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What Place for Contractual Commitments in the Protection of European Agricultural Soils? The Example of Carbon Sequestration



Alexandra Langlais

Abstract The contractual formula is becoming increasingly attractive to stakeholders, especially when it is associated with a booming market, as is the case for carbon sequestration in agricultural soils. Contracts have developed in tandem with the interest of this natural sequestration by agricultural soils to achieve climate neutrality by 2050. The parallel arrival of draft legislation with binding targets does not oppose two modes of legal intervention. On the contrary, it actually tends to strengthen the legitimacy of each of them in favour of increased protection of agricultural soils, although many questions remain unanswered.

1 Introduction

Although European law has an EU Water Framework directive¹ and a framework directive on air,² soil has long been considered the poor relation of legal protection of environmental components. However, efforts in this direction have not been spared.

A part of this work was carried out under two research contracts: project H2020 CONSOLE “*Contract solutions for effective and lasting delivery of agri-environmental climate public goods by EU agriculture and forestry*”, call H2020 RUR-O3-2018 for Contract for effective and lasting delivery of agri-environmental public goods, see in this research report “legal aspects” by A. Langlais, M. Cardwell and T. Runge, 102 p., available at <https://console-project.eu> (Last access: 22 June 2022); The second project is a national MITI-CNRS-France, “Interrogating the role of carbon capture and storage to meet the challenge of climate neutrality” (translated title).

¹Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, OJ L 327, 22.12.2000.

²Directive 2008/50/CE du Parlement européen et du Conseil du 21 mai 2008 concernant la qualité de l’air ambiant et un air pur pour l’Europe, OJ L 152, 11.6.2008 (changed in 2015).

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In 2002, a thematic strategy on soil stated the need to provide a legal framework for soil.³ Legal recognition of the preciousness of soils and the need to protect them goes back further than this, if we look at the European Soil Charter of 1972.⁴ At the international level, a first version of the world soil charter was adopted in 1981 by the FAO.⁵ Although these efforts led to a draft EU framework directive on soil in 2006, the withdrawal of this draft marks a halt to a coherent and binding legal framework for soil protection.

The contributions and reasons for the failure of this draft directive are, however, a source of particularly useful lessons for analysing the place of contractual commitments in the protection of European agricultural soils. Defining what is a contract is not as straightforward as one might think, since the form of contract varies from state to state. In particular, there is a divergence in the rules of law governing contracts as between the civil law and the common law. These divergences, which reflect cultural diversity, can affect the ways in which the contract is drawn up and implemented. However, over and above the often specific and technical rules, there are nevertheless major principles such as “*pacta sunt servanda*” (Latin for “agreements must be kept”, or the principle of good faith), which guide most legal systems. In general, a contract can be defined as an agreement which creates or purports to create a binding legal relationship, or which purports to produce some other legal effect. It is a bilateral or multilateral act.

Because of their very strong connection with the land and the soil, the latter form a particularly rich field of observation. The nature of this link was recently made clear in the European Commission’s Communication, ‘The Future of Food and Farming’ in 2017.⁶ This preparatory document for the 2023 CAP, placed particular emphasis on soils, indicating the importance of ‘increase resilience and soil health’.⁷ The mention of resilience was only made for soils, underlining the specific importance of soils for agriculture.

Despite its failure, the draft EU Soil Framework Directive explicitly stated a new angle of legal protection for soils. In fact, the draft directive has clearly focused the purpose of its protection on soil functions and services. The new European soil strategy of 21 November 2021⁸ confirms and strengthens the choice of this functions

³Communication from the Commission to the Council and the European Parliament, the European Economic and Social Committee and the Committee of the Regions: Towards a thematic strategy for soil protection, COM (2002) 179 final.

⁴“**Soil** is a living and dynamic medium which supports plant and animal life. It is vital to man’s existence as a source of food and raw materials”. This charter was revised in 2002.

⁵In 2015, a revised version was written.

⁶Communication from the Commission to the European Parliament, the Council, the European Economic and social committee and the Comitee of the Regions, The Future of Food and Farming, COM (2017) 713 final, 29.11.2017.

⁷Ibid, p. 12.

⁸Communication from the Commission to the European Parliament, the Council, the European Economic and social committee and the Comitee of the Regions, EU Soil Strategy for 2030 Reaping the benefits of healthy soils for people, food, nature and climate, COM (2021) 699 final.

and services approach to soil protection. It is in line with the aborted draft directive, which also aimed to focus on human activities that compromise the capacity of soil to perform these functions and to identify areas and processes of degradation. The new Soil Strategy 2021 also states that “as part of the Soil Health law, and in the context of an impact assessment, assess requirements for the sustainable use of soil so that its capacity to deliver ecosystem services is not hampered, including the option of setting legal requirements” (pt 4.1) as well as “significant areas of degraded and carbon-rich ecosystems, including soils, are restored” (pt 2).⁹ The new European soil strategy therefore again envisages a binding legal framework for soils. The recent proposal for a directive of 5 July 2023 qualifies this ambition (Proposal for a Directive on Soil Monitoring and Resilience, COM (2013) 416 of 5 July 2023) as it now focuses on soil monitoring rather than explicitly on soil restoration. The requirement for legally binding targets to be achieved has disappeared. Furthermore, with regard to sustainable soil management (article 10), the Member States will have to define sustainable soil management practices that will have to be progressively implemented on all managed soils, as well as soil management practices that have a negative impact on soil health and that will have to be avoided by soil managers. However, on the one hand, the obligations on land managers are not direct and, on the other hand, the time required to define these management practices is not immediate. However, the proposed text must now be examined by the European Parliament and the Council.

In addition, one of the main difficulties faced by the draft Soil Framework Directive is that the Member States’ conception of soil is not conducive to taking account of its ecological functionality. It is, in fact, a soil-surface where the sovereignty of the states is expressed and private property claims are made. From this point of view, a legal framework on soil is immediately associated with a fear of loss of prerogatives, which a contractual approach can mitigate. However, Member States’ views on soils have changed.¹⁰ They are now more receptive to a more holistic view of soil and thus more broadly to a new Soil Framework Directive which may set legal requirements for soil protection which they will have to implement. All soils, especially agricultural soils, are privately owned. Here, too, a shift towards the use of land for environmental purposes is noticeable. Both owners and tenants of agricultural land are increasingly aware of the need to use agricultural land sustainably. This awareness is driven by the Common Agricultural Policy which, through its contractual funding, guides farmers’ agricultural practices. Through their competences in the field of land use planning and land policy, the Member States are also at the origin of this change by proposing, in particular, the integration of environmental clauses in rural lease contracts.

