mineral, organic, peat or peaty horizons. The peat or peaty horizons will be either be an H horizon – an organic horizon developed in aerobic conditions, or O horizon –an organic horizon developed in waterlogged, low-oxygen conditions. The depth of organic layer to be recorded includes F, and H or O horizons.

When thick layers of moss are present, lift the moss before sampling. Replace the moss after closing the hole with a spade at the end of sampling (Figure 23).

Figure 23: Sampling point with moss on surface before (a) and after lifting (b) the moss.

It is normal for the soil to get compressed during coring (Figure 24 a). The sample can also be shorter than the sampling depth if it slides out during lifting of the corer. Sample recovery from the hole is checked by measuring the depth of the hole immediately after the core is taken out (Figure 24 b).

Figure 24: a) Illustration of sample compression b) Illustration of measurement of the sampling hole to check for sample recovery

To be able to recover full sample ABC, the depth of the hole must be greater than 40cm. For sample M, the minimum depth is 15cm. If the depth of the hole is less and it is not due to rock, resampling needs to be attempted with modifications to

sampling and extraction methods. The identification of the modifications required for the soil type and conditions at the time of the survey is to be carried out at the first sampling point in each plot. This ensures that the bias in sample properties due to method is similar in all sampling points and reduces within-plot variability of data (Table 2). In some plots, due to high inherent variability of the soil type present, modifications of sampling methods for some points only may be unavoidable.

Table 2 Modifications to the sampling method that can be applied if there are problems with sample recovery

Issue	Solution
Thick root matt combined with low strength of the soil, sampler pushing the surface down rather than cutting through it.	Stony soils: use standard tip (a, Figure 25) place the corer on the surface and cut soil around the core with a knife; do not use serrated tip.
	Stoneless or very slightly stony soils: use serrated core tip (b, Figure 25).
Sample sliding out of the core due to low strength and low density of the soil, e.g. soft and wet humified peat, alluvial sediments, high water table etc.	Excavate side of the corer using a spade, tip the core towards the horizontal position without lifting it. Then lift in a direction close to horizontal. In very soft and wet soils this may not be enough and you may need to reach the bottom of the core with your hand or trowel and gently lift the corer whilst supporting its lower end to prevent sample from falling out. In this scenario, exceptionally, due to disturbance that will be caused by excavation, you can take sample M before taking sample ABC (keep the same locations of the samples as in the diagram however).
Sample falling out of the core due to low strength and loose consistence, but otherwise firm soil, e.g. dry sand and gravel with few roots binding it together.	Use core catcher with core catcher tip and split liner (items: c, d, e, in Figure 25). Experiment with cutting some of the core catcher flaps out if resistance of the core catcher when driving the corer down is too high.
Shallow soil (on bedrock)	Record depth to bedrock in the app if shorter samples collected.
Extremely stony (skeletal) soil	Collect soil in the 15cm re-packing steel tube (liner) from the depth intervals for samples A, B, C (fill to 10cm only), and M.

