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LUCAS 2018 - SOIL COMPONENT: Sampling Instructions for Surveyors

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Abstract

The European Commission launched a soil assessment component to the periodic LUCAS Land Use/Land Cover Area Frame Survey in 2009. Composite soil samples from 0-20-cm depth were taken, air-dried and sieved to 2 mm in order to analyse physical and chemical parameters of topsoil in 25 Member States (EU-27 except Bulgaria, Romania, Malta and Cyprus). The aim of the LUCAS Soil Component was to create a harmonised and comparable dataset of main properties of topsoil at the EU. The LUCAS Soil Component was extended to Bulgaria and Romania in 2012. Overall, ca. 22,000 soil samples were collected and analysed. All samples were analysed for percentage of coarse fragments, particle-size distribution, pH, organic carbon, carbonates, phosphorous, total nitrogen, extractable potassium, cation exchange capacity, multispectral properties and heavy metals. In 2015, the soil sampling was repeated in the same set of points of LUCAS 2009/2012 to monitor changes in topsoil physical and chemical parameters across the EU. The soil component was extended to points above elevations of 1000 m, which were not sampled in LUCAS 2009/2012. Furthermore, soil samples were taken in Albania, Bosnia-Herzegovina, Croatia, Macedonia, Montenegro, Serbia and Switzerland. The soil sampling was carried out following the instructions already used in LUCAS 2009/2012. Approximately 27,000 samples were collected and will be analysed during 2016 and 2017.

In 2018, a new soil sampling campaign will be carried out within the LUCAS framework. Soil samples will be taken in repeated points of LUCAS 2009/2012 and LUCAS 2015. The novelty of the survey is that new physical, chemical and biological parameters will be analysed. Key parameters for evaluating soil quality, such as bulk density and soil biodiversity, will be analysed. These analyses require specific methods of soil sampling, preparation and storage of samples. Furthermore, field measurements such as the thickness of organic layer in peat soils, and visual assessment of signs of soil erosion will be carried out in 2018. This technical report compiles the instructions for collecting the various soil samples and for performing field measurements in the soil survey of 2018. These instructions will be used for all LUCAS surveyors, to create a comparable database of soil characteristics all over Europe.

1 Introduction: Purpose of the soil sampling in the LUCAS Survey

The soil component has been incorporated in the LUCAS survey in order to create a harmonised and comparable dataset of soil properties and to improve the quality of soil modelling in Europe. The outcome of the soil component of the LUCAS is used for assessing the state and change of soil characteristics over time, updating the European soil database and supporting the development and implementation of EU land based policies.

In the LUCAS 2009/2012 and LUCAS 2015, soil samples were collected across Europe following a standardized sampling procedure and several physical and chemical properties were analysed in them. In the LUCAS 2018, sampling will be adapted in order to collect samples for the assessment of new properties: soil biodiversity, bulk density and thickness of organic horizon in peat soils.

Results of the various analysis and measurements will be published through the European Soil Data Centre (<http://esdac.jrc.ec.europa.eu/>). Should the land owner/land user ask to obtain a copy of the results of the soil analysis, it will be possible to do so, provided that full contact details are recorded in the Field Form.

This document contains three manuals:

- **Manual 1:** standard sampling for points where bulk density will not be determined
- **Manual 2:** sampling procedure for points where bulk density and soil biodiversity will be determined
- **Manual 3:** guidelines for soil erosion assessment

Surveyors will need to read carefully the manuals before going to the field.

2 Manual 1: Standard sampling for points where bulk density will not be determined

This manual describes the standard soil sampling procedure¹ for the analysis of core physical and chemical properties (analysed also in LUCAS 2009/2012 and LUCAS 2015). This sampling will be carried out in 18,500 LUCAS points. Surveyors will receive from their coordinators the list of the specific points before the survey.

If the LUCAS points are located in peats soils, surveyors will also need to measure the thickness of the organic horizon. Surveyors will receive from their coordinators the list of the points located in peat soils before the survey.

2.1 Equipment to collect soil samples

The surveyors will be equipped with the following material for each LUCAS point:

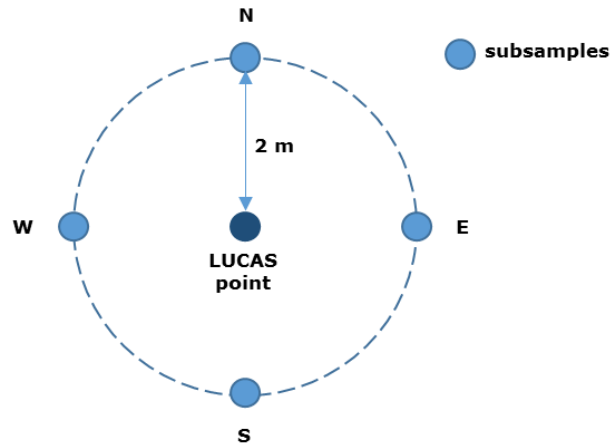
- a spade with a blade of approx. 20 cm
- a trowel (small spade)
- a bucket
- a meter stick
- 2 printed plastic labels per point
- 2 plastic bags and 2 ties per point
- a box to store and transport the samples
- mail boxes (appropriate to send 2.5 kg to 5 kg)

2.2 Collecting soil samples in the field

<p>1 <i>The sample is collected only if the point is reached!</i></p>	<p>Go to one of the LUCAS points of the list provided.</p> <p>For the soil survey, you need to be able to reach the exact point (observation distance ≤ 100 m) in contrast to the rest of the survey where you can also make observations from a certain distance.</p> <p>Soil samples should be taken within a maximum of 100 m distance from the LUCAS point and, if possible, in the same field where the LUCAS point is located. Soil samples have to be taken always from the same land cover class as observed at the LUCAS point.</p> <p>If it is not possible to take the soil sample in one LUCAS point due to inaccessibility problems (e.g. forbidden zone, wetland, impenetrable forest, barriers, access denied by landowner), then no soil sample will be collected for that point.</p>
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¹ Adapted from the Technical Documentation of LUCAS Survey in 2015 (accessed on 14/02/2017): <http://ec.europa.eu/eurostat/documents/205002/6786255/LUCAS2015-C1-Instructions-20150227.pdf>

2 Collect a composite sample of at least 500g of soil



A minimum of 500 gr ($\geq 0.5\text{kg}$) of topsoil has to be collected. This quantity should be representative of a larger area.

For this reason, the soil sample has to be a composite one, resulting from the mixture of 5 subsamples.

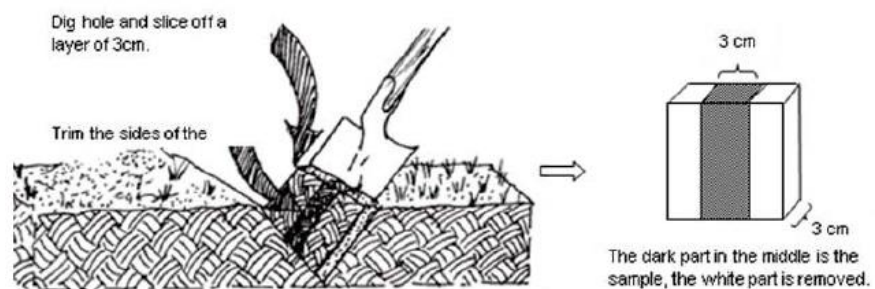
The first subsample will be collected in the LUCAS point, the other 4 subsamples will be collected at a distance of 2 meters following the cardinal directions (North, East, South, West)

3 Remove residues from the surface







Remove vegetation residues, grass and litter, if any, from the surface. Some fine roots and brownish organic material from the upper part of the soil can remain in the sample, as it is difficult to remove it completely.