⁹Ibid.

¹⁰In addition, “The proposal for a soil health law answers calls from the European Parliament and the European Committee of the Regions to develop a comprehensive EU legal framework for soil protection and to grant this valuable natural resource the same level of protection as water and air”, Proposal for a Directive on protecting, sustainably managing and restoring EU soils - Soil Health Law, Document Ares(2022)1132884, See Call for evidence for an impact assessment.

The purpose of this chapter is to highlight the existence of a particular conjunction of legal instruments for the protection of European soils, and more particularly European agricultural soils, on which we will focus. Both contractual and regulatory tools are currently being developed with the same aim of protecting soil and preserving its functions and services. The announced arrival of a new framework directive on soil containing a new regulatory approach provides an opportunity to consider the link between these two approaches, i.e. between a regulatory approach and a contractual approach. To anchor this analysis, we illustrate our remarks by focusing more specifically on carbon sequestration.

First, we will develop the contribution and the undeniable interest of the contractual approach to preserve and sustainably manage agricultural soils (Sect. 2). The aborted draft Soil Framework Directive put the functions and services of soil in the spotlight. Its withdrawal did not extinguish interest in this aspect of soil protection and in a way left the field open for other interventions than regulatory ones. In this case, the clearly stated recognition of the services provided by soils has opened up prospects to identify a new contractual object. Actions to preserve them are, in fact, at the heart of contractual arrangements that consider specific services provided by the soil, such as carbon sequestration. Protection through the preservation or restoration of these services implies new contractually agreed agricultural practices. The farmers concerned are thus encouraged to change their practices without being hindered in their freedom to use their land as they wish. The potential of the contractual tool appears undeniable to contribute to the preservation and improvement of agricultural land. In particular, in the agricultural field, the contractual tool has been able to renew itself to propose innovative formulas and thus meet specific environmental expectations, including the fight against climate change. The contract will therefore be a privileged vector to encourage agricultural practices favourable to the sustainable management of agricultural soils but also to commit to environmental performance by linking the conclusion of contracts with farmers to the achievement of environmental results.

However, in order to consolidate or even reinforce the changes in practices obtained with the help of contracts, but also to offer a common orientation to ensure the sustainable management of soils, in this case agricultural soils, the regulatory tool appears useful or even necessary. This need may arise from both greater visibility of the capacity of soils to respond to the challenges of global change, leading to a collective awareness and the urgency of the action to be taken. Agricultural soils have a special place among the responses to the reiteration of the urgency to act to curb global change.¹¹ In particular, they are being considered as negative emission technologies (NETs)¹² to remove and sustainably store CO₂ from the atmosphere. The urgency of the action to be taken certainly requires us to think

¹¹IPPC (2009).

¹²Fuss et al. (2018); IPPC (2018), pt C. 3.1; Langlais and Lemoine-Schonne (2022); Langlais (2022).

differently about the legal attention given to soils, and more specifically to agricultural soils, with regard to the expectations that are formulated for them.

This is why, in a second step (Sect. 3), we will examine the support that a regulatory approach can give to the contractual one. The new European soil strategy of 2021 allows a start to be made. This strategy proposes that the requirements for sustainable land use should be assessed during the impact assessment so that there is no obstacle to ecosystem services. This announcement is associated with a draft Soil Framework Directive for 2023.

On reading this strategy, we hypothesised that sustainable soil use was based on a high environmental ambition for the European Commission, namely not to alter the ecological integrity of soil. Based on this assumption, we saw this new binding legislative framework as an opportunity to create a synergy with the contractual approach to sustainable soil management, in this case agricultural soil. This potential synergy was tested from a spatial perspective by analyzing the relevance of ecological zoning of agricultural soils for carbon sequestration. This potential was also tested from a temporal perspective by questioning the legally binding objectives for restoring the most carbon-rich degraded ecosystems envisaged in the framework of the 2030 biodiversity strategy, on which the soil strategy also intends to rely. A truly binding legal framework around the setting of legal requirements for sustainable land use is therefore currently being developed. In this last section, the aim is to verify how this new regulatory framework can contribute to strengthening the legitimacy of the contractual tool, but also to specify how the contract can broaden the sometimes limited spectrum of action of the regulatory tool.

2 The Contractual Tool, Ideal Tool for Encouraging Changes in Agricultural Practices That Are Favourable to Agricultural Soils

The ecosystem services approach, i.e. the services provided by ecosystems for human well-being,¹³ has the merit of considering agricultural soils not only as a production support but also as an ecosystem.¹⁴ This implies that soils, in this case agricultural soils, as ecosystems, must also respect their own needs to be able to provide the required ecosystem services. Of course, the productive dimension is still present, including in the approach to services, since supply services are currently included in the categorisation developed by the Millennium Ecosystem Assessment (MEA).¹⁵ However, including in this hypothesis, the services approach allows agricultural production to be reconnected to the soil as an ecosystem, a connection that had been undermined for many years.¹⁶

¹³MEA (2005).

¹⁴Langlais (2015).

¹⁵MEA (2005).

Alongside these provisioning services, there are other services such as support, regulation or cultural services according to the categorisation established by the MEA, readapted by the CICES (Common International Classification of Ecosystem Services).¹⁷ Among the ecosystem services that have come to the fore in the agricultural sphere, the climate regulation service of carbon sequestration is particularly promoted. The issue of carbon sequestration in agricultural soils gives visibility to these soils. This highlighting of agricultural soils through carbon sequestration contributes to the development of new contracts.

One of the immediate advantages of contracts is their flexibility, both to adapt to the actors involved and to local requirements. However, precisely, the great diversity of agricultural soils, adapted and differentiated practices may be required. This valuable advantage of contracts is coupled with a recent contractual innovation to integrate the environment into agricultural production. These approaches mark a real turning point in the relationship between agricultural production and the environment, with the latter becoming an opportunity rather than a constraint. Agricultural soils are a privileged witness to this new paradigm, which is reflected in the contracts by the identification and integration of relevant agro-ecological practices for agricultural land use (Sect. 2.1) as well as a search for environmental performance (Sect. 2.2).

