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N82 | THE SOILS OF CATALONIA

P03 Soil as a Natural Resource: training and protection **P07** Soil Properties Important for Sustainable Agricultural Production: an overview **P14** The Soil Map (1: 25,000) of Catalonia **P18** The Soil Map as a Planning and Decision-Making tool **P24** The Interview

March 2016



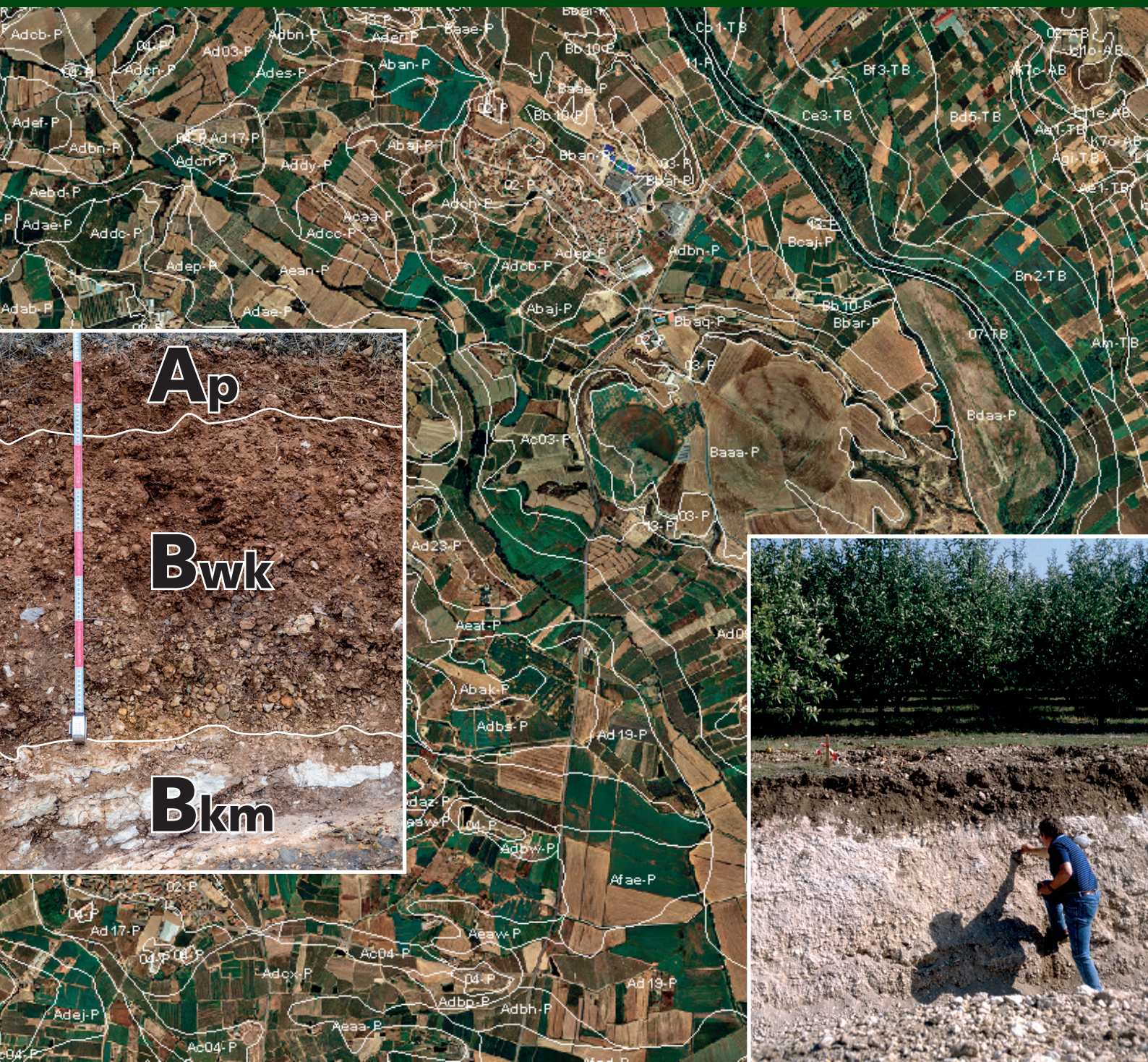
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PRESENTATION



Meritxell Serret Aleu
Consellera d'Agricultura,
Ramaderia, Pesca i Alimentació

Soils are one of the basic resources that make life on Earth possible. Food production is dependent on their quality, as are many other services that they provide, such as filtering water or retaining greenhouse gases. In more practical terms, food security and the competitiveness of agricultural companies depend on soils.