4 Cut a slice of soil, and trim the sides



Using the spade, dig a (V shaped) hole in the central point to a depth of approximately 15-20 cm (the depth of the spade) as shown in the image.

	<p>Take a slice of soil with the spade. This slice is approximately 3 cm thick. Remove any remaining vegetation residues, stones, and litter.</p> <p>Now trim the sides of the sample, leaving a 3 cm sample on the spade.</p>
<p>5 Put soil in the bucket</p>	 <p>Put the soil in the bucket. Clean soil in excess from the spade.</p>
<p>6 Repeat the process in the other 4 locations (N, E, S, W)</p>	<p>From the central point, walk 2 meters to North, take a subsample (with the same procedure as before) and put the sample to the bucket. Clean excess soil from the spade and walk back to the central point.</p> <p>From the central point, walk 2 meters to East, take a subsample (with the same procedure as before) and put the sample to the bucket. Clean excess soil from the spade and walk back to the central point.</p> <p>From the central point, walk 2 meters to South, take a subsample (with the same procedure as before), and put the sample to the bucket, clean excess soil from the spade and walk back to the central point.</p> <p>From the central point, walk 2 meters to West, take a subsample (with the same procedure as before) and put the sample to the bucket. Clean excess soil from the spade and walk back to the central point.</p>
<p>7 Use the trowel to mix the 5 subsamples in the bucket</p>	<p>Use the trowel to mix the 5 soil subsamples together. By mixing the five subsamples, you get the required composite soil sample. In addition, clods and lumps are broken up.</p> <p>Remove any extra vegetation residues and litter.</p>
<p>8 Take at least 500g of soil and put it in the smaller plastic bag. Tag it and tie it.</p>	 <p>Take minimum 500 grams (about 5-heaped trowels full) of soil; place it in the plastic bag.</p>

	<p>Put the first available plastic label with a progressive number and an "A" sign printed on it inside this bag (white label).</p> <p>Close the bag using a tie.</p>
<p>9 500g of dry soil are needed for the analysis</p>	<p>In case the soil is too wet, collect more than 500 g to compensate for weight loss during the drying process.</p>
<p>10 Put the smaller plastic bag into the larger one. Tag again and tie it.</p>	 <p>Put the plastic bag in a second one.</p> <p>Put a label with the same progressive number as in step 8, but with a "B" sign on it inside the outer bag (white label).</p> <p>Close the bag using a tie. This is the sample to be shipped.</p>
<p>11 Register the label number in the Field Form</p>	<p>Record the progressive label number in the appropriate Field Form.</p>
<p>12 Take the soil photo</p>	<p>Put the bag next to the LUCAS point. Take a photo of the LUCAS point with the bag (keep the label visible) and as many as possible of the 5 holes clearly visible.</p>
<p>13 Take additional photo of the label</p>	<p>The label has to be clearly readable.</p>
<p>14 Complete the questionnaire on soil</p>	<p>Complete the questions on the Field Form related to signs of erosion, ploughing, crop residues and stones.</p> <p>See manual 3 for assessment of soil erosion.</p>
<p>15 Percentage of residuals and percentage of stones are evaluated on the 2m radius area that serves as base for soil collection.</p>	 <p>The surveyor has to estimate the percentage of the surface that is covered with vegetation residues and stones.</p> <p>This assessment is made on the 2m radius area that serves as base for the soil collection.</p> <p>The presence of stones in the soil does not need to be estimated. As explained above, stones should be taken out of the subsamples before making a composite sample.</p>

16 <i>Take additional pictures if needed</i>	If appropriate take any additional pictures (e.g. to justify that a subsample was not taken due to excessive amount of thorny shrubs).
17 <i>Make any necessary remarks</i>	If the procedure was not followed strictly, report any changes in the comments, explaining the reason (e.g. superficial sample as underground rock, hard due to tree roots). For free text remarks, the use of English is mandatory. Special characters are to be avoided.
18 <i>If applicable take note of the land owner contacts</i>	If the land owner/land user asks to obtain a copy of the results of the soil analysis, include his/her contact details (at least name, postal address and telephone number; if available, also e-mail address) in the Field Form.
Move to section 2.3 if the point is located in a peat soil. You will need to measure the thickness of the organic horizon in the peat soil.	



Before leaving the point

<i>Close the holes</i>	Using the soil in excess, close the 5 holes you did.
<i>Clean and store the material</i>	Clean the spade, trowel and bucket. This is important in order to prevent cross-contamination.
<i>Don't forget to take all material and samples with you</i>	Be aware that you do not forget material or samples collected on the field before leaving the point. Put the closed bag in the box used for transport the samples and put the box in the trunk of the car.

2.3 Measuring thickness of organic horizon in peat soils

1 <i>Reuse the holes already dug for the soil sampling</i>	Thickness of organic horizon will be measured in the 5 holes already dug for soil sampling. Start from the central LUCAS point.
2 <i>Dig one of the faces of the hole to 40 cm</i>	Digging a hole in peat should be easy. Dig one of the faces of the hole to a depth of 40 cm. Make sure that the face is vertical to the soil surface.
3 <i>Identify the organic horizon</i>	Organic horizon is formed from the accumulation of organic material deposited on the soil surface. They must have at least 20% of organic carbon and a thickness of 10 cm. The intense dark colour of organic horizon, compared to mineral horizons, make easy to recognize them.

Examples of sections through peats showing deep organic soils:



A soil profile showing organic horizon (dark layer) overlaying mineral layers (brown/orange layer):



We are looking to see if the dark layer is at least 40 cm thick.

4 Measure the thickness of organic horizon

Using a meter stick, measure the thickness of organic horizon from the top to the bottom of the horizon on the face of the hole.

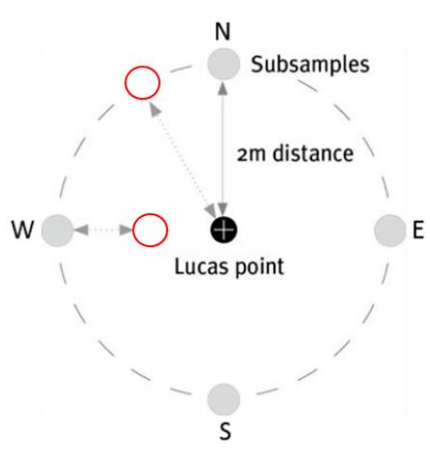
	Record the thickness in the Field Form. If the bottom limit of the organic horizon is below 40-cm depth, indicate it together with the measured thickness in the Field Form.
5 Take a picture	Take a picture of the face of the hole with the meter stick showing the scale and indicating the label number of the point.
6 Measure the thickness of organic horizon at the other 4 locations	The other 4 measurements will be done at a distance of 2 m from the central LUCAS point following North, East, South and West directions. Repeat steps 2 to 5 to do the measurements at each location.