2.1 Identification and Integration of Agro-ecological Practices Favourable to Soil Preservation Within Contracts

The identification of agro-ecological practices that are favourable to soil preservation is an essential prerequisite for initiating a change aimed at preserving agricultural soils and their capacity to provide services. Contracts are an important vehicle for this change, as they allow the desire of the person working the land to change their practices to be respected.

The contractual initiative can come from two different initiatives. It can come from the CAP wishing to encourage agro-ecological practices deemed relevant for the environment. In all EU Member States, European agricultural policy undoubtedly shapes the national agricultural policy of individual Member States through its contractual financial instruments. These long-established instruments include agri-environmental and climate change measures (AECMs) under the second pillar of the CAP, as well as the new eco-schemes under the first pillar of the CAP which came

¹⁶The work of the chemist Liebig contributed to this. He argued that the soil was not the source of all the elements necessary for the plant; his discoveries thus made it possible to get rid of “bad soils”; the soil therefore no longer became an essential resource for the proper development of plants but a “simple support”.

¹⁷<https://cices.eu> (Last access: 22 June 2022).

into force in 2023. According to Article 31 of the regulation on support for strategic plans:¹⁸ “Member States shall establish, and provide support for, voluntary schemes for the climate, the environment and animal welfare (‘eco-schemes’) under the conditions set out in this Article and as further specified in their CAP Strategic Plans” (paragraph 1). “Furthermore, the article specifies in its paragraph 3 that: “Member States shall establish the list of agricultural practices beneficial to the climate and the environment and animal welfare and combatting antimicrobial resistance”. “In mid-January, the Commission published a list of potential eco-regimes in which a wide range of agricultural practices are suggested such as agroecology (crop rotation, low-intensity grassland farming), agroforestry, precision farming (reduced use of fertilisers) and carbon sequestration (extensive use of permanent grasslands).

The initiative may also come from a landowner wishing to offer his tenant a rural lease with environmental clauses. These land tenure contracts vary from one Member State to another, as land law is a matter for the Member States. For example, French legislation has created a specific category of contracts, the rural lease with environmental clauses, with a specific legal regime.¹⁹ According to Article R.411-9-11-1 of the French Rural and Maritime Fishing Code, sixteen environmental practices, which may consist of practices to be maintained or new practices to be introduced by the tenant, may be at the heart of the contractual commitment. Among these, some directly concern soil protection. Among the practices identified, these include non-tillage of grassland, the creation, maintenance and management of grassland areas, the limitation or prohibition of fertiliser inputs, periodic or permanent plant cover for annual or perennial crops, tillage techniques and techniques combining agriculture and forestry, particularly agroforestry. The purpose of these contracts, which are granted as a derogation from the classic contracts concluded between a landowner and a tenant of agricultural land, is to “green” the contracts for access to land. In fact, this rural lease with environmental clauses has, in this French framework, a limited scope of application insofar as the environmental clauses are pre-identified, and only a lessor who is a legal entity under public law or an approved environmental protection association can envisage their implementation throughout the territory. For a private lessor, only certain designated plots are eligible. These are those that already benefit from environmental protection.

In addition to these lease contracts granting access to the land, in their ‘green’ version or not, other contracts targeting specific practices, such as those promoting carbon sequestration, may be superimposed. These contracts reflect the emergence of new forms of contractualisation based on the promotion of identified ecosystem

¹⁸Regulation (EU) 2021/2115 of the European Parliament and of the Council of 2 December 2021 establishing rules on support for strategic plans to be drawn up by Member States under the common agricultural policy (CAP Strategic Plans) and financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD) and repealing Regulations (EU) No 1305/2013 and (EU) No 1307/2013, *OJ L* 435, 6.12.2021.

¹⁹ Bodiguel (2011).

services. However, this contractual overlap on the same agricultural land is not without its difficulties insofar as the two contracts are not necessarily based on the same contractual commitment period.²⁰ Therefore, if the lessor does not allow the duration of the lease contract to be adapted to other environmental commitments made by the lessee, it will be difficult to carry out certain environmental actions on the agricultural land.

Lease contracts with environmental clauses aim at the respect of particular agro-ecological practices, which have supposed environmental effects. In this contractual hypothesis, if a farmer commits himself to respect a particular practice, he only commits himself to the implementation of this practice and not to the expected effects of the latter. However, a new logic of environmental performance, particularly present in the framework of the CAP reform, tends to modify the paradigm from action-based contracts to result-based contracts.

2.2 The Search for Environmental Performance Within Contracts

This search for environmental performance requiring specific environmental results is expressed explicitly by the establishment of result-based contracts, which would be concluded individually by a farmer. This search for environmental performance is also expressed implicitly by encouraging collective implementation, which is particularly relevant for obtaining results not on a given plot scale but on a landscape scale (Kerr et al. 2014).

These contractual forms meet with strong expectations, particularly on the part of the European institutions. The European Court of Auditors,²¹ in particular, has not hidden its interest in this area. Echoing this expectation,²² the European regulation of 6 December 2021 on national strategic plans states that ‘Member states may promote and support collective schemes and result-based payment schemes to encourage farmers or other beneficiaries to deliver a significant enhancement of the quality of environment at a larger scale or in a measurable way’ (article 70 paragraph 5).

Result-based contracts are bound to have a significant impact on carbon sequestration in agricultural soils insofar as, from the point of view of climate change mitigation, contracting is only of interest if a certain quantity of carbon is effectively and permanently sequestered. In line with this, the European Commission, in

²⁰Bodiguel (2021).

²¹European Court of Auditors, Special Report No. 7/2011, Is Agri-environment Support Well Designed and Managed, paras. 26 and 27 (available at https://www.eca.europa.eu/Lists/ECADocuments/SR11_07/SR11_07_EN.PDF, Last access: 22 June 2022).