Nevertheless, scientific and technical knowledge of soil distribution and characteristics has not been given the importance that it deserves. To fill this gap in information, in the 1980s the Government of Catalonia's Ministry of Agriculture, Livestock, Fisheries, Food (DARP) initiated a project to create a Soil Map (1:25,000) of Catalonia: a pioneering initiative within the state. As a result of this activity, we now have a detailed map of over 600,000 hectares of the most important agricultural areas in our region.

The information that the detailed maps provide on soils is crucial. In fact, it is a prerequisite for farm management, agricultural and land use planning, and protection of the soil resource. The creation of soil maps is a vital task that the most advanced countries have completed gradually over the years, as a first step in their management.

We should remember that investments in soil maps are designed to improve yields and meet international production regulations, but are also important to find out what natural resources we have available to make agriculture more sustainable.

The Soil Map (1:25,000) of Catalonia has been promoted by the DARP and the Cartographic and Geological Institute of Catalonia (ICGC), which has published 18 sheets of Geowork IV, as well as other publications on soil. All of this information is available in print, and in digital format on the websites of the DARP and the ICGC.

This *Dossier Tècnic* gathers the opinions of experts on the soils of Catalonia, from the university environment and the government. It highlights the importance of soils in daily life, discusses their protection and conservation as a non-renewable resource, and describes their properties and analyses to help farm management, forestry production and protection of aquifers. In addition, this issue explains the Soil Map (1:25,000) of Catalonia, an intensive task carried out over a long period of time and covering a large area. The Soil Map can be used to improve irrigation systems or adjust fertiliser application. Finally, it describes the direct uses of the Soil Map and its interaction with other agricultural information when costly decisions need to be taken, such as the introduction of a new crop to a farm, or evaluation of the most suitable soils for the purchase or rental of land for a particular use.

Therefore, this is very useful information and we hope that the explanations given here will be accessible to those who are interested in learning about this resource, which is available to many but not always respected.

Finally, 2015 was the International Year of Soil. Around the world many events and actions were undertaken to raise public, media and government awareness of the importance of understanding this resource and managing it well. This *Technical Dossier* could be considered one of these actions. It is particularly important in a country such as ours in which the soil capital is limited and used intensively.

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Coordinated by
Josep Maria Masses Tarragó.

Produced by
Josep Maria Masses Tarragó, Annabel Teixidó Martínez and Corina de Herralde.

Translated by
t&s.

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Ministry of Agriculture, Livestock, Fisheries and Food
Gran Via de les Corts Catalanes, 612, 4a
08007 - Barcelona
Tel. 93 304 67 45. Fax. 93 304 67 02
e-mail: dossier@ruralcat.net

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SOIL AS A NATURAL RESOURCE

FORMATION AND PROTECTION



Figure 1: Landscape value of soils, agrarian landscape of Gallecs, in the area of Vallès Occidental. The reddish colour is due to horizons enriched by clay. Author: Òscar Marín.

01 Soil, a resource?

Soil is a thin layer of living material whose thickness ranges from a few centimetres up to two or three metres. This layer covers the surface of our planet. It could be considered Earth's skin; the interface where the atmosphere, hydrosphere, biosphere and lithosphere converge. Consequently, it has major impact on all the processes of interaction between these systems.

However, the soil is also a system in itself, and the object of study in soil science or edaphology. Soil supports life on the planet: it provides anchorage for roots; it is porous and retains water that plants can use; and it contains nutrients and makes them available to living organisms. It is a medium in which a vast number of animals and microorganisms live, which play an essential role in biochemical transformations, from nitrogen fixation to the decomposition and stabilisation of organic matter. Although it is not apparent, most of the Earth's biodiversity is found within the soil, not above it. In addition to being the main source

of food, soil produces biomass and can therefore store large amounts of carbon for a long time, and thus sequester atmospheric carbon.

