Low ILUC-risk certification: Pilot report and recommendations

Spain, Severely degraded land, November 2022

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Table of Contents

List of Tables

List of Figures

1. Pilot introduction

This pilot was conducted to test the low ILUC-risk certification methodology for the cultivation of biomass on **severely degraded land**, defined as *"land that, for a significant period of time, has either been significantly salinated or presented significantly low organic matter content and has been severely eroded"* (REDII, Annex V, as referred to in Article 2(4) of Delegated Regulation 2019/807).

1.1 Reflections on phase 1

The low ILUC-risk approach allows for the certification of new cultivation on unused, abandoned or severely degraded land. In phase 1 of the low ILUC pilot project, the methodology to certify abandoned land was tested on a plot of land in Ukraine.

The plot studied in phase 1 had previously been used for crop cultivation, but since 1996 had only been used for limited animal grazing. During the period of abandonment (since 1996), vegetation naturally grew on the land. Now, the central part of the land has 6-10 year old pine trees that are approximately 2 metres tall. Satellite data confirmed that reforestation during the period of abandonment was about 15%, using the Normalized Difference Vegetation Index (NDVI). Therefore, whilst the plot would meet the definition of **abandoned land**, if it would now be converted to agriculture, it would incur *direct* land use change (dLUC) emissions. Any resulting biofuel made from feedstock grown on the land would be very unlikely to meet the required greenhouse gas (GHG) saving threshold for biofuels in the REDII, once dLUC emissions are factored into the calculation.

In phase 2, it was decided to focus on testing **severely degraded land** as restoration of severely degraded land should offer an opportunity to improve soil carbon. Testing this option also enables the project to test the thresholds proposed for severely degraded land and develop the soil sampling protocol required to implement this option in practice.

In the process of selecting a pilot, the project team conducted a literature review and spoke to several experts and organisations working on unused, abandoned and severely degraded land. A short list of pilot options was developed and discussed with the Commission. The plot in Spain was chosen as it is an example of degraded farmland in Europe, where the farmer has started growing crops for biofuel. The land was expected to have low soil organic matter and is in an area prone to erosion. This plot allows us to develop and test the soil sampling protocol methodology to determine whether the land is severely degraded.

1.2 Feedstock and Geography

For this pilot we tested the low ILUC-risk methodology on a plot of potentially severely degraded land near the town of Lerma, in the centre of Spain. The plot of land has very shallow soil due to wind erosion, which is typical of the region. It is currently used as agricultural land with a crop rotation including wheat, barley and camelina. The farm is not currently certified to a voluntary scheme. The pilot team wish to express thanks to the Camelina Company, who facilitated the search for and contact with the farmer and supported the farmer to take soil samples and through the pilot audit.

Maps show that the farm is in a region where average soil organic matter is between 1.5-2% (**Figure 1**) and in an area that is prone to wind erosion (**Figure 2**).

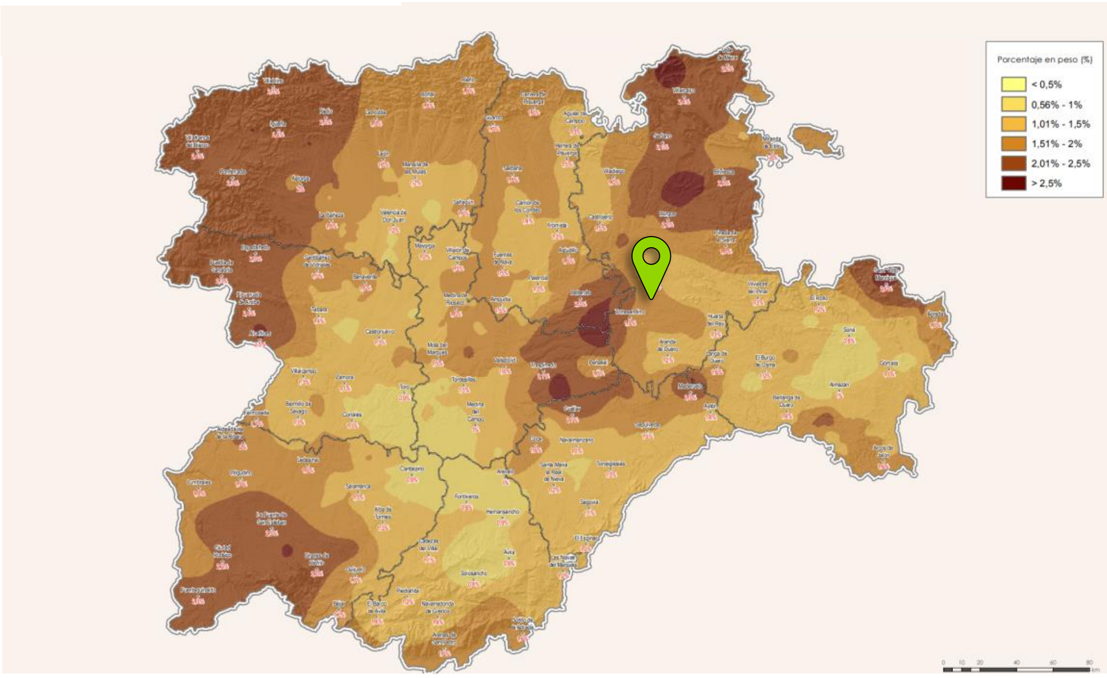

Figure 1. Average soil organic matter % across autonomous region Castilla y Leon, farm location marked. Source: AEMET & ITACyL (2017)[1]

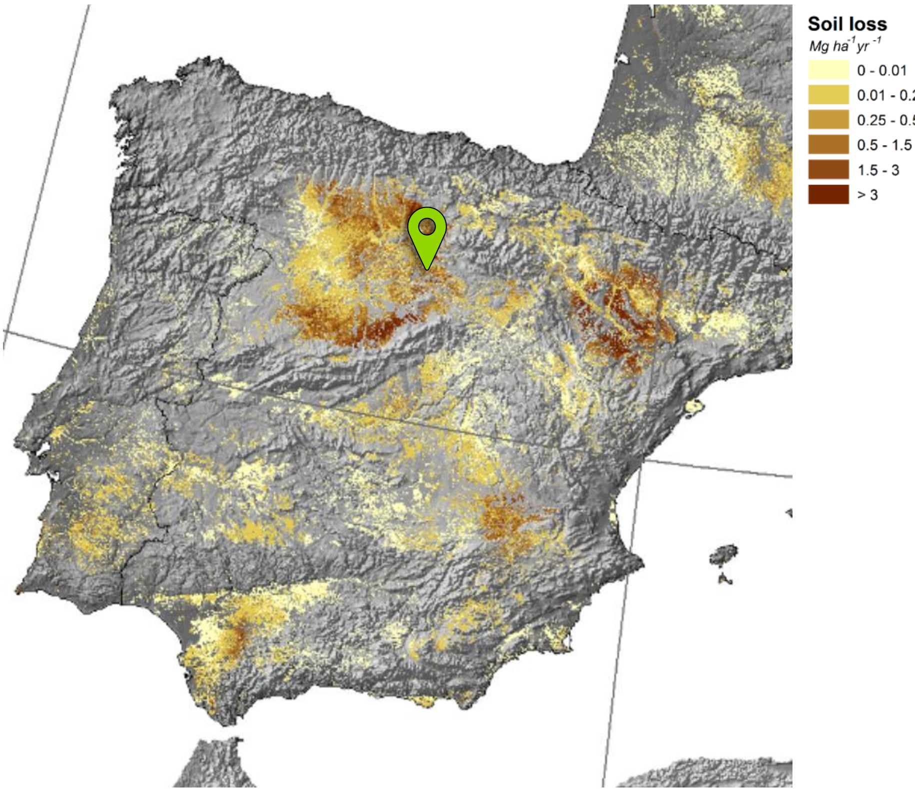

Figure 2. Soil loss by wind erosion in European agricultural soils 2001-2010, farm location market. Source: JRC (2017)[2].

[1] Agencia Estatal de Meteorología (AEMET) & Instituto Tecnologico Agrario Junta de Castilla y Leon (ITACyL) http://ftp.itacyl.es/Atlas_Agroclimatico/02_Edafologia_y_ocupacion%20del%20suelo/Edafologia/05_160_2_Atlas AC_Suelos_Textura_MO.pdf

[2] Borrelli, P., Lugato, E., Montanarella, L., and Panagos, P. (2017) A New Assessment of Soil Loss Due to Wind Erosion in European Agricultural Soils Using a Quantitative Spatially Distributed Modelling Approach. https://esdac.jrc.ec.europa.eu/public_path/u890/Erosion/GIS-RWEQ.png

1.3 Audit

The pilot audit was conducted on-site by lead auditor Arturo Sánchez Manzano from Control Union on **21 November 2022**. Prior to the audit, soil samples were taken by the farmer together with Camelina Company on 7 November and analysed in a laboratory.

The lead auditor was accompanied during the audit by three members of the consortium, two from Guidehouse and one from ISCC, and representatives from Camelina Company.

1.4 Key issues tested

The objective of this pilot audit is to verify and test the methodology and guidance for low ILUC-risk certification for severely degraded land and test a draft soil sampling protocol.

The following key issues were tested to determine and assess severely degraded land:

1. **Soil sampling and testing protocol** for soil organic matter (SOM)/ soil organic carbon (SOC). For the purpose of this pilot, we developed a **Pilot audit soil sampling protocol** by reviewing relevant literature and speaking with experts from our consortium partners (ISCC and Control Union), experts from JRC and technical staff from Camelina Company. For the pilot, soil samples were taken in a full grid formation across the plot and at two depths (0-15cm and 15-30cm). This full level of sampling across the plot was done to show the variability of SOM/SOC across the plot of land. A higher level of sampling was conducted in the pilot than would need to be done in practice to become certified. The Pilot audit soil sampling protocol is included in Appendix A to this document. Feedback on the Pilot audit soil sampling protocol, together with insights from the pilot, were used to develop a **Soil Sampling Protocol** that will serve as an **Appendix to the Low-ILUC risk Certification Guidance**.

2. **Reflection on possible thresholds** to determine whether land would be considered severely degraded (low organic matter and eroded, or salinated). A literature review was conducted to assess appropriate thresholds to define severely degraded land, as it is set out in REDII Annex V and referred to in Article 2(4) of Delegated Regulation 2019/807. This literature review is included in Appendix B. This literature review compares methodologies commonly used and reflects on the thresholds to determine whether land is “significantly low organic matter”, “severely eroded” or “significantly salinated”.

3. **Existing yield on severely degraded land**. The pilot further reflected on the distinction between severely degraded land and unused (or abandoned) land that the definitions included in the REDII and Delegated Regulation 2019/807 do not necessarily require severely degraded land to be unused. Therefore it could be interpreted that if land meets the proposed threshold for severely degraded, then any yield on that land could be counted as low ILUC, including any existing yield.

Note that cultivation on severely degraded land is exempt from demonstrating compliance with the Additionality test in Delegated Regulation 2910/805 Article 5(1)(a)(i). Therefore, compliance with the financial attractiveness and non-financial barrier analysis Additionality requirements were not tested in this pilot.