²²In The Future of Food and Farming, it was stated that there should be “a greater focus on high standards and actual results” and, more specifically, that there should be “a result-oriented delivery of environmental and climate public goods, European Commission, The Future of Food and Farming (COM(2017) 713 final), pp. 9 and 20.

launching the European initiative for carbon storage in agricultural soils, relied on a recently published study.²³ In particular, this study examined existing climate change programmes in five promising areas: peatland restoration, agroforestry, soil organic carbon (SOC) maintenance and enhancement on mineral soils, SOC management on grasslands and carbon balance on livestock farms. In addition, the study concluded, above all, that agriculture, if results-oriented, “can potentially make a significant contribution to climate change mitigation in the EU” and offer co-benefits such as increased biodiversity and ecosystem preservation. The same study points out that soil management practices that sequester carbon are already known, effective and low-cost practices.

While the logic of results in terms of carbon sequestered in agricultural soils is justified, it is nonetheless contractually risky because of the difficulties of measurement,²⁴ a certain volatility of carbon stocks over time and climatic and environmental hazards.²⁵ Indeed, since the contract is based on environmental results, failure to achieve them is contractually binding on the farmer. The latter, although having implemented all the required environmental practices, could therefore be refused any payment. In addition to a contractual risk, a logic based on environmental results is also likely to put agricultural soils at risk. Indeed, to the extent that payment is associated with tangible environmental results, a quantity of carbon sequestered could unfortunately encourage land degradation before any commitment. Such a process would aim to maximise the opportunity to improve the land and consequently the financial benefit associated with this improvement.

For this reason, it is becoming increasingly relevant to mix outcome-based approaches with practice-based approaches. A collective implementation of these contractual forms also fits well with these hybrid formats. It can indeed make it possible to reconcile a contractually secured approach to the achievement of agro-ecological practices and to finance the result of collective efforts made on a scale that goes beyond the single contracted agricultural plot. In the context of carbon sequestration, the protection of a carbon sink whose contours exceed those of the contracted agricultural plots can usefully benefit from contracts of this nature. Moreover, carbon sinks are not necessarily located on the territory of a single farm and therefore require the potential commitment of several different farmers.

However, the downside of these valuable contributions of contracts to agricultural soil conservation is the temporality of contractual obligations, the relative effect of contracts, but also simply the willingness to commit or not. Indeed, can the efforts made to increase or maintain carbon sequestration in response to a contractual commitment be sustained once the commitment has expired? Furthermore, since the contract only binds the parties to the contract, there is necessarily a risk of fragmentation of the efforts made if no rules are established to set a common measure of carbon sequestration and to ensure monitoring and control outside the

²³European Commission et al. (2021).

²⁴For example, see Schwarz et al. (2008).

²⁵Langlais (2022).

contracting parties of the results obtained. Finally, the carbon sequestration potential of certain ecosystems may not be easily subject to the willingness of farmers to contract or not. More generally, the urgency of the climate situation and the need to capture carbon in agricultural soils means that agricultural soils, whether already rich in carbon or capable of increasing the amount of carbon sequestered, must be widely mobilised.

Therefore, the flexibility offered by contracts to boost agricultural actions or practices in favour of agricultural soil protection and to give responsibility to the actors involved should be complemented by a common legal framework with common legal requirements to consolidate and guide the contractual actions undertaken. Although not yet clearly defined, this legal framework for setting legal requirements for sustainable land use is currently under construction.

3 Building a Binding Legal Framework Around the Setting of Legal Requirements for Sustainable Land Use

Setting requirements for sustainable use, to which the phrase “so that there are no obstacles to ecosystem services” has been added, offers a relatively clear orientation of the tone of the legal requirements required, which can be specified by the use of the notion of soil health²⁶ in the very title of the European soil strategy. Its definition is “Soils are healthy when they are in good chemical, biological and physical condition, and thus able to continuously provide as many of the following ecosystem services as possible: (. . .) act as a carbon reservoir”.²⁷ The definition of “healthy soil” in article 3.4 of the proposed directive of 5 July 2023 is along the same lines. A soil health approach is not insignificant, as it explicitly refers to the ecological functions of the soil. On the basis of its ecological functions, soil must be able to “function as an essential life support system, consisting of biological elements that are key to the proper functioning of the ecosystem within the limits of land use”.²⁸ Therefore, in the light of the new European soil strategy’s focus on soil health, not excluding ecosystem services in setting requirements for sustainable soil use allows an ecological, non-utilitarian view of soil use to be emphasised. The ability of land to provide ecosystem services is based on its ecological functioning. It follows that the standard on which legal requirements for sustainable land use should be based should be an ecological standard that protects the soil and is therefore less dependant of current and future land uses. In this respect, legal requirements for sustainable

²⁶The notion of quality appeared at the same time as that of soil health. It corresponds to the stability of the soil ecosystem through its resilience to stress, its biological diversity and the level of internal recycling of nutrients (Elliott and Lynch 1994).

²⁷European soil strategy, p. 5.

²⁸Kinyangi (2007).

land use offer a certain hierarchy of uses, which is often lacking in the concept of sustainability.²⁹

Moreover, the reference to the notion of soil health, far from being trivial, can also help to characterise this ecological standard. This is the choice made by the World Soil Charter in its revised version of 2015.³⁰ Although the notion of soil health does not necessarily enjoy consensus within the scientific community, soil health and soil quality now seem to be synonymous.³¹ It is stated that the notion of health is preferred to that of quality “because it maintains a more ‘living’ vision of soil, more dynamic, involving a holistic approach”.³² Moreover, these same authors emphasise that “recognising that soil has its own health means recognising that its condition can be altered” and that, regarding agricultural soils, “a certain number of practices³³ are now recognised for their contribution to good soil health”.³⁴ However, a holistic vision of the soil whose health can be altered ultimately refers to the preservation of the ecological integrity of the soil as an ecological standard of preservation: “The ecological integrity of the soil- which is the preservation of the ecosystems, including the prevention of loss of their wholeness, so as to prevent the commencement of soil degradation, to control existing soil degradation, and to protect and manage soil for its sustainable use”.³⁵

Consequently, if respect for the ecological integrity of agricultural soils is the ecological standard for preserving these soils, the legal framework for land use must naturally be consistent with this standard.

Applied to carbon sequestration in agricultural soils, it is therefore appropriate to examine this framework in the light of the conditions of spatial (Sect. 3.1) and temporal (Sect. 3.2) expression of the ecological integrity of agricultural soils.