Throughout history, humans have used soil as a dump for the waste that we generate. This waste is transformed, stabilised and filtered by the soil's biological activity and porosity, which prevents water pollution. Interaction with humanity over centuries and millennia means that soil is also an archive that stores the traces of our past activities. Through its study we can gain unique information about the life and surroundings of our ancestors. Many natural resources (peat, salt, coal, pigment and construction materials, among others) come directly from soil formation. Likewise, soil is a natural support for buildings, bridges, tunnels, roads and paths. The stability and durability of these structures depends largely on the soil characteristics. Due to the extremely high biodiversity of organisms in the soil ('there are more organisms in a spoonful of soil than people on the planet'), which is still not completely known, microorganisms have recently been found in the soil that could produce new anti-

biotics effective against diseases that are resistant to conventional antibiotics. These can only be cultivated in their original medium: soil.

All these functions of soil determine its quality, in other words, its capacity to carry out functions in an acceptable way. Clearly, not all soils are good for everything. Their quality depends on the function and the use that is under consideration. For instance, a saline soil that is bad quality for crops may be very useful as a gene pool of species that are adapted to salinity. Peatland is great for carbon sequestration, but stability problems may arise if buildings are constructed on top of it. In terms of agricultural uses, there are good and bad soils for the cultivation of rice, vegetables and fruit trees, for example. Therefore, it is clear that



**Els sòls són
un recurs natural
no renovable.**



Els sòls són sistemes dinàmics i per tant vulnerables; certes pressions ambientals en provoquen la pèrdua de qualitat, la seva desaparició per erosió o altres formes de degradació.

rational land use planning and management of the territory, taking into account soils and their suitability for the required uses, leads to lower investments and spending on maintenance and, in short, enhances the durability and conservation of soil resources for the future.

02 A reactor under our feet

Like all natural systems, soil is a body, formed by a solid, porous matrix through which pass flows of matter and energy, which are what enable it to carry out its functions. It receives energy from the sun that is transformed into the living and dead biomass that is produced. This biomass undergoes various transformations: stabilisation as soil humus and mineralisation, which determines the final amount of organic matter in the soil. Solar energy also leads to flows of water in the soil, which either concentrate certain components or leach them to a greater depth or laterally. Water, along with temperature and the action of living organisms, weathers rocks and minerals. Therefore, soil acts as a reactor in which physical, chemical and biological processes continuously take place over timescales ranging from seconds to thousands of years, as part of a dynamic equilibrium.

The processes of soil formation, which is also called pedogenesis, are highly varied and complex, and depend on specific combinations of factors such as climate, initial geological material, vegetation, position in the landscape, and time. To these natural factors, we should add human activities such as the construction of stone terraces, the addition of fertilisers, irrigation, levelling of land, open cast mining and earthworks. These actions modify the soil, of-

ten dramatically, leading to its improvement or its degradation, and even sometimes its total disappearance.

As a result of these many combinations of factors, soils are organised and ordered internally into horizons, which are layers of varying thickness that are approximately parallel to the surface and have different compositions and physical properties. In addition, soils vary from one place to another, not randomly but in a systematic way: soils in the Pyrenees are very different from those of the Ebro Delta, soils of the dry plains inland are very different from those of the volcanic region of La Garrotxa. Often soils differ over very short distances, as can be seen along road embankments along an axis.

03 Quality and soil degradation

As the formation of soil horizons is very slow (from thousands to hundreds of thousands of years), soil is a non-renewable resource, on a human timescale. Consequently, soils, particularly if they are of good quality, can be considered heritage of the towns that in a territory. Thus, the black soils or chernozems of the steppe, which are ideal for cereal production, were the source of wealth in Russia and the Ukraine. The same kinds of soils are found in the US Corn Belt or the Argentinian pampas. Similarly, the excellent soils of the Nile Delta and alluvial plain, which were

enriched every year by silt from floods, were one reason for the splendour of the Egyptian civilisation.

However, as they are dynamic systems, soils are also vulnerable to environmental pressure (waste dumping, compactation, loss of plant cover, inadequate irrigation, and others). This leads to a loss of quality or even disappearance of the soil due to erosion or other forms of degradation such as salination, acidification, pollution or loss of nutrients. Not all soils are equally vulnerable under the same pressure: some are more resilient and recover when the pressure disappears, but in most cases the soil is fragile and often does not return to its initial state. This is the case of soils that are not very deep that erode after a forest fire.