Before leaving the point

Close the holes	Using the soil in excess, close the 5 holes you did.
Clean the material	Clean the material you used. This is important in order to prevent cross-contamination.
Don't forget to take all material	Be aware that you do not forget material or samples collected on the field before leaving the point.

2.4 Collecting soil samples in special cases

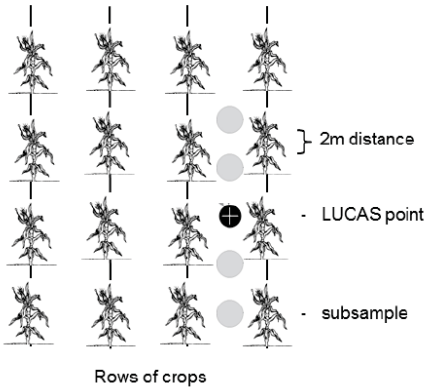
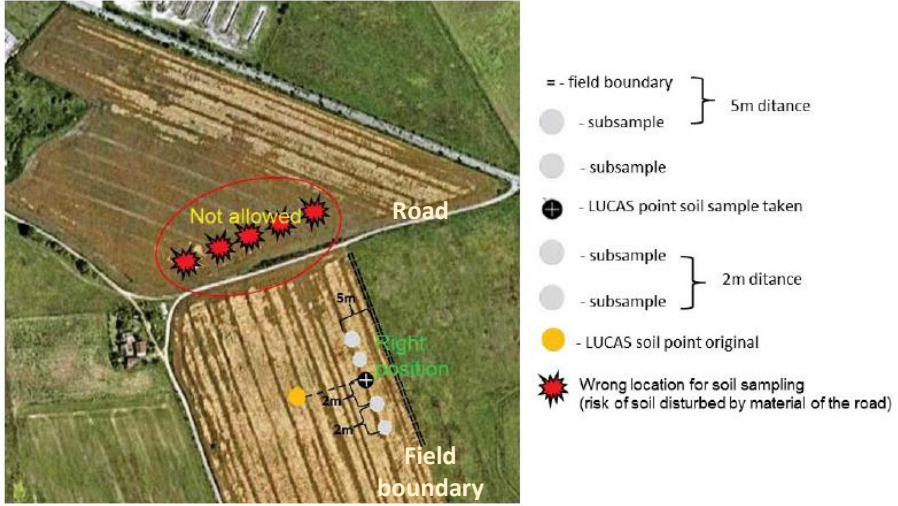
<p><i>If it is impossible to collect the subsample in the appropriate location, find a suitable location within 2m from the central point</i></p>	 <p>If in one or more of the 4 subsample locations belonging to the LUCAS soil point (central, North, East, South or West) it is not possible to collect a topsoil sample for any reason (accessibility problems, hardness of the ground, coverage – trees, houses etc.), walk along the dotted line until you find a suitable location or walk less than 2m from central point to take the subsample (represented by the small red circles).</p>
<p><i>If a sample is very wet, treat it as a normal sample. It has to be dried in the same manner</i></p>	<p>What to do if the sample is very wet or comes from a peat bog? Treat these samples in the same way as any other sample unless it is inaccessible or it is impossible to collect soil.</p> <p>Open the bag, roll down the sides and let the samples dry until you ship them.</p>

2.5 Collecting soil samples in case of difficult access

If access to the point is difficult because of:

- a risk of damage to crops,
- harvesting of a crop,
- on-going fertilizer application;

then apply one of the following methods of soil collection. The methods are presented by order of preference.

<p><i>Linear sample, at least 5m from the edge of the field</i></p>	 <p>The soil sampling is carried out inside the field, at 5m distance from the edge, in between the rows of the crops using a linear sampling pattern taking as the central one the LUCAS point (if not on the crop) or the one closest to the LUCAS point not on the crop (if LUCAS point on the crop).</p>
<p><i>Linear sample near the edge of the field</i></p>	 <p>If it is not possible to collect the soil sample in-between the rows of the crops, then the soil sample has to be taken near the edge inside the field as close as possible to where the original LUCAS point is located.</p> <p>Choose the edge closest to the LUCAS point and as farer as possible from any artificial surface (e.g. road).</p> <p>The same linear sampling pattern, as previously described for sampling in-between rows, has to be respected.</p>

<p><i>Linear sample when point is close to a road</i></p>	<p>The same linear sampling schema has to be applied if the LUCAS point is too near to the road. In this situation the soil sample can be taken between the rows or, if not possible, on the hedge of the fields with the same approach shown in the example above.</p>
<p><i>Use the remarks field</i></p>	<p>The need for using special arrangements for soil collection should be reported in the remarks section of the Field Form.</p>

2.6 Air-drying samples in the night's location

Before the shipment, soil sample need to be air-dried. Wet or damp samples may give unreliable results, if inappropriately stored.

<p>1 <i>Drying the sample</i></p>	<p>To dry the sample roll down the sides of both bags and open as much as possible at the end of the day's work when you have reached your night's location.</p>
<p>2 <i>Handle with care</i></p>	<p>Make sure that the samples do not fall over and contaminate each other.</p>
<p>3 <i>Close the bags carefully</i></p>	<p>Close the inside bag with a tie (check the label A is still inside). Close the second bag with a tie (check the label B is still in between the two bags and has the same progressive number as the other). Make sure all bags are properly closed in order to prevent contamination during transport when the boxes may not be kept upright all the time.</p>

<p>4 <i>Ship the samples to the supervisor</i></p>	<p>When 5 to 10 samples were collected (total weight around 2,5 to 5kg), they should be shipped to the supervisor (e.g. via mail). Tape the sides of the box for extra security.</p> <p>Buy a new box that you will use for storing the samples to be collected until you will come again to a post office and that you will use for the next shipment.</p>
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2.7 Impossibility to collect the soil sample

If the ground conditions prevent the surveyor from taking any soil sample in the LUCAS point.

<p><i>It is acceptable not to make a soil collection if certain conditions are met</i></p>	<p>Ground conditions that prevent the soil collection include:</p> <ul style="list-style-type: none"> - Abundance of rocks ($S \geq 50 \%$) - Excessive shrub cover that makes impossible to reach the soil (e.g. excess of thorny shrubs) <p>If it is not possible to collect soil, a compulsory remark has to be added in the Field Form for the point.</p>
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3 Manual 2: Sampling procedure for points where bulk density and soil biodiversity will be determined

This manual describes the sampling procedure for the determination of bulk density, analysis of core physical and chemical properties, and assessment of soil biodiversity. In 9,000 LUCAS points, soil samples will be taken for the determination of bulk density and analysis of core physical and chemical properties. Unlike the standard sampling, surveyors have to collect separate soil samples from the 0-10 cm and 10-20 cm depth increments in these points. Only in points located in Portugal, surveyors have to take soil samples also from the 20-30 cm depth increment. Besides, in 1,000 out of the 9,000 points, soil samples for biodiversity assessment will also be collected. Surveyors will receive from their coordinators the list of the specific points, indicating the samples that have to be collected in each one, before the survey.