²⁹Mauerhofer (2016).

³⁰In 2015, a revised version of the World Soil Charter, adopted by the FAO in its initial version in 1981, focuses on soil health and especially on soil ecosystem services. Indeed, according to the ninth principle, “All soils – whether actively managed or not - provide ecosystem services relevant to global climate regulation and multi-scale water regulation. Land use conversion can reduce these global, common-good services provided by soils. The impact of local or regional land- use conversions can be reliably evaluated only in the context of global evaluations of the contribution of soils to essential ecosystem services”, FAO, Revised World Soil Charter, June 2015, point 9, Retrieved on 9 October 2017 from www.fao.org, p. 5, available at <https://www.fao.org/publications/card/fr/c/e60df30b-0269-4247-a15f-db564161fee0> (Last access: 22 June 2022).

³¹Doran (2002).

³²Chabert and Sarthou (2017), p. 54.

³³These practices include no tillage, diversification of sales and intermediate crops, the use of plant cover and the use of organic amendments (Larkin 2015), all of which are the subject of contractual commitments (see above).

³⁴Chabert and Sarthou (2017), p. 54.

³⁵Hannam and Boer (2002), p. 38.

3.1 Respecting the Spatial Dimension of the Ecological Integrity of Agricultural Soils: The Relevance of Ecological Zoning?

Efforts to improve the quality of agricultural soils, using the contractual tool, such as an increase in the quantity of carbon in these soils, are not necessarily secure insofar as changes in land use could ruin the efforts made or even worsen the situation due to a release of the sequestered carbon. In addition to taking into account this logic of additional carbon storage to be promoted and conserved, certain naturally carbon-rich areas also deserve special attention. Many of these areas are already protected. In the case of soils, this legal protection is indirect in that it is not aimed at soils in particular but at sites identified as being of great value. These are, for example, wetlands of international importance protected under the Ramsar Convention of 2 February 1971 or Natura 2000 sites under the Habitats Directive of 21 May 1992.³⁶ In this case, what about agricultural soils, many of which are “ordinary” and therefore do not benefit from this indirect protection. Would ecological zoning be a relevant mechanism for preserving the integrity of agricultural soils in their spatial dimension and thus ensure the sustainable use of these agricultural soils?

The purpose of zoning is to divide the territory into several zones in order to think about the use of space. This spatial planning makes it possible to establish which uses will have priority or at least to reserve spaces for a particular use. In the environmental field, ecological zoning is a common technique. The motivation behind such zoning is quite diverse. For example, it may be to protect the vulnerability of an area subject to specific sources of pollution, as is the case for vulnerable areas under the directive of 12 December 1991 on water pollution by nitrates from agricultural sources.³⁷ It may also be a question of protecting threatened habitats and species. This is the purpose of the “Natura” network protection areas provided for by the above-mentioned directive of 21 May 1992. They may also be to protect drinking water catchment areas provided for by Directive of 16 December 2020 on the quality of water intended for human consumption,³⁸ the objective of which is to prevent risks to water safety. The establishment of these zones is accompanied by a set of rules intended to ensure the prevention and management of the targeted risks, guaranteeing the respect of the objective to be reached. These zones could help to calibrate the contractual tools so that they contribute, in a concerted manner, to the stated objectives of these zones. These may be public contracts or private contracts, as is the case for the Vittel company. This company is emblematic of the use of payments for environmental services³⁹ developed in drinking water catchment areas.

³⁶Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora, OJ L 206, 22/07/1992.

³⁷Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources, OJ L 375, 31.12.1991.

³⁸Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption, OJ L 435, 23.12.2020.

Faced with the high cost for water denitrification, the Perrier-Vittel company opted for a new approach by entering into long-term contracts with farmers who live near the water catchment area on land that it had bought. The aim of these contracts is to set up particularly restrictive conditions of agricultural land use for farmers in return for a payment in order to reduce as much as possible the quantity of nitrates in the water to be collected.

With regard to agricultural soils, particularly in terms of their capacity to sequester carbon, on what basis could such zoning be envisaged? Under French legislation, for example, it is possible to reserve sectors for agriculture. Such zoning, established by a public authority, is justified by the agronomic, biological or economic potential of agriculture. Traditionally, it is the agronomic and therefore economic value of the land that is emphasised. However, the agronomic and ecological quality of lands do not necessarily go hand in hand. Some lands that are poor from an agronomic point of view could be ‘environmentally-rich land, such as meadows and extensive pasture land’.⁴⁰ In this case, these soils are precisely carbon-rich.

Doesn't the IPCC's repeated finding of the disastrous consequences for the earth's livability of a temperature rise above 1.5 degrees in average surface temperatures and the call for carbon capture solutions in addition to mitigation measures⁴¹ provide a legitimate basis for establishing such zoning for agricultural soils? More specifically, do the risks associated with land use and land use change for climate change not form a valid basis?

If this is the case, the question of the territorial delimitation of these zones arises. Should we consider the territorial contours of carbon sinks? If so, what criteria should be used, given that a carbon sink is a process by which GHGs are removed from the atmosphere? This process can more easily be based on a territorial anchoring when the extraction process is chemical. However, it is more complex when the carbon sink is natural.

While the legal consequences of these carbon sinks are becoming more and more concrete, particularly in relation to agricultural soils, it is clear that there is no legal definition of these sinks that would clarify their spatial scope. This lack of definition contrasts with the strong interest in carbon sequestration in agricultural soils, particularly at the European Union level. Indeed, this sequestration echoes the 4/1000 initiative, according to which increasing the carbon stock of agricultural soils by 0.4% (or 4 per 1000) each year in the top 40 centimetres of the soil would, in theory, be equivalent to the increase in annual carbon emissions caused by human activities.⁴² This initiative launched by the French government at the 21st

³⁹For a legal analysis of PES applied to agriculture, see Langlais (2019).

⁴⁰Special Report No 14/2000 on ‘Greening the CAP’ together with the Commission’s replies (OJ C, C/353, 08.12.2000, p. 1, available at, pt 29.