1.5 Relevant documents

During the pilot, the following documents were collected:

- Pilot audit soil sampling protocol (developed by Guidehouse), Appendix A
- Reflections on severely degraded land thresholds (developed by Guidehouse), Appendix B
- Soil sample data (collected by farm, together with Camelina Company)
- Audit checklist (filled in by Control Union)
- Audit report (filled in by Control Union)

Due to time constraints and language, the farmer did not fill in a management plan in advance of the audit. The project team talked through the content with the farmer on the day.

2. Additionality measure

The “additionality measure” tested in this pilot is the cultivation of camelina on land that could be classed as severely degraded. This section describes the situation and agricultural practices of the specific pilot farm, as well as more general information related to cultivating camelina.

Farm location and crop rotation

The location of the farm for this pilot is near the town of Lerma in the centre of Spain, north of the capital Madrid (plot coordinates: latitude 41.901323, longitude -3.875780). For this pilot we worked together with Camelina Company, who facilitated contact with the farmer and supported the farmer to take the soil samples. Camelina Company has a contract with this farmer to supply camelina seeds and offtake the crop. This farmer is growing camelina in rotation on 29.73ha in 2021-2022 and 40ha in 2022-2023.

This farmer has a normal crop rotation of 1 main crop per year. The rotation used to be either wheat or barley, as is typical for the region. In the region it is common to also have a fallow year in the rotation due to poor soil quality, e.g. year 1 wheat, year 2 barley, year 3 fallow etc. This farmer added camelina to the rotation 8 years ago. Together with this, the farmer implemented several measures to improve the soil quality, thus omitting the need for a fallow year in the rotation. The new rotation became year 1 wheat, year 2 barley, year 3 camelina. Vetch is another popular crop to grow in the region instead of camelina, but the farmer commented that vetch was more difficult to harvest and there is not a large demand for it, making it less economically attractive to grow.

The main crop is sown after the first rains from mid-October and harvested in June the following year, before it becomes too hot and dry. The land is left fallow between the harvesting and sowing period (July-October). The Camelina Company is actively researching different varieties of camelina suitable for cover cropping in fallow periods in several regions of the world. However, summer cover cropping (intermediate cropping) is hardly possible in this region of Spain due to the lack of rainfall in the summer fallow period. There is no moisture in the soil in July and August, making the soil very hard and difficult to cultivate.

Camelina supply chain

In the EU certification context, Camelina Company is the first gathering point. They buy the crop from the farmer. They test the seed to document the quality which dictates the price paid to the farmer. The price for camelina that they agree with the farmer is linked to the price of soy and/or rapeseed, as well as the final quality of the camelina harvest. Sometimes the farmer has his own physical storage, other times the seed goes to Camelina Company’s warehouse. This farmer is part of a cooperative of 7 to 8 farmers. In this case, Camelina Company contract directly with the farmer, but in other cases they could contract with the cooperative. Camelina Company sells camelina oil for biofuels and produces small quantities for use in cosmetics. Although camelina is technically edible, it has a higher erucic acid content than generally acceptable for vegetable oil and fats for food use (2%). The cosmetics market is a niche market (low volume) so their main interest is the biofuels market.

Benefits of camelina

Camelina is a resilient oilseed crop, characterised by high environmental plasticity and low input requirements, making it suitable for different European conditions. One of camelina’s main differentiating characteristics as an oilseed crop is its short growth cycle (as short as 80 to 90 days from sowing to harvest[3]), which allows for flexibility to fit it into a current crop rotation. Several key characteristics make camelina attractive as a harvestable cover crop:

- easy implementation with a farmer's existing commercial machinery;
- quick soil cover with allelopathic[4] effect, which allows for good weed competition[5];
- good water efficiency, especially for low rainfall conditions (< 250 mm)[6];
- avoids nitrogen leaching[7];
- better tolerance to pests[8] than other crucifers;
- better cold tolerance than other crucifers;
- melliferous species[9], providing a source of nectar and pollen to bees at a critical moment of the year[10];
- deeper root structure, which changes the structure of the soil.

Other measures implemented by the farmer to maintain soil quality

The farmer is implementing several measures to decrease the effects of wind erosion and maintain good soil organic matter levels:

- The farmer **only works on the land after it has rained**, to prevent topsoil loss through wind erosion. Once it has rained, the topsoil is heavier and is less likely to blow away. The traditional way of farming in this region is to work the land in the beginning of October, whether it has rained or not. By waiting until rainfall, the farmer ensures the moisture levels are high enough and the soil is heavy enough to withstand the wind as much as possible.
- The farmer moved to a **mixture of low-tillage and no-tillage** (mechanical weed control). The traditional way of farming is intensive farming with full-tillage, not taking the rain into account when tilling, fertilizing or sowing. It was reported during the pilot that those farmers tend to have lower SOM than this farmer who has implemented a mixture of no-tillage and low-tillage since 2001. Intensive agriculture with tillage and high mineral fertilization does give high yields, however in the longer term that is bad for the already thin soil, as it accelerates erosion. Intensive agriculture needs more inputs as well, such as diesel for the machinery, nitrogen fertilizer as stubble is not incorporated in the soil, and plant protection products. No tillage is the best option for the soil quality, but sometimes low-tillage is preferred to get rid of weeds. The application of herbicide is not always sufficient, as some weeds reproduce with rhizomes and some are resistant, thus tillage is the only thing that can get rid of the weeds. Introducing camelina in the cereal monoculture is an advantage as camelina's allelopathic effect provides good competition with weeds and therefore supresses weeds. The farmer can employ less expensive narrow leaf herbicides, to combat weeds which typically develop in cereal monocultures.

[3] Camelina Company España (www.camelinacompany.es).
[4] Allelopathy is a biological phenomenon by which one organism produces biochemicals that influence the growth, survival, development, and reproduction of other organisms.
[5] Walsh et al. (2014), 'Allelopathic effects of camelina and canola on wild oat, flax and radish', Allelopathy Journal.
[6] D.C. Nielsen, 'Oilseed productivity under varying water availability', USDA-ARS.
[7] Thom et al. (2018), 'Reduced-nutrient leachates in cash cover crop-soybean systems', Journal of Environmental Quality.
[8] Soroka et al. (2014), 'Interactions between Camelina sativa (Brassicaceae) and insect pests of canola', Cambridge University test.
[9] A melliferous species produces substances that can be collected by insects and turned into honey.
[10] Gesch et al. (2015), 'Camelina Holds Promise for Biofuel and Bees', AgResearch Magazine

- The traditional way of farming is to remove all the straw residue from the crop (either through collecting the straw or burning the stubble). However, this farmer **incorporates the straw into the soil** to increase the organic matter by either mixing some of the straw with the topsoil or leaving it on the field. The benefits of this practice are to increase soil organic matter, suppress weeds, protect topsoil against wind erosion and increase soil moisture. Another added benefit that comes with increasing the soil organic matter content in general, is that it decreases the erodibility of the soil. However, one of the farmers explained that they cannot do this every year, as this creates a problem for seeding the following year. He mentioned that the amount of biomass/straw would be "too high" for the amount of soil as their soil is quite thin.

Soil sampling to test for severely degraded land

The farmer, together with Camelina Company, selected a 4.75 ha plot for soil sampling. This particular plot was chosen for soil sampling, as the farmer considered this to be the most degraded plot. The plot had grown camelina in 2021-2022. The camelina had been harvested in summer 2022 and the land was fallow at the time of sampling and during the on-site audit, ready for planting with barley in Autumn 2022.

There is wind erosion in this region of Spain, which results in shallow soil. The average soil depth on this plot is 15-20cm. The grid layout of the soil samples taken is shown in the map in Figure 4 of the Findings chapter. Out of the 43 soil sample points, it was only possible to take deep samples (30cm) for 24 of the sample points due to the very shallow soil.

This farm, as is the case for many fields in this region, has many small stones on top of and mixed throughout the topsoil (**Figure 3**), which makes the amount of soil even less due to the volume of stones. The farmer explained that these stones however are positive in this climate as they provide some protection to keep moisture trapped in the soil, which is valuable as this region is dry in summer. The clay grounds become stone-hard in summer, meaning cultivation in summer is hardly possible.

Figure 3 Photos of the plot taken during the on-site audit. On the left picture there is a large rock protruding from the topsoil. There are many small stones on top of the soil and mixed throughout the soil, shown in both photos.

3. Findings

3.1 Soil sampling process and cost

Soil samples were collected on 7 November 2022 by 4 people (who worked in 2 teams of 2). It took 4 hours to take samples from 43 sample points, each 25 metres apart in a grid formation across the plot. In each location, 2 samples were taken: one shallow soil (0-15 cm) and one 'deep' soil (15-30 cm). The deep soil samples were only taken if the soil was thick enough, which was the case in 24 out of the 43 locations. In total therefore, 67 soil samples were collected.

The team reported that it was difficult to take the samples due to the stones and camelina regrowth. The field grew camelina the year prior and there was some regrowth, so the team reported that it was sometimes difficult to clean the samples and prevent contamination with organic matter. The teams taking the samples tried to clean the samples (removing the stones, plant roots, and camelina regrowth) but that process is imperfect.

The laboratory analysis cost 1,400€ for 67 samples[11]. A full soil analysis (NPK, SOM, pH, electro conductivity) was conducted on 32 of the samples, as a compensation for the farmer to take part in the pilot and postpone sowing the next crop by a couple of days. The other half of the samples were just tested for SOM. Figure 4 visualises the distribution of SOM results in the top 15cm of the soil across the sample points. The asterisk indicates where the samples were used for the full soil analysis.

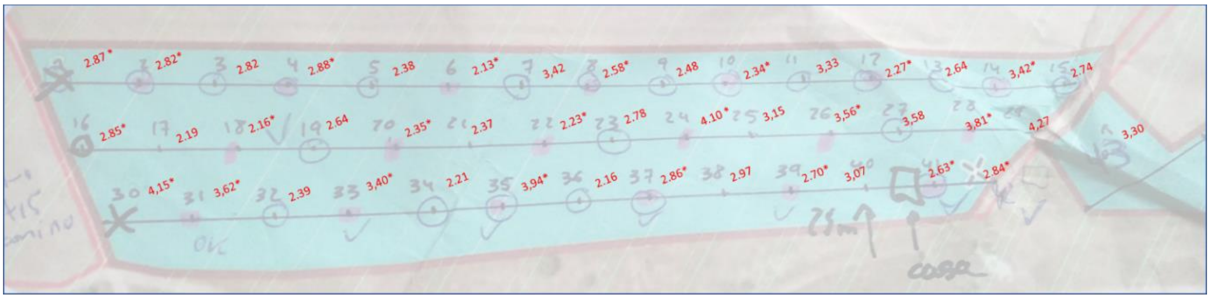

Figure 4 Grid-distribution of soil organic matter at 15cm deep.

3.2 Soil sampling results for this plot

Significantly low soil organic matter

The proposed threshold of significantly low soil organic matter is set at 1% in the draft Low ILUC-risk Certification Guidance. For the plot of land in the pilot, 50% of the tested values ranged between 2.33% and 3.17% SOM. The average is 2.78% SOM.