If the LUCAS points are located in peats soils, surveyors will also need to measure the thickness of the organic horizon. Surveyors will receive from their coordinators the list of the points located in peat soils before the survey.

3.1 Equipment to collect soil samples

Surveyors will be equipped with the following material for the 9,000 LUCAS points:

- a spade with a blade of approx. 20 cm
- a trowel (small spade)
- a bucket
- a meter stick
- a flat-bladed knife
- metallic rings
- a rubber mallet
- a wood block
- a balance to weigh the samples
- a marker to write in plastic bags
- 7 printed plastic labels per point
- 6 small plastic bags and 1 big plastic bag with their ties per point
- a box to store and transport the samples
- mail boxes (appropriate to send 2.5 to 5 kg)

Additionally, surveyors will be equipped with the following material for the 1,000 points where samples for the assessment of soil biodiversity will be taken:

- alcohol in dispenser
- 2 pairs of plastic surgical gloves per point
- 2 printed plastic labels per point
- 1 plastic jar per point
- 1 polystyrene box (to ship the sample) per point
- 2 freezer packs per polystyrene box
- packing tape to close the polystyrene box
- address label for the polystyrene box

3.2 Before going to the field



Surveyors will need to tag 2 plastic bags per point with the following labels: Bag A 0-10 cm, Bag B 10-20 cm. Surveyors in Portugal have to prepare another plastic bag with the label Bag C 20-30 cm.

For the points where samples for the assessment of soil biodiversity will be taken, surveyors will need to:

1. put the 2 freezer packs into a freezer at least 24/48 hours before the sampling,
2. the morning before going to the field place the 2 freezer packs into the polystyrene box,
3. wash the sampling material (the small and large spades, the knife, and the bucket) using water and a paper napkin to remove soil from previous sampling.

3.3 Collecting soil samples in the field

<p>1 <i>Samples are collected only if the point is reached</i></p>	<p>Go to one of the LUCAS points of the list provided.</p> <p>For the soil survey, you need to be able to reach the exact point (observation distance ≤ 100 m) in contrast to the rest of the survey where you can also make observations from a certain distance.</p> <p>Soil samples should be taken within a maximum of 100 m distance from the LUCAS point and, if possible, in the same field where the LUCAS point is located. Soil samples have to be taken always from the same land cover class as observed at the LUCAS point.</p> <p>Collected samples have to be representative of a larger area than the LUCAS point. For this reason, composite samples, resulting from the mixture of 5 subsamples, will be collected.</p> <div data-bbox="486 1160 1181 1668" data-label="Diagram"> </div> <p>The first subsample will be collected in the LUCAS point; the other 4 subsamples will be collected at a distance of 2 meters following the cardinal directions (North, East, South, West).</p>
<p>ATTENTION: <i>Do not collect a sample in saturated peat soils</i></p>	<p>Soil samples can only be taken in the mature surface layer of the peat soil under unsaturated conditions.</p> <p>If the peat soil is saturated with water, do not take samples.</p>

<p>Move to step 2 if you have to take a sample for assessment of soil biodiversity.</p> <p>Move to step 3 if you do not have to take a sample for assessment of soil biodiversity.</p>	
<p>2 Use gloves if a sample for biodiversity assessment have to be taken</p>	<p>Wear plastic gloves if you are in one of the 1,000 points where a sample for the assessment of soil biodiversity will be taken.</p> <p>Ensure that the material for the sampling (spades, the bucket and the knife) do not have soil residues from previous sampling.</p> <p>Quickly wash them first with alcohol and then with water.</p>
<p>3 Remove residues from the surface</p>	<p>Remove vegetation residues, grass and litter, if any, from the surface. Some fine roots and brownish organic material from the upper part of the soil can remain in the sample, as it is difficult to remove it completely.</p> 
<p>4 Drive the ring into soil</p>	<p>Gently press the metallic ring, bevelled edge down, into the soil with the help of a mallet. Use a block of wood to push the ring with the mallet, in order to avoid compaction of soil and protect the ring.</p> <p>Avoid pushing the ring in too far or the soil will compact.</p> 

Excavate a little bit around the outside edge of the ring with a small, flat-bladed knife. Put the plastic cap to the ring.



5 *Dig a square hole to a depth of 20 cm*

Dig a hole at a distance of 2-3 cm from the metallic ring. Make 4 cuts with the spade to dig the hole. Avoid standing/stepping where the ring is hammered.






Extract the resulting clump of soil with the spade. Take care that the hole remains clean.



Move to step 6 if you have to take a sample for assessment of soil biodiversity.

Move to step 8 if you do not have to take a sample for assessment of soil biodiversity.

<p>6 <i>Cut a slice of soil and trim the sides if a sample for biodiversity assessment have to be taken</i></p>	<p>Take a slice of soil with the spade from the face of the hole opposite to the ring. Remove any remaining vegetation residues, stones, and litter.</p>  <p>Trim the sides of the slice, leaving a 5 cm segment on the spade. Take care that the hole remains clean and that the trimmed material does not end up again in the hole.</p> 
<p>7 <i>Put collected soil in the bucket</i></p>	<p>Put collected soil in the bucket. Clean soil residues from the spade.</p> 
<p>8 <i>Remove the metallic ring</i></p>	<p>Make 3 cuts with the spade in the remaining sides around the ring, at a distance of 2-3 cm from the metallic ring.</p> <p>Place the spade (or the trowel) underneath the ring and carefully remove the clump of soil with the ring intact.</p>






Remove excess soil from the bottom of the ring and around the outside edge of the ring with the knife.



If the metallic ring is not completely filled with soil (less than 10% missing due to a stone or lost material when removing from soil), you can fill the ring with removed soil.



If the missing part in the ring is greater, discard the soil core and take other on one of the other faces of the hole following steps 3 to 8.

<p>9 Put the soil core in the plastic bag tagged as "Bag A 0-10 cm"</p>	<p>Push out the soil core into the plastic bag labelled as "Bag A 0-10 cm" using the knife.</p> <p>Make sure the entire core is placed in the plastic bag.</p> 
<p>10 Repeat the process at the other 4 locations (N, E, S, W)</p>	<p>From the central LUCAS point, walk 2 m to North and repeat steps 2 to 9. When finished, walk back to the LUCAS point.</p> <p>From the central LUCAS point, walk 2 m to East and repeat steps 2 to 9. When finished, walk back to the LUCAS point.</p> <p>From the central LUCAS point, walk 2 m to South and repeat steps 2 to 9. When finished, walk back to the LUCAS point.</p> <p>From the central LUCAS point, walk 2 m to West and repeat steps 2 to 9. When finished, walk back to the LUCAS point.</p> <p>Be aware that you take all material and samples with you when you move to a new location.</p>
<p>11 Label the plastic bag containing the 5 soil cores collected in 0-10 cm depth increment</p>	<p>Insert the first available yellow plastic label with a progressive number and "BULK 0-10 A" sign printed on it inside the bag containing the 5 soil cores collected from 0-10 cm depth increment. Close the bag with a tie.</p> 
<p>12 Put the plastic bag containing soil cores within a second plastic bag and label it again</p>	<p>Put the plastic bag containing the 5 soil cores within a second plastic bag. Insert the yellow plastic label with the same progressive number as in step 11 and with "BULK 0-10 B" sign printed on it inside the outer bag. Close the bag with a tie.</p>  <p>This will be the first sample for the determination of bulk density and analysis of core physical and chemical properties.</p>

13 Place the sample in the big plastic bag and label it

Put the plastic bag inside the big plastic bag. Insert the **yellow plastic label** with the same progressive number as in steps 11 and 12 and with "**BULK**" sign printed on it inside the big bag.