⁴¹Achieving “carbon neutrality” by 2050, i.e. reaching a balance between the amount of greenhouse gases emitted worldwide and the earth’s capacity to capture and store carbon dioxide, requires drastic GHG emission reductions. In its 2018 report (IPCC 2018), the IPCC considers other complementary options for achieving carbon neutrality.

⁴²Amelung et al. (2020).

Conference of the Parties to the United Nations Framework Convention on Climate Change as part of the Lima-Paris Action Plan is seen as an additional opportunity to counter the increase in CO₂ concentrations in the atmosphere. This 4/1000 initiative is also an integral part of the European Soil Strategy, as it expressly states that it wants to contribute to it. In particular, this strategy is in line with a number of existing objectives, including that of achieving “a climate-neutral Europe and, as a first step, aiming for terrestrial climate neutrality in the EU by 2035”. In particular, it is stated that “Achieving net-zero greenhouse gas emissions by 2050 relies also on carbon removals through the restoration and better management of soils to absorb the emissions that will remain at the end of an ambitious decarbonisation pathway. Targeted and continued sustainable soil management practices can significantly help in achieving climate neutrality by eliminating the anthropogenic emissions from organic soils and by increasing the carbon stocked in mineral soils”.⁴³

The strategy focuses on two types of soil relevant to the fight against climate change: organic soils and mineral soils, for which it envisages differentiated measures to ensure that soils play a full part in achieving the climate neutrality objective. For the former, the Commission envisages proposing legally binding objectives in the context of nature restoration law “to limit drainage of wetlands and organic soils and to restore managed and drained peatlands, in order to maintain and increase soil carbon stocks, minimise flooding and drought risks, and enhance biodiversity, taking into account the implications of these objectives for future carbon farming initiatives and agricultural and forestry production systems”.⁴⁴ For these soils, it is also to “contribute to the assessment of the state of peatlands in the context of the Global Peatland Initiative, hosted by FAO and the United Nations Environment Programme”.⁴⁵ For the second type of soil, mineral soils, several measures are envisaged by the European Commission; in particular, it is planned to “consider measures, possibly in the context of the Nature Restoration Law, to enhance biodiversity in agricultural land that would contribute to conserving and increasing soil organic carbon (SOC)”.⁴⁶ It is also planned to “Develop a long-term vision for sustainable carbon cycles (including capture, storage, and use of CO₂) in a climate-neutral EU economy. As part of this, the Commission will deliver a communication on restoring sustainable carbon cycles, in 2021⁴⁷ and present the EU carbon farming initiative and a legislative proposal on carbon removal certification in 2022 to promote a new green business model rewarding land managers, such as farmers and foresters, for climate-friendly practices”.⁴⁸

⁴³ European soil strategy, p. 6.

⁴⁴ European soil strategy, Pt 3.1.

⁴⁵ Ibid.

⁴⁶ Ibid.

⁴⁷ Communication from the Commission to the European Parliament and the Council, Sustainable Carbon Cycles, COM (2021) 800 final du 15/12/2021. This initiative aims to support the development of sustainable carbon absorption solutions to achieve climate neutrality by 2050. It includes the development of an action plan to promote carbon storage in agricultural soils and the establishment of a regulatory framework for the certification of carbon removals.

Of course, an easy solution would be to rely on the territorial delimitation of agricultural plots to anchor these carbon sinks. However, such a solution would quickly sweep aside the fact that carbon sequestration is a process and that it is highly dependent on the biological activity of a soil: soil organisms will play a role in both the carbon protection mechanisms and the mineralisation of organic matter. However, soil organisms, by their very nature, move. This characteristic may therefore make ecological zoning as such unsuitable.

Although not defined as such, carbon sinks can nevertheless be qualified as ecosystems, defined by the 1992 Convention on Biological Diversity as “a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit” (art. 2). Although the notion of ecosystem as a functional unit does not necessarily offer an easier territorial anchorage, as this notion is so variable in geometry, it nevertheless opens the doors to legal protection of ecosystems. In particular, this ecosystem-based approach makes it possible to envisage the restoration of degraded and therefore altered ecosystems, which is likely to complete the establishment of a binding legal framework based on the setting of legal requirements for sustainable land use. However, protecting the temporal dimension of ecological integrity of soils in this way can be fraught with difficulties.

3.2 Respecting the Temporal Dimension of Ecological Integrity of Agricultural Soils Through Ecosystem Restoration?

In addition to the legislative proposal on the state of soil to achieve healthy soil, the soil strategy states that the Commission will propose legally binding objectives to limit the drainage of wetlands and organic soils and to restore drained and exploited peatlands. This is based on the ‘Biodiversity 2030’ strategy,⁴⁹ which provides for legislation with binding restoration targets for degraded ecosystems. In particular, it targets those with the greatest potential to capture and store carbon and to prevent and reduce the effects of natural disasters.

By preserving soil as a resource in order to achieve its sustainable use, while considering it as an ecosystem to be restored, the European Commission is in line with the latest IPBES recommendations of 2018 on simultaneous action to combat land degradation and restore it.⁵⁰ It is also in line with the spirit of the joint IPBES and IPPC seminar of June 2021,⁵¹ which clearly identified the need to avoid and

⁴⁸European soil strategy, pt 3.1.

⁴⁹Communication from the Commission to the European Parliament, the Council, the European economic and social committee and the Committee of the Regions, Biodiversity Strategy for 2030-Bringing nature back into our lives, COM (2020) 380, 20/05/2020.

⁵⁰IPBES (2018).

reverse the loss and degradation of carbon-rich and species-rich terrestrial and oceanic ecosystems such as wetlands, peatlands, grasslands and savannas. Such a synergy of actions in favour of soils, including agricultural soils, can only be beneficial to agricultural soils. Such binding legal provisions will be likely to condition the contractual terms, and even more so to increase the environmental requirements for soil protection in contracts.

This synergy of binding legal provisions opens up a new framework for soils, including agricultural soils. However, two main points of vigilance need to be clarified with regard to the identification of the ecosystem to be restored. The first point concerns the impact of this identification on the protection of the ecological integrity of agricultural soils. The second point concerns the impact on the agro-ecological transformation of agriculture.