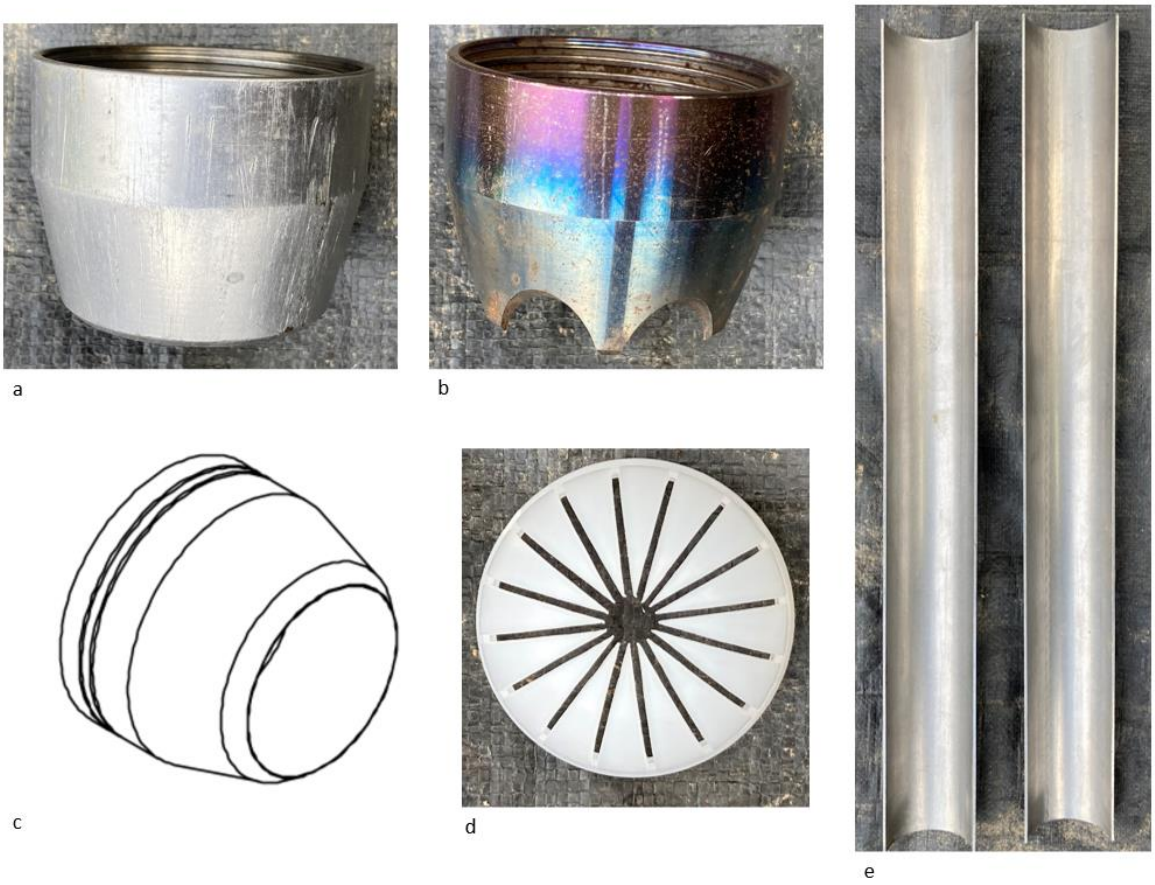


Figure 25: Core tip types: standard (a), serrated (b), core catcher tip (c); core catcher (d), split liner (e)

When sampling minimise treading on soil surface. Do not walk on the area to the north and north east of the coring points in case repeat cores need to be taken. Soil samples are taken from fixed depth, in set order and using constant volume at specific points (Figure 26).

Sample	Description
Z	Mesofauna (0-8cm)
ABC	Physiochemical (A = 0-15cm, B = 15-30cm, C = 30-40cm)
M	Microbes (0- 15cm)
rArB	Mycorrhiza (rA = 0-15cm, rB = 0-30cm)

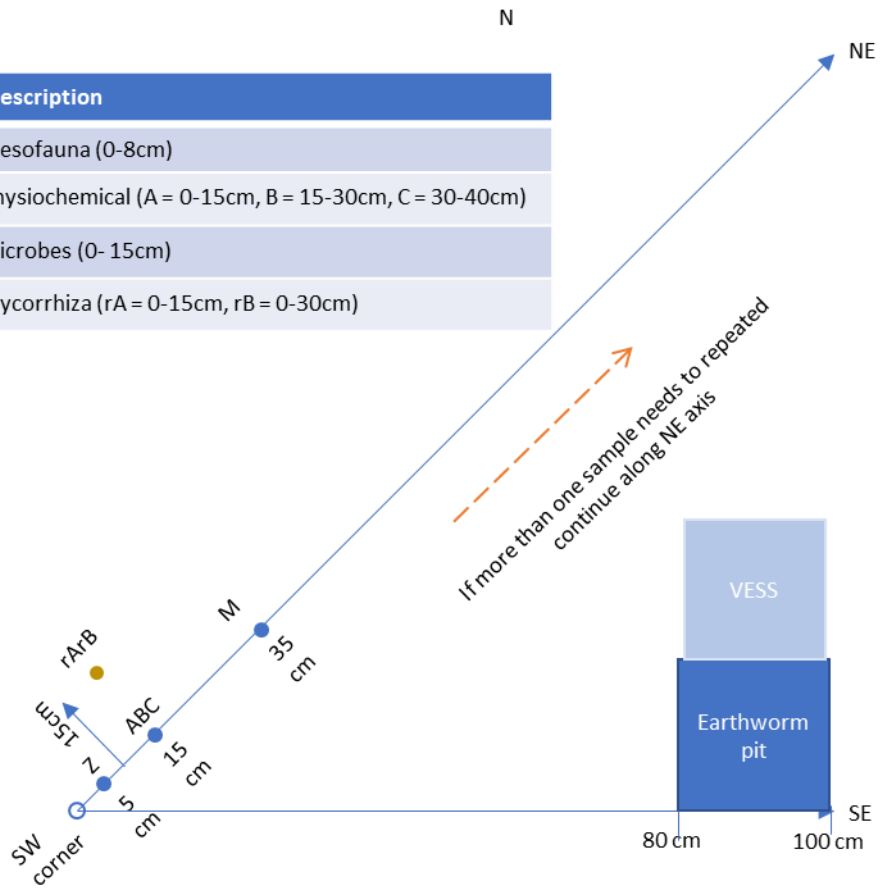


Figure 26: The diagram illustrates the arrangement of sample types at a single sampling point. Core samples (Z, ABC, M) are represented by blue circles, while rArB is denoted by a dark yellow circle. The earthworm pit (sample W) is indicated by a dark blue square, and the VESS block is marked with a light blue square. The distances from the SW corner of the sampling point are indicative minimum distances. In cases where earlier sampling causes disturbance, it may be necessary to place the sample further along the diagonal. For re-sampling, the minimum distance for moving the coring points along the diagonal is 5cm for sample Z and 15cm for samples ABC and M.

3.11.2 Sample Z

Sample Z is a soil sample taken for analysis of soil mesofauna – invertebrates measuring between 0.1mm and 2mm, which live in the soil or in a leaf litter on the soil surface. Sample Z is collected in a split liner (split steel cylinder) with a fabric mesh on top. This minimises disturbance and prevents loss of mesofauna specimens. After extraction the sample is sealed on both sides with plastic caps. All four samples from one plot are placed in one sample bag.

Key requirements for collection of this sample are:

- Minimising disturbance (compressing the core)
- Preventing escape of mesofauna specimens from the sample
- Keeping sample cool following collection.

The fabric used for covering the top of the core is a thick calico cotton type. The size required for each sample is a square 7cm by 7cm (it has been tested that this is the size that works). The uncut fabric will be provided, you will need to cut the required number of squares before the surveys.