Move to step 14 if you have to take a sample for assessment of soil biodiversity.
Move to step 17 if you do not have to take a sample for assessment of soil biodiversity.

14 Mix the 5 subsamples in the bucket if a sample for biodiversity have to be taken

Use the trowel to mix the 5 subsamples in the bucket and to get a homogeneous composite sample. Clods and lumps have to be also broken up.

Remove any extra vegetation residues, stones, and litter.




15 Transfer 500 g of soil to the plastic jar and label it

Take 500 g (about 5 handfuls) of the composite sample and place it in the plastic jar.

Insert the first available **green plastic label** with the same progressive number as in steps 11 and 12 and with "**BIO A**" sign printed on it in the jar and close it.



This will be the sample for soil biodiversity assessment. It has to be shipped fresh to the JRC as soon as possible.

<p>16 Prepare the polystyrene box for shipping</p>	<p>Place the plastic jar in the polystyrene box. Place the 2 freezer packs at the sides of the bag.</p>  <p>Insert the green plastic label with the same progressive number as in step 15 and with "BIO B" sign printed on it in the box.</p> <p>Close the box and seal it with the packaging tape to ensure the cover is secured. Attached the address label on the box.</p> <p>The box must be shipped to the JRC as soon as possible, either same day or early morning the day after (in this case, the box must be stored in a fridge overnight).</p>
<p>17 Move again to the central LUCAS point</p>	<p>Be aware that you take all material and samples with you when you move to a new location.</p>
<p>18 Drive the ring into soil from 10-20 cm depth increment</p>	<p>Measure the depth of the hole where the first soil core was taken. If the depth of the hole is less than 10 cm, dig to reach at least 10 cm depth.</p>  

Gently press the metallic ring, bevelled edge down, into the soil with the help of a mallet. Use a block of wood to push the ring with the mallet, in order to avoid compaction of soil and protect the ring. Avoid pushing the ring in too far or the soil will compact.

Excavate a little bit around the outside edge of the ring with a small, flat-bladed knife. Put the plastic cap to the ring.










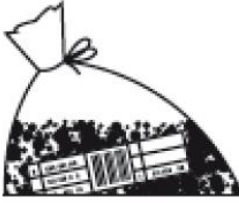
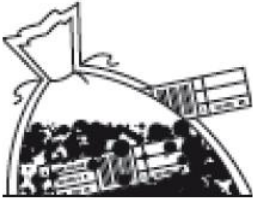

19 Remove the metallic ring

Excavate more around the outside edge of the ring with a small, flat-bladed knife.

Place the spade (or the trowel) underneath the ring and carefully remove it intact.



	<p>Remove excess soil from the bottom of the ring and around the outside edge of the ring with the knife.</p>  <p> If the metallic ring is not completely filled with soil (less than 10% missing due to a stone or lost material when removing from soil), you can fill the ring with removed soil.</p>   <p> If the missing part in the ring is greater, discard the soil core and take other on the opposite face of the hole. Dig at least to 10 cm depth and follow steps 18-19.</p>
<p>20 Put the soil core in the plastic bag tagged as "Bag B 10-20 cm"</p>	<p>Push out the soil core into the plastic bag labelled as "Bag B 10-20 cm" using the knife. Make sure the entire core is placed in the plastic bag.</p>  
<p>21 Repeat the process at the other 4 locations (N, E, S, W)</p>	<p>From the central LUCAS point, walk 2 m to North and repeat steps 18 to 20. When finished, walk back to the LUCAS point.</p> <p>From the central LUCAS point, walk 2 m to East and repeat steps 18 to 20. When finished, walk back to the LUCAS point.</p> <p>From the central LUCAS point, walk 2 m to South and repeat steps 18 to 20. When finished, walk back to the LUCAS point.</p>

	<p>From the central LUCAS point, walk 2 m to West and repeat steps 18 to 20. When finished, walk back to the LUCAS point.</p> <p>Be aware that you take all material and samples with you when you move to a new location.</p>
<p>22 Label the plastic bag containing the 5 soil cores</p>	<p>Insert the yellow plastic label with the same progressive number as in steps 11 and 12 and with "BULK 10-20 A" sign printed on it inside the bag containing the 5 soil cores collected from 10-20 cm depth increment. Close the bag with a tie.</p> 
<p>23 Put the plastic bag containing soil cores within a second plastic bag and label it again</p>	<p>Put the plastic bag with the 5 soil cores within a second plastic bag. Insert the yellow plastic label with the same progressive number as in step 22 and with "BULK 10-20 B" sign printed on it inside the outer bag. Close the bag with a tie.</p>  <p>This will be the second sample for the determination of bulk density and analysis of core physical and chemical properties.</p>
<p>24 Place the sample in the big plastic bag</p>	<p>Put the plastic bag inside the big plastic bag (the same bag in which you put the first sample from 0-10 cm depth).</p> <p>Make sure that the yellow plastic label with the same progressive number as in steps 22 and 23 and with "BULK" sign printed on it is still inside. Close the bag with a tie if you do not have to take soil cores from 20-30 cm depth increment (taken only in Portugal).</p> 
<p>Move to step 25 if you have to collect soil cores from 20-30 cm depth increment (only for Portugal).</p> <p>Move to step 33 if you do not have to collect soil cores from 20-30 cm depth increment.</p>	
<p>25 Move again to the central LUCAS point</p>	<p>Be aware that you take all material and samples with you when you move to a new location.</p>

26 Drive the ring into soil from 20-30 depth increment

Make sure that the depth of the hole, where the previous two soil cores were taken, is at least 20 cm.



Gently press the metallic ring, bevelled edge down, into the soil with the help of a mallet. Use a block of wood to push the ring with the mallet, in order to avoid compaction of soil and protect the ring. Avoid pushing the ring in too far or the soil will compact.

Excavate a little bit around the outside edge of the ring with a small, flat-bladed knife. Put the plastic cap to the ring.










27 Remove the metallic ring




Excavate more around the outside edge of the ring with a small, flat-bladed knife.

Place the spade (or the trowel) underneath the ring and carefully remove it intact.