Figure 5 visualises the distribution of SOM at both 15cm and 30cm depth. As expected, the deeper soils had lower soil organic matter than shallower soils. **The samples at 15cm depth had an average of 2.92% SOM**, 50% of the samples fell between 2.39% and 3.37%

[11] For the purpose of this pilot we took more samples than would be necessary to determine severely degraded land for Low-ILUC Certification. As this plot is <5ha and has homogeneous conditions throughout the plot, only 1 sample would need to be analysed in the lab for low ILUC-risk certification. This would cost around €30-32 to measure SOM and salinization.

SOM. **The samples at 30cm depth had an average of 2.53% SOM**, 50% of the samples fell between 2.22% and 2.99% SOM.

None of these values would pass the proposed severely degraded land threshold of 1% SOM. Note that some studies use 1% soil organic **carbon** (SOC) as a threshold to define severely degraded land (see Appendix B for the literature review of thresholds). With the commonly used conversion factor of 1.72, this would correspond to 1.72% SOM. Only 3 of the 67 samples taken were below 1.72% soil organic matter and these were all samples from the deeper 30cm depth. Based on these values, this plot of land would not qualify as severely degraded land for low-ILUC risk certification.

Another commonly used threshold is 2% SOC, which corresponds to 3.44% SOM. Of the 43 samples taken at 15cm, 35 of them fell under that threshold (81%). All soil samples at 30cm deep would fall under that threshold. Thus, if the criteria would be set at 2% SOC, then this plot of land would be considered significantly low in soil organic matter.

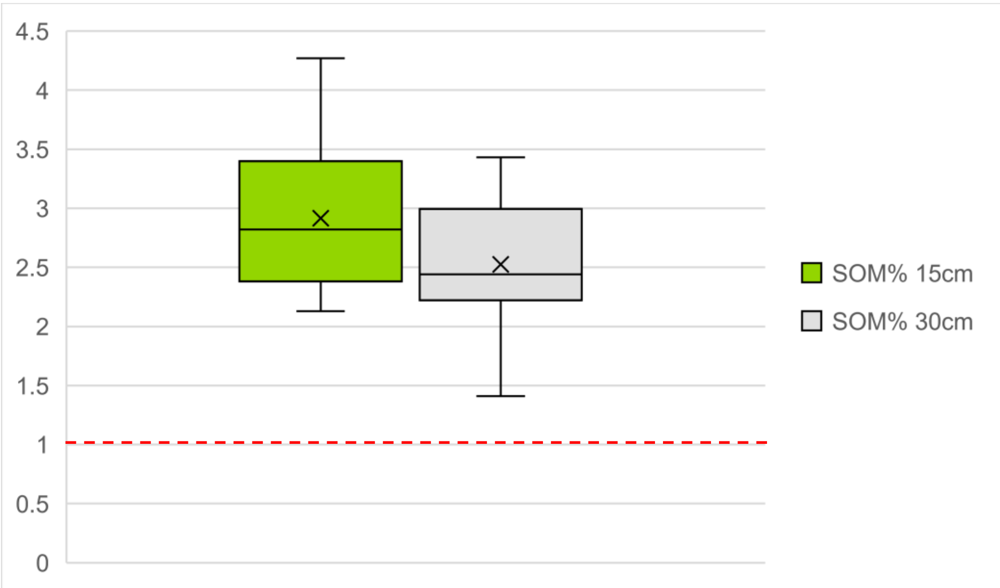

Figure 5 Boxplot analysis portraying the distribution of SOM data at both 15cm and 30cm depth, the x marks the mean SOM content. The 1% SOM threshold is marked in red.

Severely eroded

For land to be considered severely degraded it needs to be significantly low in soil organic matter **and** severely eroded (or just significantly salinated). The farm is located in a wind erosion prone region, see maps in **Figure 2**. The soil of this region, and on this farm, is very shallow (15-20cm on average) due to wind erosion.

The traditional way of farming is to work the land in late September/early October, whether it rained or not. The movement of the dry soil causes more soil loss due to wind erosion. This farmer only works on the land when there is a high soil moisture, however the soil remains thin. The land also has smaller stones littered over the top and mixed throughout the soil. The availability of soil is the main driver of yield in this region, thus soil with more stones mixed through will have less soil available per volume.

However, how to prove that there is erosion on the specific plot of land remains difficult. The farmer and the auditor reported during the pilot that it was difficult to measure erosion from a site visit to an individual farm. The farmer does not take any measurements of erosion, such as soil loss, over time.

Most literature and studies measure erosion in soil loss in t/ha/yr, however this might not be appropriate or practical for farmers to conduct themselves and would require measurements to have already been taken over a period of years. Photographic evidence is used as a proxy by both the LUCAS 2018 study by JRC[12] and an EEA review[13] on soil health thresholds. However, whilst it was possible to see one exposed rock on this plot (photo in **Figure 3**), this method was only effective to identify gully erosion and was not properly reported for other forms of erosion (sheet, rill and wind erosion, redeposited soils and mass movement).

During the pilot, the farmer and Camelina Company mentioned that 25% of the land being eroded is too severe of a threshold and difficult to implement. It was unclear how to measure 25% of the land as being severely eroded or what would constitute as signs of erosion over at least 25% of the plot. In this pilot, over 25% of the sample points did not have deep enough soil to take a deep soil sample (15-30cm). These points could be considered eroded. However, soil depth alone is not a reliable indicator of erosion without being able to compare it to a “before” scenario. Shallow soils are often due to erosion but can also be naturally occurring.

Significantly salinated

Thirty-two of the samples had a full soil analysis: 23 samples from 15cm depth and 9 samples from 30cm depth. Testing the salinity levels was one of the methods included in this full analysis by testing the electroconductivity. On average, the tested soil had an electroconductivity of 0.18 dS/m, the maximum value being 0.25 dS/m. There was one outlier of 1.29 dS/m.

The proposed threshold for significantly salinated land in the draft Low ILUC-risk Certification Guidance is 8 dS/m. The pilot plot of land is thus <u>not</u> significantly salinated (note that the analysis was conducted to test the process – this land was not expected to be significantly salinated).

3.3 Yield data and calculation of additional biomass

The farmer does not record yield at plot level, but rather at farm level (see Table 1). (Note that this explains why there is yield of each crop in the rotation every year – the individual plots have a rotation wheat – barley – camelina, but on a farm level all crops are grown every year.) The farmer mentioned that there is no significant difference in yield between the pilot plot tested and his other plots on the same farm.

This region of Spain is prone to extreme droughts and hail, it is therefore common for famers to have ‘agro-insurance’ for their crops. In the event of extreme weather, this insurance can be used to covers crop losses. The insurance company calculates the yield loss due to the extreme weather and compensates the farmer accordingly. The farmer has applied for

[12] JRC (2022): https://esdac.jrc.ec.europa.eu/public_path/shared_folder/dataset/75-LUCAS-SOIL-2018/JRC_Report_2018-LUCAS_Soil_Final.pdf

[13] Baritz et al. (2021): https://www.eionet.europa.eu/etcs/etc-di/products/etc-uls-report-2021-soil-monitoring-in-europe-indicators-and-thresholds-for-soil-quality-assessments

compensation for his camelina harvest every year from 2019-2022, as there were extreme weather events in each of these years. The values in the table for camelina are the insurance-corrected values, thus what the farmer would have harvested if there was no extreme weather event. In the footnotes, the actual yield for camelina is recorded. Wheat and barley are insured differently than camelina. Camelina is a relatively new crop, thus it is insured by estimating loss in weight, compared to other plots the farmer has. Wheat and barley are only compensated if the yield is less than 70% of a set regional average (3 t/ha), thus lower than 2.1 t/ha. The farmer has a higher yield than the average in the region, making it difficult for him to claim losses for wheat and barley.

Table 1 Recorded yield in t/ha at farm-level.

	2019	2020	2021	2022
Vetch[14]	1.10	-	-	-
Wheat	3.38	5.50	4.30	2.80
Barley	3.00	4.60	4.80	3.20
Camelina	1.49[15]	0.83[16]	1.23[17]	1.20[18]

3.4 Sustainability of the additionality measure

The land is not currently certified to a voluntary scheme. The auditor did check for compliance with the core REDII sustainability criteria for biofuels and there were no concerns raised.

There are some broader sustainability benefits to growing camelina, such as good water efficiency, acting as a catch crop to avoid nitrogen leaching and its allelopathic effect which allows for good weed competition. These were reported by the farmer and the Camelina Company but not directly tested in the pilot.

The farmer implemented several new practices from 2001 to improve the soil quality, such as ploughing the straw back into the soil and practising a mixture of no and low-tillage. These practises could be the reason why the plot has a higher soil organic matter content and higher yield than is typical in the area, in which most farming is done by removing straw and other crop residues and implementing full tillage.

[14] Vetch is a legume, planted to diversify rotation (can also be planted as a cover crop), but it is difficult to harvest and there is not a large market for it. This farmer stopped cultivating vetch after a year.

[15] In 2019, camelina harvest suffered from extreme drought. The insurance audited the drought damage and paid an additional 18.200 kg in 21,25 ha. Final harvested yield (clean and dry seed) was 634 kg/ha.

[16] In 2020, camelina harvest suffered from hail before harvest. The insurance audited the hail damage and paid an additional 4.000 kg in 23,18 ha. Final harvested yield (clean and dry seed) was 655 kg/ha.

[17] In 2021, camelina harvest suffered from hail before harvest. The insurance audited the hail damage and paid an additional 12.100 kg in 46,0 ha. Final harvested yield (clean and dry seed) was 964 kg/ha.

[18] In 2022, camelina harvest suffered from extreme drought. The insurance audited the drought damage and paid an additional 7.000 kg in 29,73 ha. Final harvested yield (clean and dry seed) was 963 kg/ha.

4. Conclusions and recommendations for low ILUC

4.1 Key conclusions from this pilot

The overarching conclusions that can be drawn from this pilot are:

- **It was possible to follow the soil sampling protocol**, take the required measurements, perform the laboratory analysis and audit the findings for SOM and salination.

- **Erosion is difficult to demonstrate at individual farm level**. Compared to soil organic matter and salination, it might be better suited to demonstrate especially wind erosion through the use of erosion risk maps to indicate whether a farmer is located in a region with a high risk of erosion. In case of short-term erosion (such as water erosion due to heavy rainfall), photographic evidence can still provide useful evidence, although the implementation of the minimum 25% area threshold is difficult through photos.

- **This plot of land does not meet the proposed threshold for low soil organic matter** and therefore would not be considered severely degraded land, according to the definition set out in the draft low ILUC-risk certification guidance.

- **The farm has pre-existing yield**. Specific yield data was not available for this sub-plot, but the farm does have pre-existing yield which includes yield from this plot. The farmer also mentioned that there were no significant differences in yield between this plot and his other plots in the region. According to the legislation, if a plot passes the severely degraded land criteria, then all yield from the land could be considered low ILUC-risk, even pre-existing yield.

- **Camelina is grown in an otherwise fallow year, therefore not triggering demand for additional land**. Camelina is being grown in a time when the land would otherwise have been fallow. This is considered to be a good agricultural practice to help with weed management and to improve the soil structure and prevent erosion. As the land would otherwise be fallow, growing camelina should not trigger demand for additional land. Therefore, this situation could be classed as an intermediate crop, according to REDII Article 2(40) and the proposed Annex IX Part B, point (p), pending any more detailed guidance from the European Commission relating to the definition of main crops and intermediate crops.