When the sample liners are used for the first time, they may have some residue from manufacturing. Please wipe them with paper with some Propellar on it (when preparing a batch of liners for the survey wear gloves as the liners have sharp edges). When you receive the liners back from Fera to reuse them, they will be clean and there will be no need to wipe them.

The step-by-step procedure for collecting sample Z is as follows:

1. Assemble the corer with the spacer liner inside (Figure 27).

Figure 27: Spacer plastic tube in the corer before assembly (steel spacers provided in your toolset).

2. Insert the split liner with the fabric mesh on top. When placing fabric inside the corer push it inside a little first so that it is not stretched. Then push the split liners inside, with the split of the liners aligned perpendicular to the split of the corer, as shown in Figure 28.

Figure 28: a) Inserting split liner into the corer before taking sample Z (spacer liner has already been placed inside the corer) b) Liner to take sample Z inside the corer with fabric mesh between the sample liner and the spacer.

3. If thick root mat is expected and the soil is not stony, use serrated core.
4. Place the corer in the vicinity of the coring point (sample Z; Figure 14).
5. If possible, part the vegetation by hand rather than cut (Figure 29 a). If vegetation cannot be parted or is very woody, cut it with scissors or secateurs down to the plant litter layer (dead plant material laying on the ground). Leave the litter layer undisturbed, it must be included in the sample.
6. Lift the corer up and place on the soil surface immediately after the previous step. (Figure 29 c) to prevent any specimen to be measured escaping.
7. If thick plant litter or root mat is present and you cannot use serrated core because of stones, cut around the core vertically using scissors or a knife. This prevents the corer pushing down the soil rather than cutting through it.
8. Drive the core down to a depth of 8cm (Figure 29 b and d) measured from the top of gently flattened (just to enable measurement), but not compressed, litter layer.

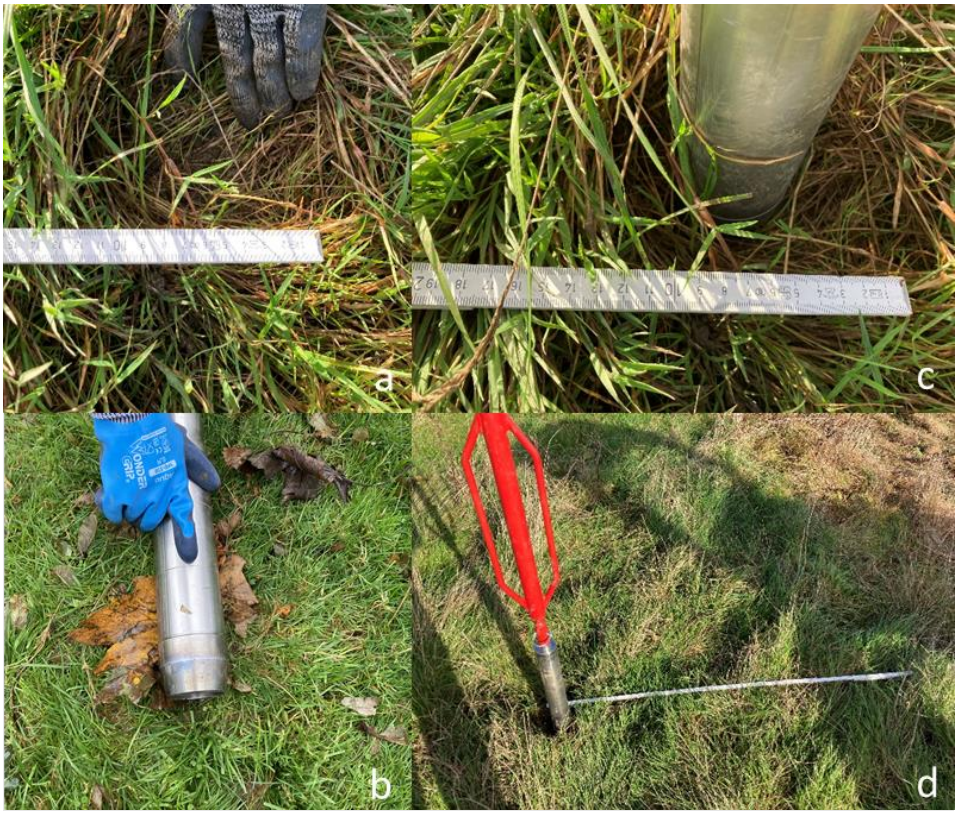


Figure 29: Examples of placement of corer for sample Z a) low and soft vegetation parted by hand b) 8 cm mark on corer – sampling depth c) placement of corer on surface d) soil corer in position before sampling.

9. After reaching the depth of 8cm, detach the hammer from the corer.
10. Tip the corer to c. 30° angle from vertical to break it from the base of the soil, without disturbing surrounding soil too much. Do not turn.
11. Lift the corer and check the end of to ensure that the sample has not been pulled back out during lifting (Figure 30 a).
12. Undo both ends and place the corer on a clean plastic sheet. Open the corer but do not take out the sample yet (Figure 30 b).

Figure 30: Sample Z after the sample has been taken a) check bottom of corer if soil has been pulled out b) sample slightly pushed out of corer

13. Examine the sample, look at the bottom and top of the sample without opening the split liners and without removing the fabric. If upon examination, it appears that part of the core has been left in the ground because of thick roots, lack of cohesion, or stones, then resample at an alternative point. Further along the NE axis of the sampling point (Figure 14).

14. Whilst the sample is still in the corer trim off excess soil from the base of the sample without compressing or smearing the base.