Firstly, concerning the impact of the identification of the ecosystem to be restored and its impact on the protection of the ecological integrity of agricultural soils, the issue is to take into account the storage potential of all agricultural soils. The draft European legislation providing for binding objectives for the restoration of degraded ecosystems targets in particular those that have the best potential to capture and store carbon. This would therefore mainly lead to thinking through the prism of ecosystems identified as the main carbon sinks. In this case, do the issues of agricultural soil protection arise in the same terms depending on the ecosystem chosen? Indeed, insofar as the ecosystem is a variable geometry concept, the ecosystem targeted can be both the agricultural soil as an identified carbon sink and a more targeted ecosystem such as a wetland or a meadow. Therefore, there is a potential risk of fragmentation of the legal protection of agricultural soils, if cultivated soils, with a lower carbon sequestration potential, are neglected.

Secondly, concerning the impact of identifying the ecosystem to be restored and its impact on the agro-ecological transformation of agriculture, the challenge is to fully integrate these ecological soil dynamics into agricultural production. Here again, it is important to consider agricultural soils as a fully-fledged ecosystem on two scales. Firstly, it arises from the now well-known perspective of competition between agriculture and forests, the latter being reputed to have a greater carbon sequestration capacity. Agriculture therefore has a role to play in reconciling food production and carbon sequestration, which is also said to have positive effects on biodiversity. The same question also arises within the farm itself, insofar as carbon stocks are generally found in the maintenance of permanent grasslands, wetlands and forests and less in cultivated soils. Carbon sequestration should be an opportunity for the farmer to change his practices and not to consider it as a new environmental constraint confined to a specific plot. This plot is, moreover, likely to be modified according to new production orientations or new arbitrations of the common agricultural policy. The maintenance or otherwise of carbon-rich permanent grasslands has been a casualty of these choices and orientations. The newly reformed CAP should provide new sources of funding to support sustainable agricultural land use.

⁵¹ Pt 7, Pörtner et al. (2021).

Indeed, because of its direct link with agricultural soils, the CAP is likely to play an important role in the development of carbon sequestration-friendly practices. Under the current CAP, this is already the case. The first pillar of the CAP includes obligatory climate and environmentally beneficial agricultural practices. This mandatory ecological component includes the maintenance of existing permanent grasslands which are identified as high carbon sequestration environments.⁵² As for the second pillar of the CAP dedicated to rural development,⁵³ its flagship measure, agri-environmental measures, are now called agri-environmental and climate measures, a testimony to the CAP's role in the fight against climate change. The promotion of "resource efficiency and (support for) the shift towards a low-carbon and climate-resilient economy in the agricultural, food and forestry sectors" (art. 5.5) is listed as one of the Union's priorities for rural development. More specifically, the promotion of carbon conservation and sequestration in the agricultural and forestry sectors is one of the priority areas for action (art. 5.5 e).

This ambition should be increased tenfold in the new CAP, which came into force in 2023, at the same time as many pieces of legislation that contain legal provisions to promote carbon sequestration in agricultural soils. Certain guarantees to ensure this implementation within the new CAP have been already foreseen. These include a requirement that the ambitions of the Green Pact for Europe,⁵⁴ a document in which the issue of carbon sequestration has been clearly reinforced, be taken into account in the texts that shape the new CAP. Even before the adoption of the final texts of this new CAP,⁵⁵ a link between it, the Green Pact and its different variations had been the subject of an important working document by the Commission services.⁵⁶ The aim of this document was to facilitate the preparation of national strategic plans and was intended to integrate the issues of the Green Pact. This

⁵²Regulation (EU) No 1307/2013 of the European Parliament and of the Council of 17 December 2013 establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy and repealing Council Regulation (EC) No 637/2008 and Council Regulation (EC) No 73/2009, *OJ L 347*, 20.12.2013, *See Recital 42*: "For the sake of the environmental benefits of permanent grassland and in particular carbon sequestration, provision should be made for the maintenance of permanent grassland. This protection should consist of a ban on ploughing and conversion on the environmentally most sensitive areas in "Natura 2000" areas covered by Directives 92/43/EEC and 2009/147/EC, and of a more general safeguard, based on a ratio of permanent grassland, against conversion to other uses".

⁵³Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) and repealing Council Regulation (EC) No 1698/2005, *OJ L 347*, 20.12.2013.

⁵⁴Communication from the Commission to the European Parliament, the Council, the European economic and social committee and the Committee of the Regions, The European Green Deal, COM (2019) 640, 11/12/2019.

⁵⁵The main text for the new CAP: Regulation (EU) 2021/2115 establishing rules on support for strategic plans to be drawn up by Member States under the common agricultural policy (CAP Strategic Plans) and financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD), *OJ L 435*, 6/12/2021.

⁵⁶Analysis of links between CAP Reform and Green Deal, SWD (2020) 93.

integration is particularly important insofar as these plans are now the nerve centre of the reformed CAP. In addition, more specifically, recommendations on carbon sequestration in agricultural soils were made to Member States for the preparation of their strategic plans. These strategic plans must contain all the tools of the different pillars of the CAP, including the eco-schemes, which have been identified as the ideal tools for accommodating new measures in favour of carbon sequestration.⁵⁷ Finally, in order to ensure that these carbon sequestration issues are taken into account at the heart of CAP documents, the European Commission is to monitor the directions taken by these national strategic plans.

The regulatory approach still being developed also potentially has a number of limitations in addressing the issues of carbon sequestration currently largely absorbing soil protection as an ecosystem. These measures are still far from being defined, but it is important to consider in advance the risks that any particular legal requirement affecting agricultural land use could entail for soil protection, i.e. an overly fixed or fragmented approach to protection.

4 Conclusion

Through carbon sequestration in agricultural soils, we have analysed the role of the contractual tool in protecting these soils. Although it appears that contracts alone cannot ensure this protection, it is not a question of depriving ourselves of its incentive dynamic but rather of linking it to a regulatory approach to preserve the ecological integrity of agricultural soils in all their dimensions. Although increasing carbon sequestration in agricultural soils has the virtue of meeting the objectives of combating climate change and preserving biodiversity, as well as preserving food sovereignty, the legal responses, although abundant, are still hesitant and marked by scientific uncertainties about the future of this carbon storage and, more generally, about the legal protection of this storage.