4.2 Improvements to the certification guidance

The soil sampling protocol in Appendix A as developed specifically for use in this pilot. A relatively high soil sampling rate was chosen and samples were taken in a full grid pattern, to allow the pilot team to see the variation in soil carbon measurements across the plot. The level of intensity of soil sampling can be lower for low ILUC-risk certification. The following improvements will be made to the **final soil sampling protocol** that is recommended to be used for low ILUC-risk certification:

- **Lower sample intensity and combining samples in a composite sample for laboratory analysis.** The pilot sampling protocol took samples in a grid formation at a distance of 25 metres. It took a team of 4 people half a day to take 67 soil samples (working in teams of 2). The grid formation sampling was done to assess the variability of soil organic matter across the plot. The samples were also analysed individually in the laboratory to assess the variation. The laboratory analysis cost 1,400€ for 67 samples[19]. A full soil analysis (NPK, SOM, pH, electro conductivity) was conducted on 32 of the samples, as a compensation for the farmer to take part in the pilot and postpone sowing the next crop by a couple of days. The other half of the samples were just tested for SOM. This was more cost and labour intensive than necessary for certification. To reduce the administrative burden for the farmer, the final Soil Sampling Protocol should require a **lower sampling intensity** and that the samples can be taken in a **standard W-formation** (as is common for soil sampling) instead of a full grid-formation. Additionally, farmers should be able to send **one composite sample** per field for laboratory analysis. This reduces the laboratory analysis cost to the farmer and gives an average SOM measurement for the samples taken across the field. If a farmer desires more detailed information regarding SOM distribution, it should be allowed to take and send multiple samples and **use an average of the laboratory results per field** to create a 'post-analysis composite' result.

- **Ideally the soil sampling approach for low ILUC-risk certification should follow other standards or existing practices**, to ensure that farmers do not need to follow several different protocols for different purposes. One approach could be to follow Annex V of Implementing Regulation (EU) 2022/996, which details guidance for measuring soil carbon in the context of emissions from soil carbon accumulation "Esca" in the GHG calculation for biofuels. Aligning with the Esca approach would make it easier (from a soil sampling perspective) for farmers cultivating on severely degraded land to also claim the Esca bonus. The Esca approach recommends that farmers take 15 well-distributed sub-samples and mix them into 1 composite sample per every 5 hectares or per field, whichever is smaller, to send to the laboratory for analysis. The composite sample should be at least 500 grams. Smaller fields with the same climatic conditions, soil type and reference farming practice (if farming is present) can be grouped. Adopting this approach would have the advantage of consistency with another approach related to the REDII, however several stakeholders mentioned that the Esca approach is not feasible in practise, as the number of samples required is high and therefore results in a high cost, especially for large plots. This same argument could apply for low ILUC-risk certification, however for low ILUC-risk certification the soil sampling in theory only has to be done once up-front upon certification and not annually. Furthermore, farmers cultivating on severely degraded land or thinking of bringing severely degraded land into cultivation may anyway need to take soil samples to understand the state of the soil in order to take appropriate improvement measures. Nevertheless, effort needs to be proportionate. Other potential protocols to align with could be the upcoming **EU Soil Health Directive** and **CAP reforms**, which might include requirements for farmers to measure soil organic carbon.

The following aspects will be further detailed or clarified in the Low ILUC-risk certification guidance:

- **Demonstrating erosion using maps or weather records.** It is difficult to demonstrate erosion at a farm level, especially if it has taken place over a number of years. Furthermore, if a farmer has to prove that there is no topsoil, as currently proposed in the definitions, this would mean it is not possible to grow anything on that land. We therefore propose that it should be allowed to instead demonstrate that

[19] For the purpose of this pilot we took more samples than would be necessary to determine severely degraded land for Low-ILUC Certification. As this plot is <5ha and has homogeneous conditions throughout the plot, only one composite sample would need to be analysed in the lab for low ILUC-risk certification. This would cost around €30-32 to measure SOM and salinization.

the plot is in a location with **high erosion risk** via existing maps or models, for example those from JRC or other peer-reviewed sources. The farmer would have to prove that his plot is located in a region with a high risk of erosion. It should also be accepted that the farmer provides photographic evidence that show signs of erosion. This may be especially relevant in the case of erosion occurring in the shorter term, such as water erosion due to intense rainfall. Alternatively, this could be proven by showing weather records of intense rainfall. For land to be eligible for low ILUC-risk certification, high erosion risk has to be combined with a measured soil organic matter below the SOM threshold.

- **Demonstrating that 25% or more of the plot is eroded.** It is challenging to estimate the approximate land cover of erosion, especially in cases where erosion is not immediately visible (such as with wind erosion). Maps are often not detailed enough to distinguish erosion differences on a single plot (they are likely to be at regional level). Therefore if the plot of land is located in an mapped area (region) with high erosion-risk, then it can be considered that the 25% threshold is met. However, with photographic evidence or looking for visual signs of erosion, it is much more difficult to implement the 25% threshold, which could meet the 25% threshold. Figure 6 gives a schematic overview of erosion in a field. For example, (A) decades of wind erosion has depleted the top soil to the point where on average there is 15-20cm depth and in one area there is a large rock protruding. This rock is not 25% of the field, but there are smaller rocks scattered around the field impacting the total bulk density and soil availability of the already thin top soil. It is not feasible to calculate whether these smaller rocks and the thin top soil would pass the 25% threshold. Example (B) is based on a situation where the farmer would not cultivate 25% of their plot due to a gully splitting the field, creating a natural border. The erosion itself is not 25% of the field, but the practical impacts of the gully impacts the field for 25%. Field (C) is an example where there is a large gully splitting the field in half. The surface of this gully is not 25% of the entire field, but it does lead to substantial impacts on the usability of this field.

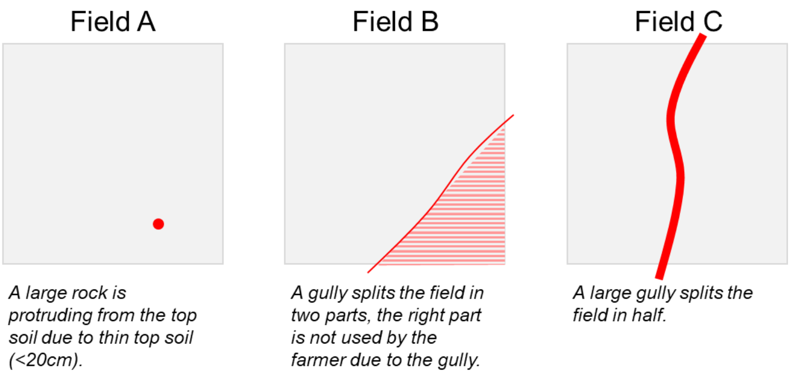

Figure 6 Examples of visual signs of erosion in a field

- **Insurance-corrected yield data should not be used in low ILUC calculations**. In the certification guidance it should be clarified that insurance-corrected yield shall not be used to set a baseline and calculate additional biomass. Actual yields should always be used and not insurance corrected yield, as the aim is to calculate actual **additional** biomass that may be claimed for low ILUC-risk certification. Using insurance corrected yields may result in claiming more yield as additional than was harvested in reality. Furthermore, not all crops or regions may have the same insurance calculation factor, as seen in this pilot. This causes asymmetrical corrections leading to an inaccurate baseline or an uneven playing field across different crops and regions.

Appendix A. Pilot audit soil sampling protocol

As part of the low ILUC-risk pilot project[20] for the European Commission, DG ENER, we are conducting a pilot to test how to measure the indicators for severely degraded land. Based on literature research and discussions with experts, this **soil sampling protocol** was drafted **for use in the pilot audit** to measure soil organic carbon. This approach was tested during the Low ILUC-risk pilot and those findings served as input for the final soil sampling protocol, which will included as an appendix to the Low ILUC-risk Certification Guidance.

A.1. Introduction

Low ILUC-risk certification aims to certify "additional biomass" produced either from yield increase measures on existing crop systems above a dynamic yield baseline, or from new cultivation on unused, abandoned or severely degraded land. This paper focuses on the category **severely degraded land**. The current Renewable Energy Directive 2018/2001/EU (the REDII), Annex V, referred to in Article 2(4) of Delegated Regulation 2019/807 gives the following definition:

*"'Severely degraded land' means land that, for a significant period of time, has either been **significantly salinated** or presented **significantly low organic matter** content and has been **severely eroded**."*

The draft Low ILUC-risk Certification Guidance[21], developed as part of the Low ILUC-risk pilot project, aims to further specify this definition of severely degraded land by providing thresholds and methods to measure the indicators. Thresholds are proposed in the guidance separately for land that would be defined as: significantly salinated, significantly low organic matter, and severely eroded.

Definition of significantly low organic matter

The draft Low ILUC-risk Certification Guidance proposes a threshold of 1% soil organic matter (SOM), below which land should be considered to have significantly low SOM.

Note on soil organic matter versus soil organic carbon: Soil organic matter (SOM) is the organic component of soil. Small fresh plant residues, small living soil organisms, decomposing organic matter and stable organic matter (humus) are all part of SOM. A majority (58%) of SOM consists of soil organic carbon (SOC), the other part is a combination of water and nutrients, such as potassium and nitrogen. It is common practice to measure soil organic **carbon** rather than soil organic **matter**, as SOC is easier to measure. A conversion of 1.724 will be used to calculate SOM from the SOC measurements.

[20] Guidehouse, Low and High-ILUC risk fuels: https://iluc.guidehouse.com/

[21] Guidehouse, Draft Certification Guidance Low ILUC-risk fuels: https://iluc.guidehouse.com/publications/28-draft-low-iluc-risk-certification-guidance

A.2. Soil sampling protocol

This soil sampling protocol includes information on how many soil samples to take, how to take the samples, how to store the samples and what to measure.

A.2.1. How many samples to take and selecting sample locations

For the purpose of the pilot, more soil samples will be taken than will be recommended in the draft guidance in a grid formation, to allow us to see the variation in soil organic matter in the pilot plot.

Many soil sampling frameworks, such as the framework compiled by Cornell University[22] recommend that soil samples are taken at regular intervals in a "W-shape" across a plot of land. However, to get an overview of the distribution of SOM on the severely degraded land pilot plot, we propose to take samples in a uniform grid (see Figure A-7), with sampling points 25 meters apart.