	<p>Remove excess soil from the bottom of the ring and around the outside edge of the ring with the knife.</p>  <p> If the metallic ring is not completely filled with soil (less than 10% missing due to a stone or lost material when removing from soil), you can fill the ring with removed soil.</p>  <p> If the missing part in the ring is greater, discard the soil core and take other following steps 26-27.</p>
<p>28 Put the soil core in the plastic bag tagged as "Bag C 20-30 cm"</p>	<p>Push out the soil core into the plastic bag labelled as "Bag C 20-30 cm" using the knife. Make sure the entire core is placed in the plastic bag.</p>
<p>29 Repeat the process at other 2 locations (N, E, S, W)</p>	<p>Select 2 other locations from the 4 cardinal directions (North, East, South, West).</p> <p>From the central LUCAS point, walk 2 m to the selected locations.</p> <p>At each location, repeat steps 26 to 28 to take the soil core from 20-30 cm depth increment.</p> <p>Be aware that you take all material and samples with you when you move to a new location.</p>
<p>30 Label the plastic bag containing the 3 soil cores</p>	<p>Insert the yellow plastic label with the same progressive number as in steps 11-12 and 22-23, and with "BULK 20-30 A" sign printed on it inside the bag containing the 3 soil cores collected from 20-30 cm depth increment.</p>

	<p>Close the bag with a tie.</p> 
<p>31 Put the plastic bag containing soil cores within a second plastic bag and label it again</p>	<p>Put the plastic bag with the 3 soil cores within a second plastic bag. Insert the yellow plastic label with the same progressive number as in step 30 and with "BULK 20-30 B" sign printed on it inside the outer bag. Close the bag with a tie.</p>  <p>This will be the second sample for the determination of bulk density and analysis of core physical and chemical properties.</p>
<p>32 Place the sample in the big plastic bag and close it</p>	<p>Put the plastic bag inside the big plastic bag (the same bag in which you put the samples taken from 0-5 cm depth and 10-20 cm depth).</p> <p>Make sure that the yellow plastic label with the same progressive number as in steps 30 and 31 and with "BULK" sign printed on it is still inside. Close the bag with a tie.</p> 
<p>33 Register the label number in the Field Form</p>	<p>Record the progressive label number in the appropriate Field Form.</p>
<p>34 Take the soil photo</p>	<p>Put the bag and the polystyrene box (if a sample for assessment of soil biodiversity has been taken) next to the LUCAS point. Take a photo of the LUCAS point with the bag (keep the label visible) and the box and as many as possible of the 5 holes clearly visible.</p>
<p>35 Take additional photo of the label</p>	<p>The label has to be clearly readable.</p>
<p>36 Complete the questionnaire on soil</p>	<p>Complete the questions on the Field Form related to signs of erosion, ploughing, crop residues and stones.</p> <p>See manual 3 for assessment of soil erosion.</p>

<p>37 Percentage of residuals and percentage of stones are evaluated on the 2m radius area that serves as base for soil collection.</p>	<div style="display: flex; justify-content: space-around; align-items: center;">  10%  25%  50% </div> <p>The surveyor has to estimate the percentage of the surface that is covered with vegetation residues and stones.</p> <p>This assessment is made on the 2m radius area that serves as base for the soil collection.</p> <p>The presence of stones in the soil does not need to be estimated. As explained above, stones should be taken out of the subsamples before making a composite sample.</p>
<p>38 Take additional pictures if needed</p>	<p>If appropriate take any additional pictures (e.g. to justify that a subsample was not taken due to excessive amount of thorny shrubs).</p>
<p>39 Make any necessary remarks</p>	<p>If the procedure was not followed strictly, report any changes in the comments, explaining the reason (e.g. superficial sample as underground rock, hard due to tree roots).</p> <p>For free text remarks, the use of English is mandatory. Special characters are to be avoided.</p>
<p>40 If applicable take note of the land owner contacts</p>	<p>If the land owner/land user asks to obtain a copy of the results of the soil analysis, include his/her contact details (at least name, postal address and telephone number; if available, also e-mail address) in the Field Form.</p>
<p>Move to section 3.4 if the point is located in a peat soil.</p> <p>You will need to measure the thickness of the organic horizon in the peat soil.</p>	

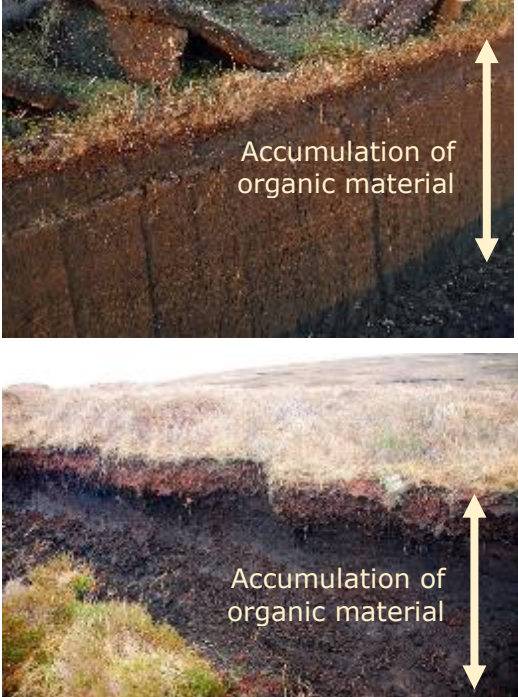
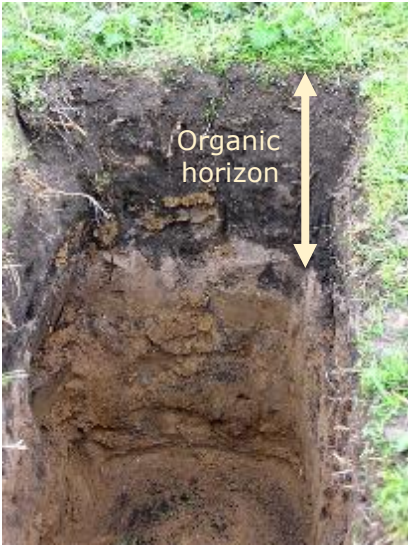


Before leaving the point

<p><i>Close the holes</i></p>	<p>Using the soil in excess, close the 5 holes you did.</p>
<p><i>Clean and store the material</i></p>	<p>Clean the spade, trowel and bucket. This is important in order to prevent cross-contamination.</p>
<p><i>Don't forget to take all material and samples with you</i></p>	<p>Be aware that you do not forget material or samples collected on the field before leaving the point.</p> <p>Put the closed bag in the box used for shipping the samples and put the box in the trunk of the car.</p>

3.4 Measuring thickness of organic horizon in the field

<p>1 Reuse the holes already dug for the soil sampling</p>	<p>Thickness of organic horizon will be measured in the 5 holes already dug for soil sampling.</p> <p>Start from the central LUCAS point.</p>
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<p>2 Dig one of the faces of the hole to 40 cm</p>	<p>Digging a hole in peat should be easy. Dig one of the faces of the hole to a depth of 40 cm. Make sure that the face is vertical to the soil surface.</p>
<p>3 Identify the organic horizon</p>	<p>Organic horizon is formed from the accumulation of organic material deposited on the soil surface. They must have at least 20% of organic carbon and a thickness of 10 cm.</p> <p>The intense dark colour of organic horizon, compared to mineral horizons, make easy to recognize them.</p> <p>Examples of sections through peats showing deep organic soils:</p>  <p>A soil profile showing organic horizon (dark layer) overlaying mineral layers (brown/orange layer):</p>  <p>We are looking to see if the dark layer is at least 40 cm thick.</p>