References

Amelung W, Bossio D, de Vries W, Kögel-Knabner I, Lehmann J, Amundson R, Bol R, Collins R, Lal R, Leifeld J, Minasny B, Pan G, Paustian K, Rumpel C, Sanderman J, van Groenigen JW, Mooney S, van Wesemael B, Wander M, Chabbi A (2020) Towards a global-scale soil climate mitigation strategy. *Nat Commun.* <https://doi.org/10.1038/s41467-020-18887-7>

⁵⁷Communication from the Commission to the European Parliament, the Council, the European economic and social committee and the Committee of the Regions, Recommendations to the Member States as regards their strategic plan for the Common Agricultural Policy, COM (2020) 846 final, 18.12.2020.

- Bodiguel L (2011) Les clauses environnementales dans le statut du fermage. (2011) 8-9 Environnement, étude 10. Translated title: Environmental clauses in the statute of tenancy
- Bodiguel L (2021) CO₂ vert et bail rural: les interactions entre le contrat de séquestration de carbone et le bail rural. In: Millard J-B, Bosse-Platière H (dir.) Le CO₂ vert “capturé” par le droit, Lexis Nexis, Paris, 2022, pp 132–143. Translated title: Green CO₂ and rural leases: the interactions between carbon sequestration contracts and rural leases
- Chabert A, Sarthou JP (2017) Le sol agricole, une ressource indispensable négligée. *Revue Droit et ville* 84:49–63 translated title : Agricultural soil, an essential and neglected resource
- Doran JW (2002) Soil health and global sustainability: translating science into practice. *Agric Ecosyst Environ* 88:119–127
- Elliott LF, Lynch JM (1994) Biodiversity and soil resilience. In: Greenland DJ, Szabolcs I (eds) *Soil resilience and sustainable land use*. CAB International, Wallingford, pp 353–364
- European Commission, Directorate-General for Climate Action, Radley G, Keenleyside C, Frelil-Larsen A et al (2021) Setting up and implementing result-based carbon farming mechanisms in the EU: technical guidance handbook. Publications Office. <https://data.europa.eu/doi/10.2834/056153> (Last access: 22 June 2022)
- Fuss S et al (2018) Negative emissions - Part 2: costs, potentials and side effects. *Environ Res Lett*. <https://doi.org/10.1088/1748-9326/aabf9f>. Last access: 22 June 2022
- Hannam I, Boer B (2002) Legal and institutional frameworks for sustainable soils: a preliminary report. IUCN, Gland, Switzerland and Cambridge, UK, 88 p
- IPBES (2018) The IPBES assessment report on land degradation and restoration. In: Montanarella L, Scholes R, Brainich A (eds) Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany, 744 pp
- IPCC (2018) Global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte V, Zhai P, Pörtner H-O, Roberts D, Skea J, Shukla PR, Pirani A, Moufouma-Okia W, Péan C, Pidcock R, Connors S, Matthews JBR, Chen Y, Zhou X, Gomis MI, Lonnoy E, Maycock T, Tignor M, Water eld T (eds)]
- Kerr JM, Vardhan M, Jindal R (2014) Incentives, conditionality and collective action in payment for environmental services. *Int J Commons* 8(2):595
- Kinyangi J (2007) Soil health and soil quality – a review. Draft September 27, 2007, p 1
- Langlais A (2015) L’appréhension juridique de la qualité des sols agricoles par le prisme des services écosystémiques. *Revue de droit rural* 435:28–33 (in french). Translated title: Legal understanding of agricultural soil quality through the prism of ecosystem services
- Langlais A (ed) (2019) L’agriculture et les paiements pour services environnementaux: quels questionnements juridiques? Presses universitaires de Rennes, Rennes, France, 447 p. Translated title: Agriculture and payments for environmental services: what legal issues?
- Langlais A (2022) Legal issues of implementing agricultural soil organic carbon sequestration as negative emission technology. In: Rumpel C (ed) *Understanding and fostering soil carbon sequestration*. Burleigh Dodds Science Publishing, pp. 851–875
- Langlais A, Lemoine-Schonne M (2024) Construire le droit des ingénieries climatiques- Pour une approche croisée des enjeux climatiques et écosystémiques, UGA Editions, à paraître 2021. Translated title: Building the law of climate engineering - For a cross-cutting approach to climate and ecosystem issues, in press (february, 2024)
- Larkin RP (2015) Soil heath paradigms and implications for disease management. *Annu Rev Phytopathol* 53:199–221
- Mauerhofer V (2016) 3-D sustainability and its contribution to governance assessment in legal terms: examples and perspectives. In: Mauerhofer V (ed) *Legal aspects of sustainable development: horizontal and sectorial policy issues*. Springer International Publishing, Switzerland, pp 35–56. https://doi.org/10.1007/978-3-319-26021-1_4
- Millennium Ecosystem Assessment (2005) *Ecosystems and human well-being: synthesis*. Island Press, Washington, DC, 137 pp

- Pörtner HO, Scholes RJ, Agard J, Archer E, Armeth A, Bai X, Barnes D, Burrows M, Chan L, Cheung WL, Diamond S, Donatti C, Duarte C, Eisenhauer N, Foden W, Gasalla MA, Handa C, Hickler T, Hoegh-Guldberg O, Ichii K, Jacob U, Insarov G, Kiessling W, Leadley P, Leemans R, Levin L, Lim M, Maharaj S, Managi S, Marquet PA, McElwee P, Midgley G, Oberdorff T, Obura D, Osman E, Pandit R, Pascual U, Pires APF, Popp A, Reyes- García V, Sankaran M, Settele J, Shin YJ, Sintayehu DW, Smith P, Steiner N, Strassburg B, Sukumar R, Trisos C, Val AL, Wu J, Aldrian E, Parmesan C, Pichs-Madruga R, Roberts DC, Rogers AD, Díaz S, Fischer M, Hashimoto S, Lavorel S, Wu N, Ngo HT (2021) IPBES-IPCC co-sponsored workshop report on biodiversity and climate change. IPBES and IPCC. <https://doi.org/10.5281/zenodo.4782538>
- Schwarz G et al (2008) An analysis of the potential effectiveness of a payment-by-results approach to the delivery of environmental public goods and services supplied by agri-environment schemes: Final Report Project No: 23192, Land Use Policy Group, 2008, p 13

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