15. Have the plastic caps for the sample ready. Stretch the plastic cap using both hands so that it is easier to place on the sample with less force.

16. Push the sample out of the corer so that the split liner is half-way out of the corer.

17. Holding the sample in place to ensure the halves of the liner do not move, put the first plastic cap on the bottom of the split liner. If pushing of the cap requires too big a force, make a c. 5mm straight cut in the side of the cap to alleviate this.

18. Lift the sample out of the corer, keeping the mesh fabric on top of the sample in place.

19. Cover the top of the sample with the second plastic cap, keeping the fabric between soil surface and plastic cap.

20. Place sample in the labelled bag for sample Z for this plot.

21. Once all plots of a monad have been sampled, please make sure that sample bags are carefully folded down multiple times (e.g. at least three) at the top, and are stapled a sufficient number of times as to keep the contents contained.
22. Scan the barcode of the label on the bag at each sampling point. This begins the process of sample tracking. The barcodes will be used for unambiguous sample identification in the laboratories.
23. Place sample bag with Z sample in the cooler bag immediately after collection.
24. Record the attempt at which the core was collected and the type of the core tip used.
25. The sample requires special handling when back at the car (see section 4 below).
26. Remove excess soil residue from the corer body, grooves and threads using knife and wire brush.
27. Do not mix soiled tools with clean tools in the toolbox, use polythene bag for carrying soiled tools between sampling points in the same plot if needed.
28. Before moving to the next plot, after taking all samples, clean and disinfect tools as described in section 3.16 below.

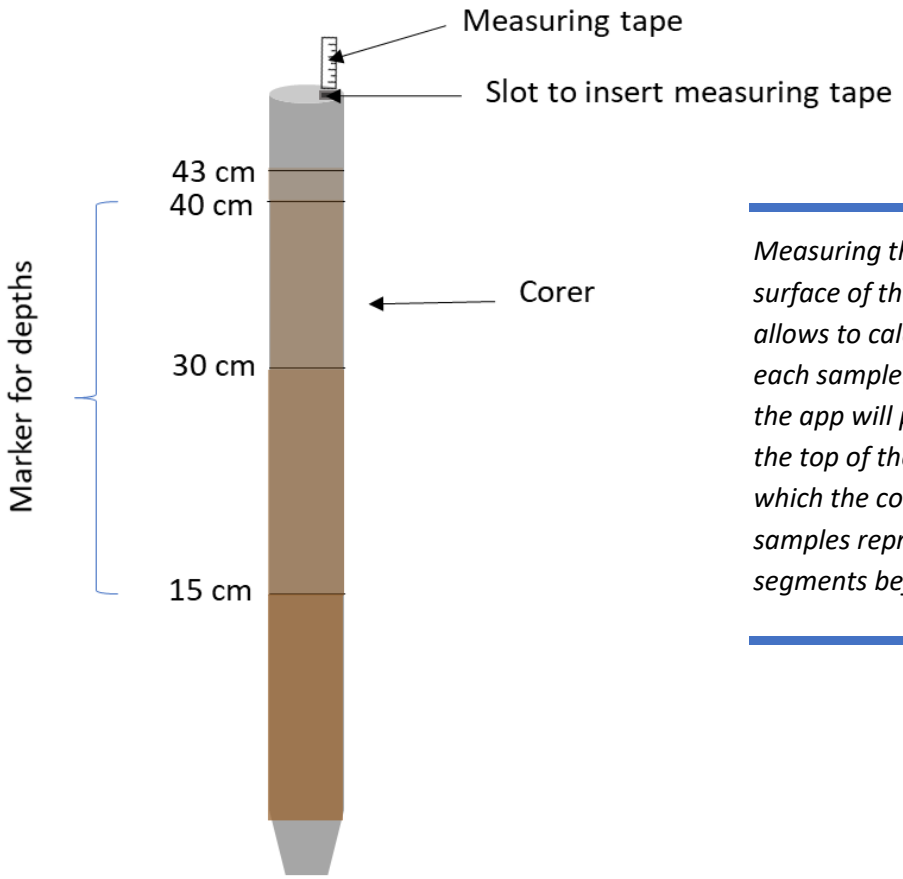
3.11.3 Samples A, B, and C

Samples A, B, and C are taken from a single continuous core. The samples are used for physicochemical analysis, including determination of soil organic carbon content. They are composite samples – for each sample type, four samples from a plot are combined in one bag. A key requirement for these samples is accurate collection of their full volume.

The step-by-step procedure for collecting samples A, B, and C is as follows:

1. Locate the point of coring (Figure 14; Figure 32 b).
2. Cut the vegetation and remove loose litter down to the soil surface. Matted, fermenter litter, if present, is included (Figure 32 a).
3. Place the corer tip on the surface of the soil. If thick root matt is present and serrated corer cannot be used due to stoniness, cut roots vertically at the edge of the corer.
4. Drive the corer down to 15cm depth. Stop at 15cm mark. Insert measuring tape through slot on top of corer and measure distance from top of corer to soil surface in corer (Figure 31). Record depth in app.

5. Continue to drive corer down to 30cm depth. Stop at 30cm mark. Insert measuring tape through slot on top of corer and measure distance from top of corer to soil surface in corer (Figure 31). Record depth in app.
6. Continue to drive corer down to 40cm depth. Stop at 40cm mark. Insert measuring tape through slot on top of corer and measure distance from top of corer to soil surface in corer (Figure 31). Record depth in app.