<p>4 Measure the thickness of organic horizon</p>	<p>Using a meter stick, measure the thickness of organic horizon from the top to the bottom of the horizon on the face of the hole.</p> <p>Record the thickness in the Field Form. If the bottom limit of the organic horizon is below 40-cm depth, indicate it together with the measured thickness in the Field Form.</p>
<p>5 Take a picture</p>	<p>Take a picture of the face of the hole with the meter stick showing the scale and indicating the label number of the point.</p>
<p>6 Measure the thickness of organic horizon at the other 4 locations</p>	<p>The other 4 measurements will be done at a distance of 2 m from the central LUCAS point following North, East, South and West directions.</p> <p>Repeat steps 2 to 5 to do the measurements at each location.</p>



Before leaving the point

<p><i>Close the holes</i></p>	<p>Using the soil in excess, close the 5 holes you did.</p>
<p><i>Clean the material</i></p>	<p>Clean the material you used. This is important in order to prevent cross-contamination.</p>
<p><i>Don't forget to take all material</i></p>	<p>Be aware that you do not forget material or samples collected on the field before leaving the point.</p>

3.5 Collecting soil samples in special cases

<p><i>If it is impossible to collect the subsample in the appropriate location, find a suitable location within 2m from the central point</i></p>	<div style="text-align: center;"> </div> <p>If in one or more of the 4 subsample locations belonging to the LUCAS soil point (central, North, East, South or West) it is not possible to collect a topsoil sample for any reason (accessibility problems, hardness of the ground, coverage – trees, houses etc.), walk along the dotted line until you find a suitable location or walk less than 2m from central point to take the subsample (represented by the small red circles).</p>
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If a sample is very wet, treat it as a normal sample. It has to be dried in the same manner

What to do if the sample is very wet or comes from a peat soil? Treat these samples in the same way as any other sample unless it is inaccessible or it is impossible to collect soil.

Open the bag, roll down the sides and let the samples dry until you ship them.

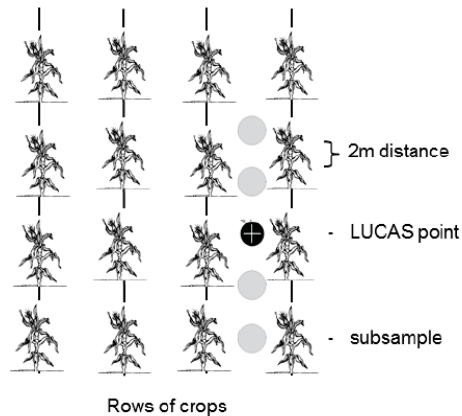
3.6 Collecting soil samples in case of difficult access

If access to the point is difficult because of:

- a risk of damage to crops,
- harvesting of a crop,
- on-going fertilizer application;

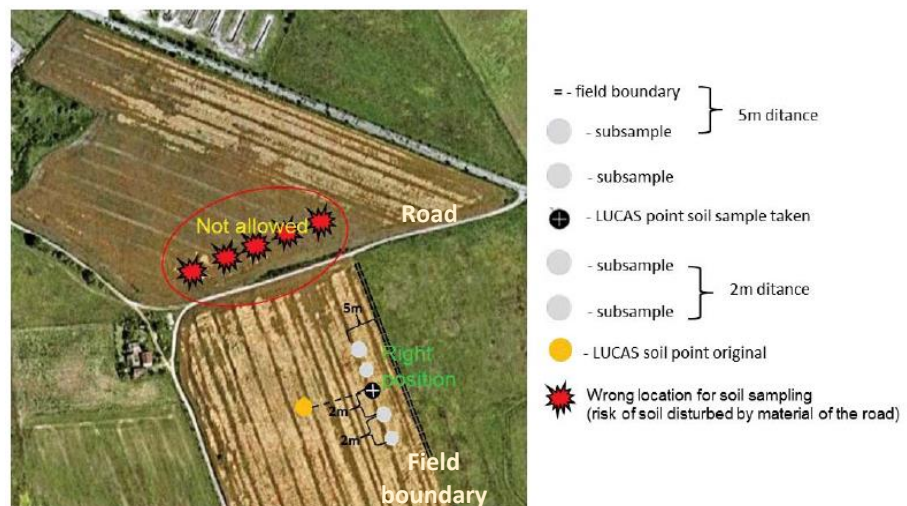
then apply one of the following methods of soil collection. The methods are presented by order of preference.

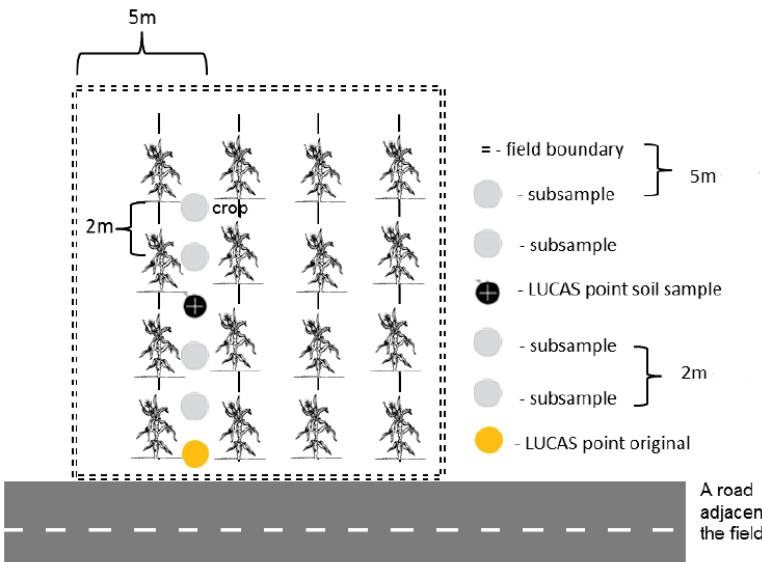
Linear sample, at least 5m from the edge of the field



The soil sampling is carried out inside the field, at 5m distance from the edge, in between the rows of the crops using a linear sampling pattern taking as the central one the LUCAS point (if not on the crop) or the one closest to the LUCAS point not on the crop (if LUCAS point on the crop).

Linear sample near the edge of the field



	<p>If it is not possible to collect the soil sample in-between the rows of the crops, then the soil sample has to be taken near the edge inside the field as close as possible to where the original LUCAS point is located.</p> <p>Choose the edge closest to the LUCAS point and as farer as possible from any artificial surface (e.g. road).</p> <p>The same linear sampling pattern, as previously described for sampling in-between rows, has to be respected.</p>
<p><i>Linear sample when point is close to a road</i></p>	 <p>The diagram illustrates a linear sampling pattern in a field adjacent to a road. The field is 5m wide and 2m deep. A road is shown at the bottom. A LUCAS point (black circle with a plus sign) is located near the road. A LUCAS point original (yellow circle) is also shown. The diagram shows a grid of crop rows with various sampling points (grey circles for subsamples, black circle with plus for LUCAS point soil sample, and yellow circle for LUCAS point original). A dashed line indicates the field boundary.</p> <p>The same linear sampling schema has to be applied if the LUCAS point is too near to the road. In this situation the soil sample can be taken between the rows or, if not possible, on the hedge of the fields with the same approach shown in the example above.</p>
<p><i>Use the remarks field</i></p>	<p>The need for using special arrangements for soil collection should be reported in the remarks section of the Field Form.</p>

3.7 Weighing and air-drying samples in the night's location

Soil samples, except samples for soil biodiversity determination, need to be weighed before and after air-drying prior to shipping the samples to JRC. Wet or damp samples may give unreliable results, if inappropriately stored.