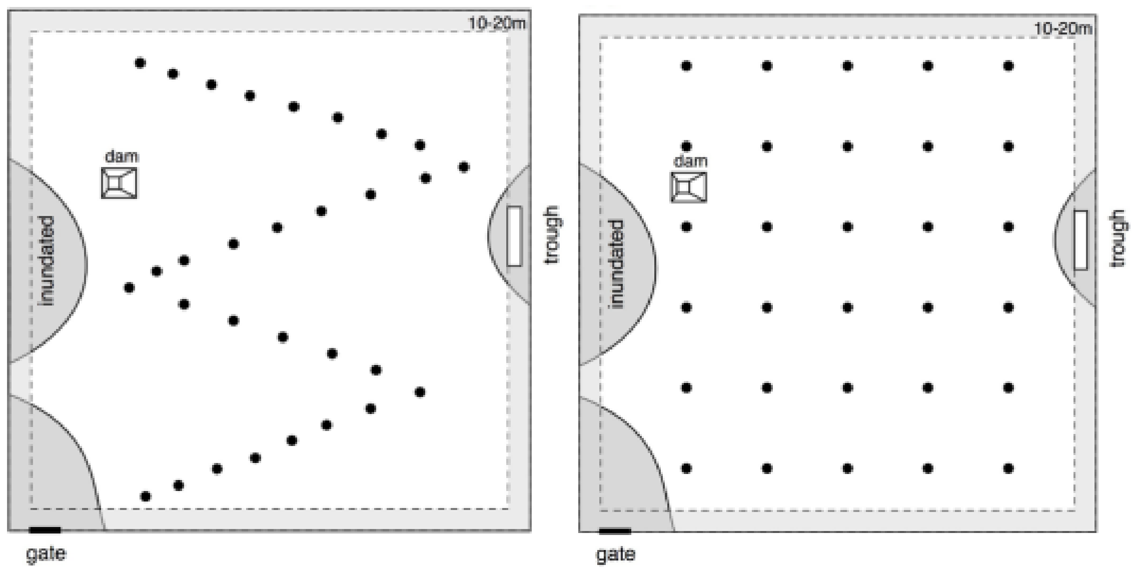

Figure A-7 W-method (left) and uniform grid method (right)[23]

A.2.2. When to take soil samples

For the pilot, the samples will be taken in autumn 2022, before sowing of the crop and once sufficient rainfall allows soil samples to be taken.

(For the final guidance it will be necessary to state when soil sampling needs to be conducted - to be developed)

22 Cornell University (2017) Comprehensive Assessment of Soil Health: http://www.css.cornell.edu/extension/soil-health/manual.pdf

23 Gourley CJP and Weaver DM (2019) A guide for fit for purpose soil sampling, Fertilizer Australia, Canberra, Australia: https://www.hort360.com.au/wordpress/wp-content/uploads/2019/11/Fertcare-Soil-Sampling-Guide.pdf

A.2.3. Soil sampling depth

FAO published a document on measuring and modelling soil carbon stocks, following the IPCC 2006 guidelines for National Greenhouse Gas Inventories. FAO recommends a sampling depth of at least 30cm, and deeper if the soil allows to[24]. However, in practise 15cm is more commonly used. In this pilot we will measure both 0-15cm and 15-30cm to test the difference in SOC at the different soil depths. Per location, samples at both depths will be taken where the soil depth allows it.

A.2.4. How to create a composite sample

As FAO recommends, per sample location 5 sub samples should be taken and mixed thoroughly to create a composite sample. From this composite sample, minimum 500 gram shall be used for analysis[25]. The remaining soil can be returned to the land. This will be done for both 15cm and 30cm depth.

A.2.5. How to collect soil samples

There are two commonly used methods to extract soil samples: either by shovel (method 1) or with a metal ring (method 2).

Method 1

These steps are based on the framework compiled by Cornell University[26]. They also made a practical video of 8 minutes long which can be viewed here[27]. See Figure A-8 below for a visual representation of the steps.

The steps are:

1. Remove surface debris
2. Use a shovel to dig a small hole that is 35 cm deep
3. From the side of the hole, use the shovel to take a thick slice of soil at 15cm deep
4. Remove any excess soil from the shovel and make sure it is level to have an even distribution of topsoil and subsoil
5. Place into clean pail
6. Repeat steps 1-5 for the 5 sub samples and mix thoroughly. Place into a clearly labelled and re-sealable 4-liter bag.
7. Repeat steps 2-6 with a depth of 30cm
8. Before moving to another sampling location, make sure to clean the shovel to avoid soil contamination/or mixing the last sampling soil residues with the new sampling location

[24] FAO (2019), Measuring and modelling soil carbon stocks and stock changes in livestock production systems https://www.fao.org/3/ca2934en/ca2934en.pdf

[25] JRC (2018) LUCAS Soil Module: https://esdac.jrc.ec.europa.eu/public_path/shared_folder/dataset/75-LUCAS-SOIL-2018/JRC_Report_2018-LUCAS_Soil_Final.pdf

[26] Cornell University (2017) Comprehensive Assessment of Soil Health: http://www.css.cornell.edu/extension/soil-health/manual.pdf

[27] Please note that there are differences between the Cornell Framework and our soil sampling protocol: sampling will be done in a grid for the purpose of this pilot, not a W-shape and we will take samples at both 15cm and 30cm depth

Figure A-8 Soil sampling protocol method 1[28]

Method 2

Similar to method 1, but instead of a shovel, a metal ring (15cm and 30cm) is used to extract the soil. These steps are compiled by Regenerative Organic Alliance[29]. See Figure A-9 for a visual representation of the steps.

1. Remove surface debris and place the metal ring on the flat field surface
2. Place wood block on top of the metal ring and use it to drive the ring fully into the ground
3. Use a garden trowel to dig around the ring and carefully lift it with the trowel underneath
4. Make sure the sample is flat and even before putting it in a clean pail
5. Repeat steps 1-4 for the 5 sub samples and mix thoroughly in the pail. Place into a clearly labelled and re-sealable 4-liter bag.
6. Before moving to another sampling location, make sure to clean the shovel to avoid soil contamination/or mixing the last sampling soil residues with the new sampling location

[28] Cornell University (2017) Comprehensive Assessment of Soil Health: http://www.css.cornell.edu/extension/soil-health/manual.pdf

[29] Regenerative Organic Certified (2020) Soil Sampling Guidelines: https://regenorganic.org/wp-content/uploads/2020/06/ROC_June2020_Soil_Sampling_Guidelines.pdf

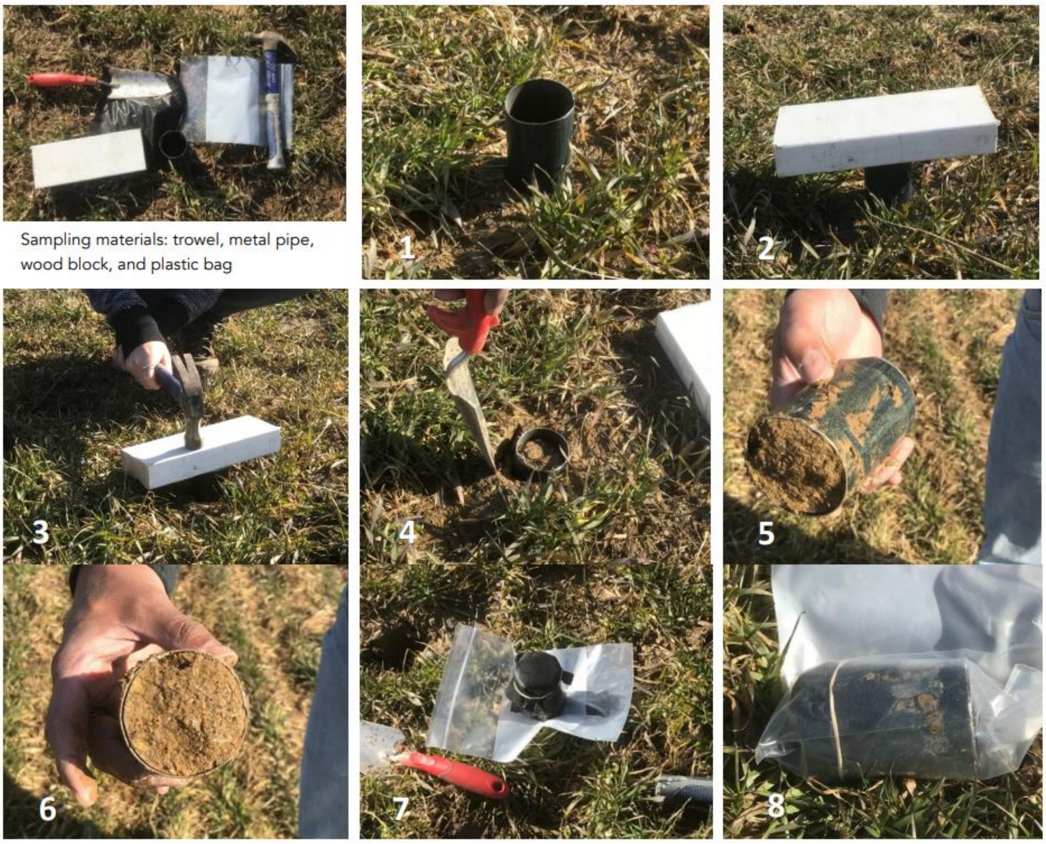

Figure A-9 Soil sampling protocol method 2[30]

A.2.6. What materials are needed

What is needed:

- 1 bucket for each sampling location
- 1 bucket to hold supplies
- Marker or pen
- Straight shovel (sharpshooter or drain spade style) OR two metal rings (15cm and 30cm)
- Cooler for sample storage and transfer
- Ice packs (optional); only needed for very hot days
- Gloves
- Sealable 4-liter (1-gallon) plastic bags, such as zip-top; double-bagging recommended

A.2.7. How to store the soil samples

After the samples are taken, the fresh soil shall not be stored in temperatures above 4 degrees Celsius or for more than 28 days after sampling, as per FAO recommendation.

[30] Regenerative Organic Certified (2020) Soil Sampling Guidelines: https://regenorganic.org/wp-content/uploads/2020/06/ROC_June2020_Soil_Sampling_Guidelines.pdf

A.2.8. How to conduct sample analysis

The sample analysis procedure is similar to what was used in the LUCAS 2018 study by JRC.[31] The soil samples should be processed in a lab that follows the ISO 10694:1995 standard for organic carbon, which is dry combustion (elementary analysis) method. The dry combustion method is also required in Implementing Regulation (EU) 2022/996[32] 'rules to verify sustainability and greenhouse gas emissions saving criteria and low indirect land-use change-risk criteria' to measure soil organic matter. The Walkley-Black method was the method used in this pilot, as this was mostly used by the laboratories in Spain.

[31]JRC (2018) LUCAS Soil Module: https://esdac.jrc.ec.europa.eu/public_path/shared_folder/dataset/75-LUCAS-SOIL-2018/JRC_Report_2018-LUCAS_Soil_Final.pdf

[32]Implementing Regulation (EU) 2022/996: https://eur-lex.europa.eu/eli/reg_impl/2022/996

Appendix B. Reflections on severely degraded land thresholds

B.1. Introduction

The EU Renewable Energy Directive (REDII) 2018/2001 sets renewable energy targets for 2030. Any bioenergy needs to meet mandatory sustainability and greenhouse gas (GHG) saving criteria. The REDII also introduces the concepts of high indirect land-use change (ILUC) feedstocks and low ILUC-risk certification. These are further defined in Delegated Regulation (EU) 2019/807 of March 2019. Implementing Regulation on voluntary schemes (2022/996) sets out more detailed guidance for low ILUC certification. Renewable transport fuels produced from feedstocks considered high ILUC-risk will be capped at the 2019 consumption level and will be phased out by 2030, unless they can be certified as low ILUC-risk.