Measuring the distances between the surface of the cap at each depth allows to calculate compression of each sample. Formula embedded in the app will provide distances from the top of the core (soil surface) at which the core is to be cut to obtain samples representative of the soil segments before compression.

Figure 31: Schematic drawing of measurements taken when taking samples A, B and C to account for sample compression at 15, 30 and 40 cm depth.

7. Continue to drive corer into soil until 43cm marker is aligned with the soil surface (Figure 32 c, d).
8. Remove the hammer, attach the extension with T-handle and rotate by 360° clockwise to detach the soil core inside the corer from the soil below.
9. Pull the corer out vertically using the lifting jack.

Figure 32: a) Vegetation removed from sample area b) Corer placed at 30 cm on the NE axis on the soil surface c) 43 cm marker on the corer d) Corer inserted to 43 cm depth.

10. Check sample recovery by measuring depth of the hole. It should measure more than 40cm. Record in the app for the attempt at which the sample was taken.

11. If necessary, repeat sampling using one of the modifications of the coring and lifting methods (for guidance see Table 2). Continue with the method chosen in the first sampling point, if possible.

12. If sampling depth is less than 40cm due to rock, record the sampling depth reached in the app in the ‘Depth to rock sample ABC’ section.

13. Clean soil sticking to the corer from outside using spatula. Do not include soil from the outside in the sample. Minor soiling of the corer is acceptable.

14. Place the corer on clean plastic bags, 3 bags on top of one another. This will help with transfer from the corer into the sample bag without mixing segments and loosing parts of sample.

15. Undo the cap and tip. Use the pipe wrenches if needed. Undo the cups.

16. Check if the sample is not distorted, look for discontinuities caused by large stones pushed down by the corer through soft soil and other anomalies.

17. If the core is acceptable, record the core tip and lifting method used in the app.

18. Take a picture with colour correction card and tape measure ribbon staff placed next to the core visible (align point zero of the tape with soil surface in the core) before splitting the core. Using the lengths of segments calculated by the app, align edges of the underlying plastic bags with them, so that each segment is on top of a different bag.

19. Measure and mark distances calculated by the app on the core using the tape measure. Adjust bags under the corer so that any soil falling out of a given segment is collected.

20. Split samples into A, B, and C segments using spatula (Figure 33 a and b).

Figure 33: a) Example of compression in sample A; b) segmented sample.

21. Place sample bags next to the core in the order of A, B, and C from the top to the bottom. Scan the barcodes of the bags using the app (at each sampling point).
22. For each sample, starting with sample A, open the correct sample bag. Place the end of the corer into the bag. Slide the sample into the bag using spatula.
23. Slide remaining residue of the sample from the bag under the corer into the bag.
24. Once all plots of a monad have been sampled, please make sure that sample bags are carefully folded down multiple times (e.g. at least three) at the top, and are stapled a sufficient number of times as to keep the contents contained.
25. If any sample is spilled onto the ground when sampling and not collected in full (quantitatively), the coring must be repeated.
26. Place the soil from below the sample C back into the coring hole.
27. Remove excess soil residue from the corer body, grooves and threads using spatula and wire brush. Re-assemble the corer.
28. Record the attempt at which the core was collected, the type of the core and tip used, and the method of extraction in the app.
29. Do not mix soiled tools with clean tools in the toolbox, use polythene bag for carrying soiled tools between sampling points in the same plot if needed.
30. Before moving to the next plot, after taking all samples, clean and disinfect tools as described in section 3.16 below.

3.11.4 Sample M

Sample M is a soil sample taken for microbiological and other analysis on fresh soil. It is a composite sample – four samples from a plot are combined in one bag. Key requirements for this sample are:

- Avoidance of cross-contamination with soil from another plot
- Keeping sample cool following collection.

The step-by step procedure for collecting sample M is as follows:

1. Sample M will be taken 35cm from the SW origin (Figure 14).
2. Before taking the sample, remove the vegetation with scissors or secateurs but, unlike for samples ABC, do not remove plant litter, if present (Figure 34).

Figure 34: Removing vegetation with scissors.

3. If plant litter is present, do not remove it, but after placing the core on top of it, cut it around with scissors or a knife (this can also help with thick root matt) to prevent the corer from pushing it down. This may not be required if you can use serrated core tip (fine-textured, stoneless soils).

4. Drive the corer down until the 15cm marker (Figure 35) is level with the soil surface (if loose litter layer is present, measure from its base).

Figure 35: The marker indicating 15cm sample length.

5. Detach the hammer and attach the extension with ‘T’ handle.
6. Turn the core 360° clockwise.
7. Lift the corer vertically. Use lifting jack if necessary.
8. Measure the length of the hole after the sample has been taken, it should be more than 15cm.
9. If necessary, repeat sampling using one of the modifications of the coring and lifting methods (for guidance see Table 2).
10. If sampling depth is less than 15cm due to rock, record the sampling depth in the app.
11. Clean soil sticking to the corer from outside using spatula. Do not include soil from the outside in the sample. Minor soiling of the corer is acceptable.
12. Place the corer on a clean plastic sheet and open the corer.
13. Cut the length of the core looking at where the cup ends. If the sample does not slide out during lifting, the cut should fall right at the end of the cup (Figure 36).

Figure 36: Sample M, photo illustrating minor compression of the sample.

14. If the sample slides out a little during lifting, but the depth of the hole is still more than 15cm. The sample can be made up with the part of the sample in the tip or protruding out of it. To take correct sample length in such case, subtract 15 from the depth of the hole. The value will be the thickness of the bottom part of the core that is not to be included in the sample.