<p>1 <i>Weigh the samples placed in the big plastic bag</i></p>	<p>At the end of the day's work, when you have reached the night's location:</p> <p>Take out the small bags containing the samples from the big plastic bag. Open the bags removing the ties.</p> <p>Weigh the samples within their bags. Record the weight of each sample (field-moist weight) in the Field Form.</p>
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<p>2 <i>Air-dry the samples</i></p>	<p>Roll down the sides of the bags, and open them as much as possible.</p> <p>Crumble samples into small clods/peds by hand.</p> <p>Air-dry samples until constant weight within their bags, in a well ventilated room.</p> <p>Make sure that samples don't fall over and contaminate each other.</p>
<p>3 <i>Weigh the air-dried samples</i></p>	<p>Weigh the air-dried samples within their bags. Record their weight (air-dried weight) in the Field Form.</p>
<p>4 <i>Close the plastic bags carefully</i></p>	<p>Close the inside bag containing the sample with a tie (check that label A is still inside).</p> <p>Close the outer bag with a tie (check that label B is still inside and has the same progressive number as the other).</p> <p>Make sure all bags are properly closed in order to prevent contamination during transport when the boxes may not be kept upright all the time.</p>
<p>5 <i>Put them again in the big plastic bags</i></p>	<p>Put them again in their corresponding big plastic bags. Make sure that the plastic label is still inside the big plastic bag.</p> <p>Close the bag with a tie.</p> <p>Make sure all bags are properly closed.</p>
<p>6 <i>Ship the samples to the supervisor</i></p>	<p>When 5 to 10 samples are collected (total weight around 2.5 kg to 5 kg), they should be shipped to the coordinator (e.g. via mail). Tape the sides of the box for extra security.</p> <p>Buy a new box that you will use for storing the samples to be collected until you will come again to a post office and that you will use for the next shipment.</p>



4 Manual 3: Guidelines for soil erosion assessment

Erosion by water and wind can be a major type of soil degradation. While it is a naturally occurring process on all land, soil erosion can cause serious losses of topsoil, which results reduced crop yields, lower surface water quality, damaged drainage networks and the release of greenhouse gases. Water and wind erosion are responsible for about 84% of all degraded land on the planet.

In this instance, we are asking surveyors to notice if there is any evidence of erosion by water and/or wind within a distance of 500 m from the LUCAS point. In case of any evidence of erosion, surveyors have to take a picture of the area and indicate in the Field Form how far from the LUCAS point erosion occurs and in which direction (North, East, South or West of the LUCAS point).

4.1 Types of water and wind erosion

Examples of the main types of water and wind erosion are shown below, together with the appropriate code for the Field Form (e.g. 2 for rill erosion).

<p>1 <i>Sheet erosion</i></p>	<p>A thin layer of topsoil is removed over a significant area —often not be readily noticed.</p> <p>Sheet erosion is usually only a few cm deep but several meters wide.</p> 
<p>2 <i>Rill erosion</i></p>	<p>Rill erosion occurs when water running along the surface forms narrow and relatively shallow channels (<30 cm deep), often evident where gradient becomes steeper. Rills tend to develop from sheet erosion.</p> 

3 *Gully erosion*

Gullies are significant features that occur when water runoff concentrates to cause a significant movement of soil particles. Gully depth is > 30 cm often limited by the depth of the underlying rock, which means gullies are but may reach 10–15m on deep soils.



4 *Mass movement*

Mass movement occurs when gravity moves soil (and sometimes rocks) downslope either slowly (millimetres per year) or suddenly during periods of prolonged and heavy rainfall (e.g. landslides, rock falls).

Different forms of mass movement include:

- Landslide



- Soil creep - small natural terraces/ripples on hill slopes (can result in tilted poles, misaligned fences, curved tree trunks)



- Rock slides



5 *Re-deposited soil*

Perhaps evidence of erosion is not obvious but clear signs that water has moved soil across the land surface.



6 *Wind erosion*

Signs of wind erosion may be harder to spot than water erosion. Examples include visible soil particles being blown off the soil, dust clouds following tractors tilling the land, accumulated particles along barriers.



The following table shows the details of practices that can reduce soil erosion.

Plough direction

Is the direction of ploughing across or down the slope?



In this field, plough is across the slope as evidence by the channel (flowing downslope) that cuts across. Ploughing along constant elevations (contours) is a good way to reduce erosion.



In the example 2, ploughing has been done up and down the slope.

Stone Walls

Not maintained



Well Maintained



Presence of crop residues

Example of crop residues on soil surface



Grass margins

Example of grass margins between fields



4.2 Questionnaire for soil erosion

Erosion signs

1 Type of erosion

- | | |
|---|---|
| <input type="checkbox"/> 1 Sheet erosion | <input type="checkbox"/> 5 Re-deposited soil |
| <input type="checkbox"/> 2 Rill erosion | <input type="checkbox"/> 6 Wind erosion |
| <input type="checkbox"/> 3 Gully erosion | <input type="checkbox"/> Not applicable |
| <input type="checkbox"/> 4 Mass movement | |

2 How far from the LUCAS point erosion occurs? _____

3 In which direction is erosion occurring?

- | | |
|---|--|
| <input type="checkbox"/> North of LUCAS point | <input type="checkbox"/> East of LUCAS point |
| <input type="checkbox"/> South of LUCAS point | <input type="checkbox"/> West of LUCAS point |

4 Number of rills or gullies observed

- < 5 rills or gullies
- 5-10 rills or gullies
- >10 rills or gullies

Practices to reduce erosion

5 Plough direction

- Across the slope
- Down the slope
- Not applicable

6 Slope of the ploughed field

- Flat
- Gently sloping (no effort when walking up to slope)
- Steeply sloping (requires effort to walk up the slope)
- Undulating (land slopes in more than one direction)

7 Presence of crop residues

- Yes
- No

8 Presence of grass margins

- No
- <1 m wide
- >1 m wide

9 Stone Walls

- No
- Yes, but not maintained
- Yes, well maintained

5 Conclusions

This technical report compiles the instructions for surveyors to collect the various soil samples and to perform the field measurements specified in the soil survey of LUCAS 2018. Surveyors will have to take the following type of soil samples: (1) composite soil samples, following the procedure used in LUCAS 2009/2012 and LUCAS 2015, for analysing standard physical and chemical properties monitored in every LUCAS soil survey (2) soil cores for measuring bulk density, and (3) fresh soil samples for analysing soil biodiversity. Furthermore, surveyors will measure thickness of the organic horizon in peat soils and carry out a visual assessment of erosion signs in the field. Using the same soil sampling methodology all over EU in LUCAS creates an archive of comparable soil samples of Europe. AS in LUCAS 2009/2012 and LUCAS 2018, physical, chemical and biological parameters will be then analysed on collected soil samples with standard methods in a central laboratory.

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