Low ILUC-risk certification aims to certify "additional biomass" produced either from yield increase measures on existing crop systems above a dynamic yield baseline, or from new cultivation on unused, abandoned or severely degraded land This paper focuses on the category **severely degraded land**. The REDII, Annex V, referred to in Article 2(4) of Delegated Regulation 2019/807 gives the following definition:

"'Severely degraded land' means land that, for a significant period of time, has either been significantly salinated or presented significantly low organic matter content and has been severely eroded."

The draft Low ILUC-risk Certification Guidance aims to further specify this definition by providing thresholds and methods to measure the indicators. Thresholds are proposed in the guidance separately for land that would be defined as: **significantly salinated**, **significantly low organic matter**, and **severely eroded**. Based on literature research and discussions with experts, questions arose that we would invite your opinions and reflections on – listed below.

Questions

General

1. Would it be more appropriate to have separate criteria between soils that are naturally low in SOC and eroded, or saline due to human influences?
2. The thresholds are currently static. Is that appropriate or should these be changing over time or be relative to the surrounding or climatic region.

Significantly salinated

3. Is our proposed threshold of 8 dS/m appropriate as a definition of severely degraded land?
4. Should we distinguish between saline and sodic soil, and natural salinity or salinity due to human practises?
5. Is the proposed method of measuring salinisation appropriate?

Significantly low organic matter

6. The draft guidance proposes 1% SOM (0.58% SOC based on conversion of 1.725), which is significantly lower than what is commonly used (1% SOC or 3.4% SOM). Keeping in mind the definition is regarding severely degraded land, is this threshold appropriate?

7. Is a static threshold appropriate or would it be recommended to use different thresholds for different landscapes (as Pawar et al.) or have a SOC/clay ratio as a criterion?

Severely eroded

8. Is using photographic evidence an appropriate proxy to measure erosion, or are there alternative methods that are better suited for a farmer to execute?
9. Is the combination of the two proposed criteria (signs of erosion and all topsoil removed, leaving hardpan) too harsh to assess severely degraded land? Would it be more appropriate to meet one criterion, or perhaps include 'no topsoil' as a type of erosion?
10. Would it be an improvement to include erosion due to mismanagement of the land in the proposed definition of erosion?
11. Would it be an improvement to include contaminated land in the proposed definition of erosion?

B.2. Significantly salinated

Salts may be naturally present in the soil due to the soil and rock type, or due to the proximity of the land to the sea. However, most of the time in agricultural areas, high levels of salination are due to irrigation techniques. In warm regions, water evaporates before it can penetrate the soil, leaving the salt behind. There are three main soil conditions resulting from excess salt: saline, sodic and saline-sodic soils.

- When soils are saline, it means that there is an excess of salt. This manifests itself through a white crust on the soil surface, water stressed plants and leaf tip burn.
- Sodic soils are due to an excess of sodium. Sodic soils usually have poor drainage and a black powdery residue on the soil surface.
- Saline-sodic soil have the same symptoms as saline soil.

Many crops are sensitive to salts in the soil and will either result in lower yields or will not be able to grow at all. Figure B-10 visualises the distribution of saline and sodic soils in Europe, as mapped by JRC in 2008. This map was compiled with data from the European Soil Database and all saline soils were included that are above the threshold of 15 dS/m, or 4 dS/m and a pH above 8.5. In Europe, most saline soils are in Spain and coastal areas of Germany, Spain and Portugal. Sodic soils are mainly located in Hungary.

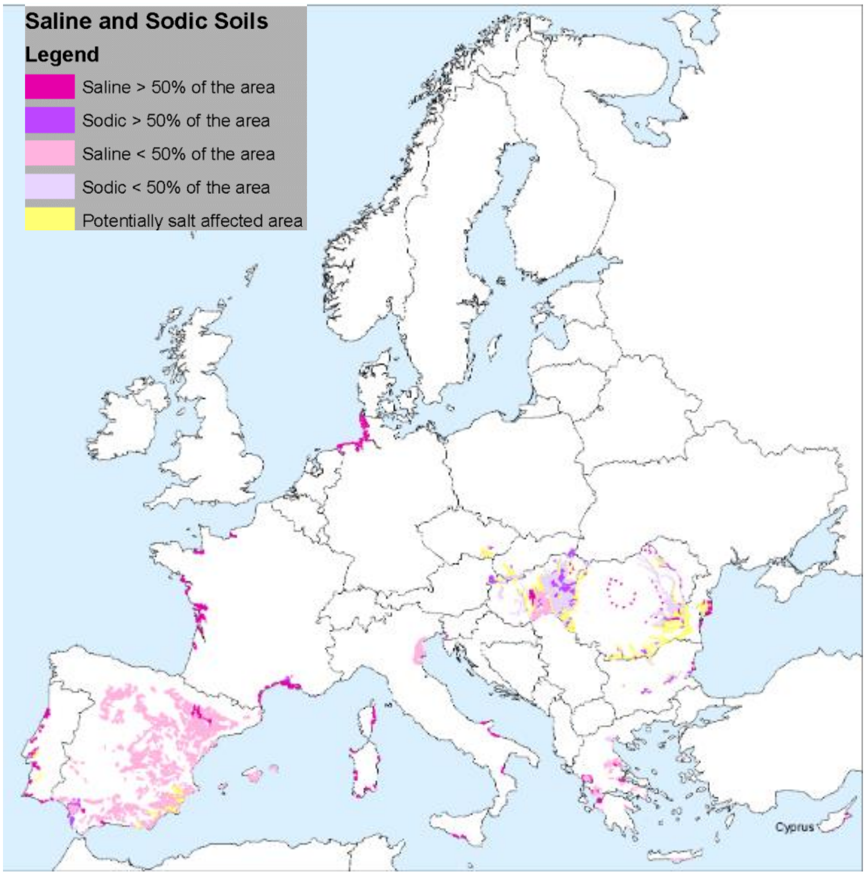

Figure B-10 Salt in European soils[33]

The draft Low ILUC-risk certification guidance proposes the following definition for 'significantly salinated' soils:

[33] https://esdac.jrc.ec.europa.eu/content/saline-and-sodic-soils-european-union

*"**Severely salinated soils** are defined as those having an electroconductivity (as measured by the saturated paste method) of more than **8 deci-siemens per metre (dS/m)**. The yield achievable from most crops is reduced at this level of salinisation. Electroconductivity at or above this threshold must be present on average within the rooting zone of **0-30cm depth** across at least **80% of the area** of the delineated site."*

To test soil salinity, an electrical conductivity test should be performed which measures the ability of the soil to conduct electricity. Water conducts electricity quite badly, so the conductivity goes up as the soil gets more salinated. Typically, a pH soil sample is taken as well. If the pH is high (>8.5), a sodium adsorption ratio (SAR) is recommended to be calculated to determine whether the soil can be considered sodic.

Waksom et al. (2010) provide generally accepted critical thresholds of saline and sodic soils, which are visualised in Table B-2 below. They suggest measuring the pH values to determine whether the soil could be sodic or saline-sodic. However, as sodic soils are not included in the severely degraded land definition of the European Commission, we will further focus on the saline soils critical thresholds.

Table B-2 Critical thresholds for saline and sodic soils[34]

Classification	Electrical conductivity (dS/m)	Soil pH	Sodium adsorption ratio
Saline	>4.0	<8.5	<13
Sodic	<4.0	>8.5	>13
Saline-sodic	>4.0	<8.5	>13

Diaz & Presley (2017) provide further context and interpretation to the electrical conductivity measurements, see Table B-3 below. The proposed threshold of 8 dS/m would mean that the ranking is 'excessive' and that salt-tolerant plants will grow, but most others show severe injury. The map on saline soils in Europe that JRC compiled with a threshold of 16 dS/m will only visualise soils that have a salt rank of 'very excessive' and very few plants will tolerate this soil and grow there, according to Diaz & Presley (2017).

Table B-3 Interpretations and salt ranks of electrical conductivity values[35]

Electrical conductivity (dS/m)	Salt Rank	Interpretation
0-2	Low	Very little chance of injury on all plants
2-4	Moderate	Sensitive plants and seedlings of others may show injury
4-8	High	Most non-salt tolerant plants will show injury; salt-sensitive plants will show severe injury
8-16	Excessive	Salt-tolerant plants will grow; most others show severe injury
16+	Very excessive	Very few plants will tolerate and grow

As mentioned above, certain saline soils can still bear to cultivate crops, depending on the electrical conductivity and the salt-tolerance of the crop. In the guidelines for agricultural areas with natural constraints, JRC sets the threshold at 4 dS/m[36] as that's where most non-salt tolerant plants will show injury. Saline soils with an electroconductivity value higher than 4 dS/m can still grow various crops, albeit with lower yields as a result. With values higher than

[34] Waskom et al (2010): Diagnosing Saline and Sodic Soil Problems https://extension.colostate.edu/docs/pubs/crops/00521.pdf
[35] Diaz & Presley (2017): Management of Saline and Sodic Soils https://bookstore.ksre.ksu.edu/pubs/MF1022.pdf
[36] JRC (2016): Updated Guidelines for Applying Common Criteria to Identify Agricultural Areas with Natural Constraints

8 dS/m, only salt-tolerant plants will grow, and non-salt tolerant plants will not generate substantial yields.

FAO reports thresholds on various salt-tolerant crops, see Table B-4 below. The threshold is set where it will affect the yield, meaning these crops will only start showing negative impact in yield beyond these thresholds. Only crops with a threshold >8 dS/m are mentioned in the table.

Table B-4 Salt-tolerant crops and their critical thresholds[37]

Common name	Botanical name	Electroconductivity threshold (dS/m)
Barley	*Hordeum vulgare L.*	8.0
Rapeseed	*Brassica campestris L. [syn. B. rapa L.]*	9.7
Rapeseed	*B. napus* L.	11.0
Guar	*Cyamopsis tetragonoloba* (L). Taub.	8.8
Kenaf	*Hibiscus cannabinus* L.	8.1
Rye	*Secale cereale* L.	11.4
Wheat	*T. aestivum* L.	8.6
Guayule	*Parthenium argentatum* A. Gray	8.7

Our proposed definition of significantly salinated lands has a threshold of 8 dS/m. The table by Waksom et al. (2010) suggests that these lands would fall under the ‘excessive’ category regarding salt ranks. FAO stat shows that salt tolerant crops can in fact grow, although they would be affected by the high salt levels and show lower yields. To allow for the improvement of degraded land and have successful yield increase measures, we propose to lower the threshold to >4.0 dS/m, which would fall under the category ‘high’ regarding salt ranks. This is also the threshold that JRC used in their maps.

Our proposed method of measurement using the dS/m unit and electro conductivity method is commonly used to measure salinity. We recommend that a pH measurement is not needed in this case, as the RED definition excludes sodic soils.

[37] FAO (1999): Annex 1. Crop salt tolerance data https://www.fao.org/3/y4263e/y4263e0e.htm

B.3. Significantly low in organic matter

Soil organic matter (SOM) is the organic component of soil. Small fresh plant residues, small living soil organisms, decomposing organic matter and stable organic matter (humus) are all part of SOM. A majority (58%) of SOM consists of soil organic carbon (SOC), the other part is a combination of water and nutrients, such as potassium and nitrogen. SOM benefits soil health and aboveground vegetation, as it retains moisture and is part of the nutrient cycle. Healthy SOM means that less fertilizer needs to be used and there is a positive relationship between SOM and crop yield. If SOM levels are depleted, the soil is at a higher risk of desertification and erosion. Wind and water erosion can also cause depletion of SOM. Other factors are cultivation and climatic factors.