15. Before taking the sample out of the corer take a picture with colour correction card and tape measure ribbon staff placed next to the core visible (align point zero of the tape with soil surface in the core).
16. Place the M sample bag next to the core. Check if it is correct. Scan the barcode using the app. Do this at each sampling point.
17. Transfer the sample into the bag. Check the label on the bag to ensure it contains sample M.
18. Place sample M in the cooler bag to keep away from direct sunlight or high temperature.
19. Once all plots of a monad have been sampled, please make sure that sample bags are carefully folded down multiple times (e.g. at least three) at the top, and are stapled a sufficient number of times as to keep the contents contained.
20. The sample requires special handling when back at the car (see section 4 below).
21. Remove excess soil residue from the corer body, grooves and threads using knife and wire brush.
22. Do not mix soiled tools with clean tools in the toolbox, use polythene bag for carrying soiled tools between sampling points in the same plot if needed.
23. Before moving to the next plot, after taking all samples, clean and disinfect tools as described in section 3.16 below.

3.11.5 Sample rA and rB

Two samples are taken for mycorrhizal sampling, sample rA (0 to 15cm) and sample rB (15cm to 30cm). They are taken using the 2cm diameter Oakfield tube corer (Figure 37). The samples rA and rB are taken from the same four sampling points selected for the rest of soil samples. Unlike other samples, each rA and each rB sample are placed in individual bags. There will be four bags with rA samples and four bags with rB samples, eight bags in total per soil plot.

Figure 37: The small corer for mycorrhizal sampling has a T-handle, extension rod, foot jack and soil sampling tube.

24. Ensure the soil corer has been cleaned and disinfected if starting sampling in a new plot (see section 3.16 below).

25. Take sample in two steps, first 0 to 15cm then 15 to 30 using the same hole. This ensures the samples represent two soil depth sections accurately.

Figure 38: a) The small corer with 15 and 30 cm depth points marked, note the points are NOT where the stippled factory markings are (these are in inches). It is suggested that 15 and 30cm depths are marked on the corer using a marker pen and then more permanently with metal hacksaw for accurate sampling. b) Corer inserted to 15cm depth mark before extracting sample rA

26. Cut the vegetation at the point of core entry into the soil.
27. Place the soil corer tip on the surface of the soil at a right angle to the soil surface.
28. Push the sampler by applying pressure intermittently on the foot jack and handle until the 15 cm mark is levelled with soil surface (Figure 38). Maintain right angle between the corer and the ground as you apply pressure, this avoids bending/damaging the corer. Take extra care when sampling stony or hard soils as corer may get twisted when strong force is applied.
29. Rotate the corer by a full turn.
30. Lift the corer by pulling up slowly. Do not rock sideways as this bends/damages the corer.
31. Measure the depth of the hole to check if sample has been fully extracted (Figure 39).

Figure 39: Measuring depth of hole to check if sample has been fully extracted for rA; if full extraction not possible record this in the app and mark on the bag (if conditions allow)

32. The resulting core should be about 15cm long. If the core is shorter and it is not because of compaction, then resample (Figure 40).

Figure 40: Sample rA after extraction, note compression.

33. Scan the barcode on the labels of the bag for sample rA of the sampling point and place the sample into the plastic bag. Complete at each sampling point with separate bags. If needed, use a spatula or butter knife. Check the tip of the corer for any remaining part of sample rA.

34. Insert the corer into the same hole where sample rA was collected to collect sample rB (15 to 30 cm).

35. Push the sampler by applying pressure intermittently on the foot jack and handle until the 30 cm mark is levelled with soil surface (Figure 41). Maintain right angle between the corer and the ground as you apply pressure, this avoids bending/damaging the corer.

Figure 41: a) Sample inserted to 30cm to take sample rB in the same hole sample rA was taken from. b) Close-up of correct depth for sample rB – note black mark below the stippled factory mark.

36. Measure the depth of the hole to check if sample has been fully extracted (Figure 42).

Figure 42: Measuring depth of hole to check if sample has been fully extracted for rB; if full extraction not possible record this in the app and mark on the bag (if conditions allow)

37. If 30cm cannot be reached ensure you take as much soil as possible.

38. Rotate the corer by a full turn.

39. Lift the corer by pulling up slowly. Do not rock sideways as this bends/damages the corer.

40. The resulting core should be about 15cm long. If the core is shorter and it is not because of compaction or shallow soil, then resample (Figure 43).

41. Discard loose soil from above, as this is soil originating from above (Figure 43).

Figure 43: a) Sample rB after extraction, note loose soil originating from above the sample that needs to be discarded. b) Sample rB, soil fragments from above depth of 15cm separated, note slight sample compression.

42. Scan the barcode on the labels of the bag for sample rB of the sampling point and place the sample into the plastic bag. Complete at each sampling point with separate bags. If needed, use a spatula or butter knife. Check the tip of the corer for any remaining part of sample rB.

43. If 30cm cannot be reached ensure you get at least half of the length of the corer.

44. Per soil plot there will be four rA and four rB sample bags.

45. Take care when placing sample in bag and seal the bag as soon as possible to avoid dehydrating the sample, especially on a sunny day.

46. If 30cm could not be reached e.g. due to soil being shallow, record the length of the sample that is shorter in the app and on the bag (writing the top and end depth).

47. Ideally, each core will be 15cm long providing a 0cm to 15cm and a 15cm to 30cm depth soil core. However, if this is not the case make sure to write the exact length of the core on the label of the bag and record in the app. This will help measurements of soil volume.

48. If there is an air pocket (break) in the soil sample, it is likely because the lower part of the core has slid out of the corer. Try and resample, if the pocket is there again, make up the length of the sample dissected by the pocket with soil from below the pocket as if the sample was continuous.

49. Taking samples using the small corer may not always be possible due to high density of soil and high stone content. If taking rA or rB samples with small corer is not possible and if you have time to do so within your organisation's time estimates for this work the sample(s) can be taken using the large corer and following the same procedure as for sampling samples ABC. Find out at the first sampling point if use of the larger corer is needed to take samples rA and rB. Take the sample to a depth of 30cm using the larger corer. Use the same process of adjustment for compression as for taking samples ABC but take half of the sample. To do this, halve the sample along the edge of the large corer cup. Use serrated knife to cut through roots. Then split the rA and rB samples in length segments given in the app. If stones prevent halving, remove them and do not include in the sample.

50. Record the type of corer used in the app.

51. Place sample bag with Z sample in the larger plot bag (containing all samples from the plot) and the cooler bag immediately after collection to avoid dehydrating and overheating it.

52. If some samples could not be collected, include empty bags for this plot in the larger bag containing all individual bags from this plot.

53. Once all four plots of a monad are sampled, please make sure that sample bags are carefully folded down multiple times (e.g. at least three) at the top, and are stapled a sufficient number of times as to keep the contents contained.

54. Fill in the crib sheet provided by Fera and send to Kew with the samples. Note down if monad was completed or how many plots are remaining.

55. The sample requires special handling when back at the car (see section 4 below).

56. Remove excess soil residue from the corer body, grooves and threads using knife and wire brush and brush/place uncollected excess soil spoils back into the hole.

57. Do not mix soiled tools with clean tools in the toolbox, use polythene bag for carrying soiled tools between sampling points in the same plot if needed.

58. When moving to another plot, after taking all samples, clean and disinfect tools using Propellar (alcohol) disinfectant as described in section 3.16 below.

59. Record information about the plot on the paper form for samples info form (Appendix 5) and any unavoidable deviations from the protocol. The samples must be cooled after collection and kept cool until processing at the laboratory (see section 4.4). Do not freeze.

3.12 Identifying peat and measuring peat depth

1. To identify peat follow the training and guidance provided in Appendix 6. Use observations from coring and pits.
2. On sites with organic horizon (H or O) thicker than 2cm, measure peat depth using the probe and record it.
3. Peat depth is to be taken in the SW corner of the sampling point using a fiberglass ‘utility’ probe.
4. When measuring peat depth follow the method described in Appendix 7.
5. Depth is recorded to the nearest centimetre in the app. The depth fields will appear in the app if you selected yes for the presence of peat.

3.13 Finalising Survey123 app data collection form

Submit the survey by pressing the tick at the bottom right-hand corner of the screen. A pop up will appear. While you are in the field with no access to Wi-Fi select the ‘Save in Outbox’ option. Later, when you are connected to Wi-Fi go to your outbox from the home screen where you would usually choose to collect data. In the outbox press the send icon in the bottom right of the screen to send all the surveys. Please do this at the end of every day.

3.14 Returning soil surface to acceptable condition after sampling

You must return the soil profile and soil surface close to it’s the condition it was in before sampling took place. This is to minimise disturbance and prevent injury to animals. See examples of surface condition before and after sampling in Figure 44.

1. Use the spade and disturb the soil around the coring points to close them off. The spade needs to be inserted to full length of the blade if possible to disturb soil well below the surface so that the hole does not re-open itself later.
2. Backfill the earthworm and VESS pits keeping to the original order of soil layers.
3. Place turf and disturbed turf on top.
4. Tread on the soil to even out the surface as necessary.
5. If sampling at a location with moss, replace the moss lifted before sampling.

6. Take a photo of the surface after sampling using the app, in the same way the ‘before’ photo was taken (Figure 44).

Figure 44: Soil surface in a sampling point (1 by 1m area) of arable land in wet weather condition before sampling (a) and after (b) sampling and soil surface in a soil sampling point (1 by 1m area) of grassland before sampling (c) and after sampling (d).

3.15 Clean-up **within the plot**

1. Clean used tools with spatula and wire brush to remove excess soil.
2. When moving between sampling points keep soiled tools separately from clean tools by either carrying them separately or placing into a polythene bag.

3.16 Clean-up between the plots

To avoid cross-contamination of samples from different plots and prevent spread of animal and plant diseases, it is important to clean the tools before starting work in a new soil plot. Clean all tools that have had contact with soil samples including:

- Soil corer cap, coring tips, core catcher and liners
- Small soil corer
- Spatula, knife, scissors, secateurs, trowel
- Spade

- Thick plastic bags that are placed under the corers when collecting samples.
- Thick plastic bags used for placing soiled tools used in the plot (dispose of if cannot be cleaned)

The process should be carried out after finishing work in a plot, before moving to the next one:

1. Remove bulk of soil residue from corer body, cap and coring tip using the spatula and wire brush.
2. Remove bulk soil from other used tools using spatula and wire brush
3. Use water sprayer and the wire brush followed by a soft brush to remove the remainder of soil residue.
4. Clean the wire brush with water to remove soil residue from it.
5. Place all rinsed tools on clean large plastic bag or clean tarpaulin.
6. Spray the tools with the Propellar disinfectant.
7. Clean and disinfect working surfaces of the gloves.
8. Wipe the tools clean using paper towel.
9. Place clean tools in the toolbox or, if carried in the backpack, clean plastic bag.