It is common practice to measure soil organic **carbon** rather than soil organic **matter**, as SOC is easier to measure. The conversion of SOC to SOM uses a factor of 1.724.

The draft Low ILUC-risk certification guidance proposes the following definition for ‘significantly low’ soil organic matter:

“Soil should be considered to be low in soil organic matter, if organic matter of ***less than 1%*** *is measured from* ***representative soil samples*** *taken from the delineated plot and tested by the dry combustion method, correcting as necessary for bulk density.”*

Figure B-11 below maps the estimated percentage of SOC in European soils. Note that this map shows the soil organic **carbon** content in European soils, not soil organic **matter**. This map is compiled by JRC in 2010 for the European Environmental Agency. Soils low in organic matter are mainly located in Southern Europe and France.

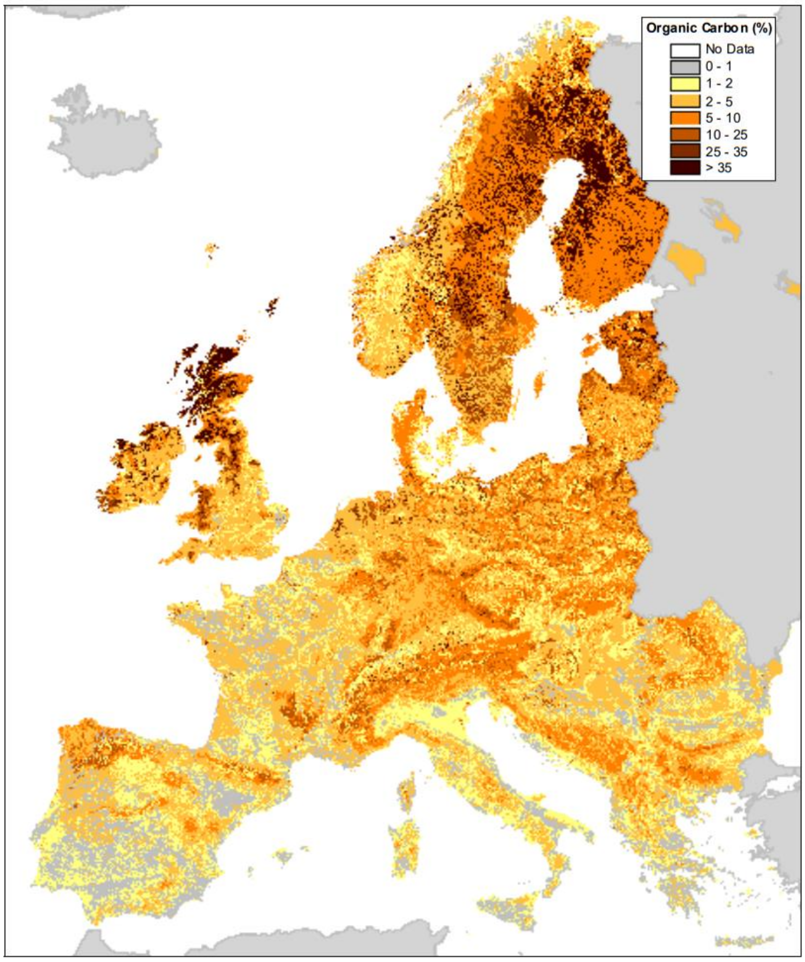

Figure B-11 Estimated soil organic carbon (SOC) levels in European soils[38]

Thresholds between 1% and 2% are commonly used to determine critically low levels of SOC. Table B-5 portrays common SOC/SOM thresholds used in literature. Hijbeek et al. (2019) [39] conducted a survey among more than 1500 farmers in 5 countries (Belgium, Austria, Germany, Italy and Spain) and asked them about their perceptions regarding critical SOM thresholds. Those results can be found in Table B-6. Both tables show various SOM and SOC thresholds, however on average the thresholds are between 1 and 2% SOC (1.7% - 3.4% SOM).

[38] https://www.eea.europa.eu/data-and-maps/figures/variations-in-topsoil-organic-carbon
[39] Hijbeek et al. (2019): https://edepot.wur.nl/511835

Table B-5 Critical thresholds used in literature

Thresholds SOC	Thresholds SOM[40]	Source
2%	3.4%	Oldfield et al. (2019)[41]
1%	1.7%	Grilli et al. (2021)[42]
2% in temperate regions, 1.1% in tropical regions	3.4% 1.9%	Pawar et al. (2017)[43]
0.6 – 1.2%	1.0 – 2.0%	Kemper & Koch (1966)[44]
2%	3.4%	Greenland et al. (1975)[45]

Table B-6 SOM thresholds for cropland based on farmer's questionnaire

Climate	Texture	Threshold (SOM)	Threshold (SOC)[46]
Atlantic	Coarse	2.1% – 3.5%	1.2% – 2.0%
	Medium	1.7% – 2.6%	1.0% – 1.5%
	Medium fine	NA	NA
Continental	Coarse	1.8% – 2.1%	1.0% – 1.2%
	Medium	2.3% – 3.2%	1.3% –1.9%
	Medium fine	2.0% – 2.4%	1.2% – 1.4%
Mediterranean	Coarse	1.4%	0.8%
	Medium	1.0% – 2.0%	0.6% – 1.2%
	Medium fine	1.3% – 1.4%	0.8% – 0.8%

Loveland and Webb (2003)[47] argue that due to the differences in soil types and the clay to SOC ratio it might be more appropriate to avoid using one universal value and rather base it on soil properties such as the clay ratio. Johannes et al. (2017)[48] suggest a 1/10 SOC/clay ratio as a threshold for degradation. Prout et al. (2020)[49] agree, but propose a different ratio for grassland degradation, namely 1/13 as the 1/10 SOC/clay ratio rarely appeared in their study of degraded grasslands. Table 5 also shows differences between farmers perceptions of critical thresholds based on the texture of the soil and the climate in which they are located. Farmers in a Mediterranean climate find lower SOM/SOC thresholds less critical than farmers Atlantic and Continental climates.

Garratt at al. (2018)[50] looked at the yield differences in eight plots of land cultivating wheat in the UK, the Netherlands, Sweden, and nine fields in Germany and Portugal with varying SOC and fertilizer levels. The SOC thresholds per country can be found in Table B-7 below. The categorisation of high or low SOC was region specific. For example, a low SOC scenario in Sweden is higher than the high SOC scenario in Portugal, Germany and the UK.

[40] Based on conversion of 1.724
[41] Oldfield et al. (2019): https://doi.org/10.5194/soil-5-15-2019
[42] Grilli et al. (2021): https://doi.org/10.1016/j.jenvman.2021.112285
[43] Pawar et al. (2017): https://doi.org/10.20546/ijcmas.2017.605.256
[44] Kemper & Koch (1966): https://ageconsearch.umn.edu/record/171386/files/tb1355.pdf
[45] Greenland et al. (1975): https://doi.org/10.1111/j.1365-2389.1975.tb01953.x
[46] Based on conversion of 1.724
[47] Loveland and Webb (2003): https://doi.org/10.1016/S0167-1987(02)00139-3
[48] Johannes et al. (2017): https://doi.org/10.1016/j.geoderma.2017.04.021
[49] Prout et al. (2020): https://doi.org/10.1111/ejss.13012
[50] Garratt et al. (2018): https://doi.org/10.1007/s10021-018-0228-2

Table B-7 Low and high SOC levels per country[51]

Country	Average low SOC sites	Average high SOC sites
UK	1.05%	1.48%
The Netherlands	1.39%	2.00%
Sweden	1.89%	1.95%
Germany	1.20%	1.63%
Portugal	0.84%	1.26%

Garratt et al. (2018) found that the Harvest Index, aboveground biomass and yield all increased in low SOC fields when fertiliser was applied. In every case, the low SOC field with fertiliser surpassed the high SOC field without fertiliser, meaning that the fertiliser had a higher impact on the yield than the SOC levels did. When looking at aboveground biomass, the fields with low SOC levels and fertiliser even surpassed the fields with high SOC levels and fertiliser, see Figure B-12 below. Loveland and Webb (2003) also found that 90% of the potential yield can be achieved in low SOC soils when using fertilizer. However, an increase of N-fertiliser leads to an increase of costs and N_2O emissions. An increase of emissions could mean that the crop is no longer suitable for biofuels, if it does not meet the GHG savings criteria set in the REDII[52].

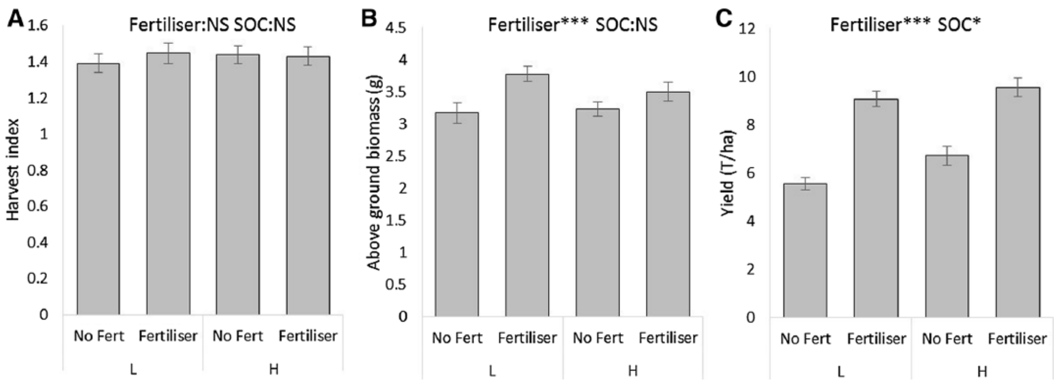

Figure B-12 The effects of SOC and N-fertilizer on wheat growth[53]

It is debated in scientific literature whether 2% or 1% SOC (3.4% or 1.7% SOM) would be an appropriate measure, or if it would be better to have various thresholds based on soil types and clay ratio. The guidance proposes a threshold of 1% SOM, which would mean 0.58% SOC (based on traditional conversion of 1.724). It is important to note that massively increasing fertilisation to have higher yields in low SOC soils might not be suitable as biofuels need to adhere to a certain GHG savings threshold set by the REDII. We propose to lower the threshold to 1% SOC (1.7% SOM) to reflect a conservative but moderate approach following the studies quoted.

[51] Garratt et al. (2018): https://doi.org/10.1007/s10021-018-0228-2

[52] REDII GHG savings threshold from 1 January 20201 for biofuels, bioliquids and biomass fuels is 65% for the transport sector and 70% for electricity, heating and cooling (compared to the fossil fuel comparator). Fossil fuel comparator for transport is 94 g CO2eq/MJ, for electricity 183 g CO2eq/MJ and for heating and cooling 80 g CO2eq/MJ

[53] Garratt et al. (2018): https://doi.org/10.1007/s10021-018-0228-2

B.4. Severely eroded

Soil erosion is when sediment of soil particles gets displaces by wind, water or due to anthropogenic causes such as tillage or removal of vegetation cover. Erosion itself occurs naturally and is not an immediate cause for concern, if the erosion rate stays below a certain threshold which will be discussed later.