When moving between different landholdings (even if you are unsure), clean the following equipment to prevent spread of animal and plant pathogens:

- Boots and knee pads
- Trolley wheels
- Tarpaulin used for VESS and earthworm search
- The tools used for clean-up.

The process is as follows:

1. Remove soil residue.
2. Spray with water to rinse soil residue further.
3. Spraying Safe4 disinfectant and leave on the surface.
4. Rinse and disinfect cleaning tools with water and Propellar (as they have direct contact with the soil sampling tools Safe4 is not suitable).

3.17 Clean-up back at the car at the end of the day

Use the same procedure for tools that have had contact with the soil during the sampling as for when moving to another soil plot (see 3.16).

For tools that do not have direct contact with soil samples:

1. Rinse with water and brush to remove soil and plant residues.
2. Rinse and brush the tarpaulin used for VESS and earthworm search.
3. Place tools on the tarpaulin and spray with Safe4 disinfectant cleaner solution.
4. Leave to dry overnight.
5. If there is any wet disinfectant residue remaining wipe with paper towels.
6. Transfer to clean toolbox or, if caried in backpacks, clean plastic bags to be placed in the backpacks.

4 Management of soil samples after collection

Unless instructed otherwise, you must post samples once a week.

Please be aware of your obligations under Animal and Plant Health Agency (APHA) guidance for moving soil: *"You must make sure any specified material you are moving under your authorisation is stored in 3 layers of packaging. At least 1 of the layers must be escape-proof and shatter-proof."* This means that you need to place all the individual bags in one more collective bag before placing the samples in the box. This way there will be three layers: the box, the outer large bag and the individual bags. More info at: https://www.gov.uk/guidance/moving-prohibited-plants-plant-pests-pathogens-and-soil.

Note that the samples are sent to three different locations.

4.1 Use of freeze blocks

Samples rA, rB, M, Z, and W must be kept cool after collection. In the field this is done by using insulated bags. After collection the samples are cooled by placing them into the insulated boxes with ice packs.

During the surveys the ice packs need to be checked daily and replaced with frozen ice packs from the cool box. On the day of postage, fresh ice packs (from the freezer, not the cool box) must be placed in the parcel box.

You will need to have a freezer at your office or home, to be able to freeze the ice packs before the surveys and have freshly frozen ice packs available for postage when your return from the surveys. A portable mini freezer has been provided.

Cooling of the samples is an essential part of the survey process. Lack of cooling of the samples would invalidate much of very laborious laboratory analysis. If you are unable to follow any parts of the process or you have concerns about effectiveness of it, please inform your survey coordinator before proceeding with the surveys.

4.2 Cooling samples rA, rB, Z, M and W

1. Freeze ice packs before the survey. The freeze blocks need a long time, minimum 24 hours, to freeze completely.
2. You will need four ice packs per plot. Typically, for a monad with 6 plots you will need a minimum of 40 frozen ice packs to keep samples cool in 6 boxes (two boxes per two plots, one with samples rA and rB, one with samples Z, M, and W). This is to have: 4 ice packs per box, 8 to replace after 24 hours in the samples collected on the first day of surveys, another 8 to replace after 24 hours in the boxes containing samples from the second day of the surveys. More ice packs will be required if working in warm weather. [details subject to refinement]
3. Place frozen blocks in the insulated cool boxes.
4. Before leaving for the survey place enough ice packs in the freezer to have freshly frozen ice packs ready to use on the day of postage when you return to base.
5. Build the insulated boxes that each box has fitting polystyrene sides (4 sides) and bottom and roof. If you have issues with missing polystyrene panels, please let your Fera contacts know – you should have 3 different sizes. The polystyrene is key to keeping the samples cooled in transit. [details to be included]
6. Every day upon returning to the van, place newly collected samples in an insulated box with the frozen ice packs.
7. At the accommodation store the boxes with the samples in a dark place away from sources of heat.
8. Replace ice packs first after 24 hours to cool the samples down quickly, then minimum every 2 days.
9. Replace the ice packs with freshly frozen ones (from the freezer, not from a cool box) just before the postage, even if it the ice packs have been replaced the day before. This is critical as the temperature during transit may be high.
10. Instructions for postage of samples are provided in the crib sheets. Please fill in the list of the samples on the crib sheet and place in the parcel boxes before postage.

4.3 Sample ABC

1. When you return to the vehicle, place samples ABC in the postage cardboard box.
2. At the accommodation, store the collected samples in a cool and dark place away from sources of heat.
3. Include a list with the number of samples and additional information using the crib sheet provided, follow the postage instructions given there and post the samples to NRM laboratories.

4.4 Postage of samples rA and rB

1. Replace the ice packs with freshly frozen ones (from a freezer) on the day of posting. This will keep samples cool during transit which keeps plant roots and mycorrhizal fungi alive.
2. Each box shall have a list of samples (use the crib sheet provided) with sample information and postage label.
3. Post samples no later than 12 noon on a Wednesday or Friday (no posting on Thursday) to: Laura Martinez Suz, Kew Gardens, Jodrell Laboratory, Kew Road, Richmond TW9 3DS.
4. When you post the boxes, you must send an email kew-ncea@kew.org.
5. In the email, inform them that the package has been sent and state the tracking information.
6. NE and Fera survey coordinator to keep Kew informed about the ID's of plots sampled [arrangements TBC].