The draft Low ILUC-risk certification guidance proposes the following definition for erosion:

*"In the case of severe erosion, at least **25% of the delineated plot** shall have been eroded. Severe erosion due to water is assessed to be present when:*

- *In deep soils (those with a rooting depth of 50cm or more) all of the topsoil and some subsoil has been removed, and/or there are moderately deep gullies less than 20m apart;*
- *In shallow soils all topsoil has been removed, leaving hardpan or bedrock.*

Severe erosion due to wind is assessed to be present when:

- *In deep soils, all topsoil and part of the subsoil has been removed and/or there are many (>70% of area) shallow (<5cm) or frequent (40-70% of area) moderately deep (5-15cm) or few (10-40%) deep (>15cm) hollows or blowouts;*
- *In shallow soils all topsoil has been removed, leaving hardpan or bedrock.*

In the case of severe erosion, photographs to support the opinion of a qualified agronomist that such erosion is present on at least 25% of the delineated plot."

Panagos et al. (2015)[54] investigated water erosion-prone lands in Europe, which mainly consists of agricultural land, forests, and semi-natural land. In their study, they reported that around 25% of EU land has a higher erosion rate than 2 t/ha/yr (2.46 t/ha/yr on average, 6% of the agricultural land even shows severe erosion of 11 t/ha/yr). Their study was replicated for the UK, and it overestimated the erosion rate compared to field measurements. In both the UK and Germany, an average erosion rate of 0.85-0.86 t/ha/y were reported based on field measurements (Darmendrail et al., 2004; Steinhoff-Knopp and Burkhard, 2018)[55][56]. Cerdan et al. (2010)[57] report an average erosion rate of 3.6 t/ha/yr, of which 70% occurs in 15% of the area. OECD[58] reports a threshold for moderate erosion of 11 t/ha/yr, and 22 t/ha/yr for high erosion and 33 t/ha/yr for severe erosion.

Verheijen et al. (2009) [59] looked at actual soil erosion rates in Europe per erosion type, see

Table B-8 Table B-8. In their study, they compared actual erosion with the soil formation rate between 0.3 - 1.4 t/ha/yr. Verheijen et al. (2009) also highlighted that erosion due to human practises (such as tillage, with a mean of 3 – 9 t/ha/yr)) tend to be more severe than erosion due to natural causes (wind erosion was between 0.1 – 2.0 t/h/yr).

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[54] Panagos et al. (2015): https://doi.org/10.1016/j.envsci.2015.08.012
[55] Darmendrail et al. (2004): https://www.researchgate.net/publication/235759282_Assessing_the_Economic_Impacts_of_Soil_Degradation
[56] Steinhoff-Knipp and Burkhard (2018): https://doi.org/10.3897/oneeco.3.e26382
[57] Cerdan et al (2010): https://doi.org/10.1016/j.geomorph.2010.06.011
[58] OECD, agri-environmental indicators: https://stats.oecd.org/index.aspx?queryid=79113
[59] Verheijen et al. (2009): https://doi.org/10.1016/j.earscirev.2009.02.003

Table B-8 Soil erosion rates in Europe[60]

Erosion type	Mean rates (t/ha/yr)	Maximum rates (t/ha/yr)	Main factors
Rill, sheet erosion	0.1 – 8.8	23.4	Land use, soil cover, slope
Gullies	NA	455	Climate, land use
Wind erosion	0.1 – 2.0	15	Soil type, soil cover, climate
Tillage erosion	3.0 – 9.0	NA	Soil management
Slope engineering	NA	454	Soil management
Crop harvesting	1.3 – 9.0	NA	Crop type, soil moisture content at time of harvesting

Figure B-13 below maps the soil erosion risks due to water and wind in Europe. Water erosion is mainly prevalent in Italy and Southern Spain while wind erosion has a higher soil loss in Eastern England, Denmark and the East of Romania and Bulgaria.

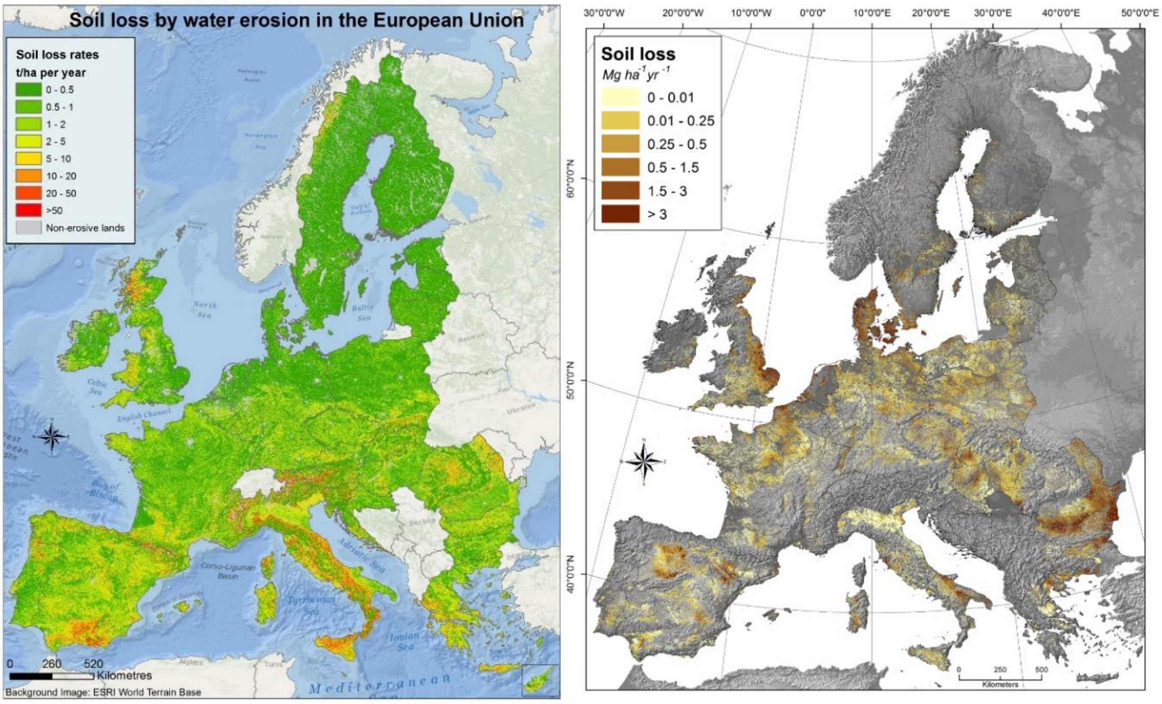

Figure B-13 Soil erosion due to water (left)[61] and wind (right)[62] in 2016

The review on soil thresholds by EEA (2021)[63] report that the main indicator to measure erosion is the loss of topsoil mass, expressed in t/ha/yr. If this data is not available, a proxy may be used, such as evidence of erosion features, exposure of plant roots, reduced SOM, and reduced rainwater infiltration. There are three main methodologies used to determine topsoil loss, namely using models, direct measurements in the field, and indirect measurements on run-off plots.

[60] Verheijen et al. (2009): https://doi.org/10.1016/j.earscirev.2009.02.003
[61] https://esdac.jrc.ec.europa.eu/content/soil-erosion-water-rusle2015
[62] https://esdac.jrc.ec.europa.eu/content/Soil_erosion_by_wind
[63] Baritz et al. (2021): https://www.eionet.europa.eu/etcs/etc-di/products/etc-uls-report-2021-soil-monitoring-in-europe-indicators-and-thresholds-for-soil-quality-assessments

The LUCAS 2018[64] study by JRC aimed to map various soil properties, such as erosion. The questions in the field form are to determine whether there is erosion (yes/no ticking box) and the type of erosion present (sheet, rill, gully, or wind erosion, mass movement, re-deposited soil). Of the 19.345 points assessed only 850 showed signs of erosion, mainly due to gully erosion. Sheet, rill and wind erosions, redeposited soils and mass movements were not correctly identified by the participants, gully erosion was correctly identified by most. Figure B-14 below visualises the gullies reported in the LUCAS 2018 study. Gullies seem to be mainly present in Spain and Greece.

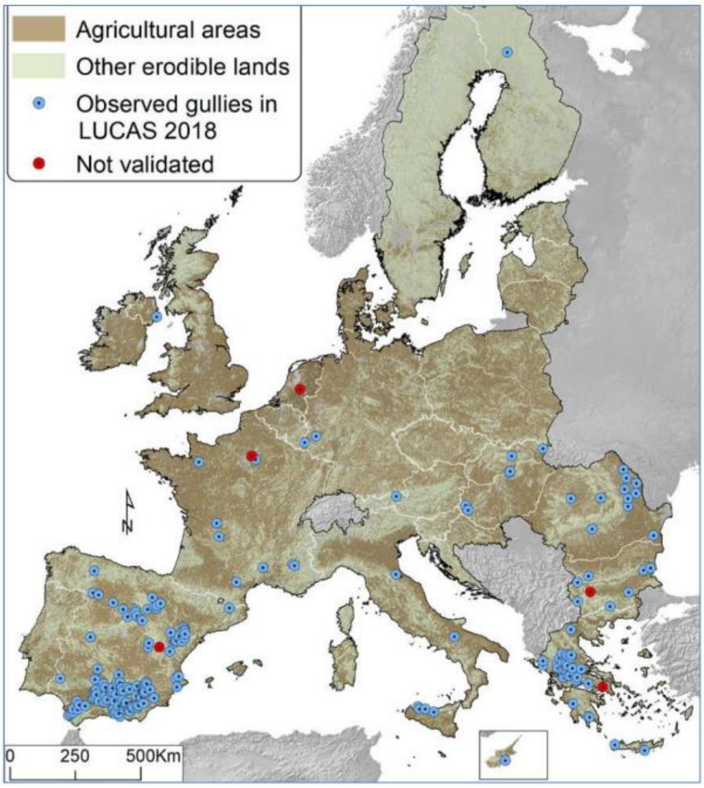

Figure B-14 Distribution of gully erosion

Most literature and studies measure erosion in soil loss t/h/yr, however this might not be appropriate for the farmers to conduct themselves. The LUCAS 2018 study and the review by EEA both mentioned photographic evidence as a proxy to measure erosion. However, this method was only effective to identify gully erosion and was not properly reported for the other forms of erosion. A downside of using photographic evidence, is that erosion can only be reported once it is severe. When setting thresholds with t/ha/yr, the process of erosion can be halted and steps could be taken to restore the land. The mentioned study did not set a criterion that all the topsoil should have been removed in order for the soil to be considered eroded, which is a criterion in the draft guidance.

We propose to add to the methodology, where the farmer is allowed to use peer-reviewed maps or modes to prove that their plot is in a region with a high risk or erosion (a higher soil loss than soil formation rate of >1.5 t/ha/yr). If such maps are not available, the farmer should provide photographic evidence of the signs of erosion and shallow topsoil (such as gullies, protruding rocks, exposed roots).

[64] JRC (2022): https://esdac.jrc.ec.europa.eu/public_path/shared_folder/dataset/75-LUCAS-SOIL-2018/JRC_Report_2018-LUCAS_Soil_Final.pdf