Soil is an incredibly robust system in which many substances can break down, which makes them less hazardous. This quality of 'cleaning' materials has led to soil frequently being used as a dump for organic and inorganic waste. If the amount of substances dumped exceeds the soil's capacity to destroy them, the soil will be degraded and its biological activity will be considerably reduced. Soil is most severely affected when it is sealed in by constructions or infrastructure, which often occurs in industrialised countries. Once soil has been sealed by asphalt or buildings, it is totally lost and cannot carry out the functions that we expect of it.



Figure 2: Soils on loess, at Tivissa. Loess is a silty material transported by the wind during the glacial period. As the age of the soil deposits can be determined (in the order of dozens of thousands of years), these soils are a unique source of information on types of climate, vegetation and relief during the Quaternary period. Author: Rosa M. Poch

Soil degradation, which is defined as loss of its capacity to carry out its functions, has caused the disappearance of many civilisations that could not sustain their populations due to a massive decline in agricultural production (Porta & Poch, 2011). One example is the Mesopotamian Empire, which developed on the soils of the terraces of the Tigris and Euphrates. Continuous irrigation of the soils led to salination, which was worsened by a lack of maintenance of the irrigation channels that were rendered useless by the accumulation of sediment. The decline of the Aztecs and Mayans is associated with the disappearance of soils due to erosion, probably caused by over exploitation of sloped areas when the population increased. Closer to home, the excessive exploitation of soils in North Africa by the Roman Empire and the subsequent erosion was one of the reasons behind its fall.

Agricultural production, or a support that protects biomass, is one of the most important criteria of soil quality, but not the only one. If we take into account various functions, we can see that different types of soil are valuable, as shown in Table 1 for the case of Catalonia.

04 How to protect and conserve soil

The slow rate of soil formation processes on the human timescale means that the

Table 1: Potential criteria for classifying a soil as valuable (expanded version of Alcañiz et al., 2005)			
Function/characteristic	Territorial range	Classification	Observations and examples from Catalonia
Production	General	Prime farmlands	Vall d'en Bas, Delta del Llobregat, alluvial terraces of the fastest-flowing rivers.
	Local	Unique farmlands	Importance to the municipality or province, as it can be used to produce quality, specialised crops: grapes, asparagus, potatoes, beans and peas, among others, that are associated with a specific form of management.
Singularity	Local	Soil heritage	Volcanic soils of Olot, peatlands of the Ebro Delta, soil containing travertine gypsum in Algerri, podzols in the Pyrenees.
Environmental	General	Environmental assurance	Part of valuable and/or fragile ecosystems. Key environmental function, for example, to protect aquifers and prevent erosion.
Educational	Local	Typical soils	Profiles of representative, accessible soils in a zone/region (benchmark or reference soils).
Conservation of biodiversity	General	Soils as a habitat and gene pool	Close relationship between specific soils and threatened species that are adapted to extreme environments (very acidic soils, saline soils, chalky soils), which maintain gene pools.
Landscape	General	Aesthetic	Colours in the landscape (Segarra, Vallès, Alt Camp).
Paleoenvironmental record	Local	Paleosols	Peatlands of the Pyrenees, soils buried under stone terraces in Les Garrigues, loess in El Baix Ebre, soil in the high terraces of rivers.

strategy for soil use should be focused on conservation, rather than rehabilitation or restoration. Rehabilitation and restoration are only appropriate in places where the soil has been dramatically altered or disappeared, for example, in soils affected by open cast mining or mining activities in general; or artificial slopes beside linear infrastructure such as motorways or railways. In these

cases, the soil must be 'remade' so that vegetation can be established. This is possible because only a small surface area is affected in these cases, and because environmental legislation determines that the environmental impact of works should be minimised. For soil rehabilitation, Catalonia has successfully used organic waste, such as sewage sludge, urban waste compost



Figure 3: The change to an irrigation system such as the one shown in this image of Les Garrigues may eliminate very effective soil conservation techniques such as stone terraces, leaving large areas with little control of runoff that are more susceptible to erosion. Author: Rosa M. Poch.



La lentitud dels processos de formació dels sòls fa que sigui més efectiu conservar-los que recuperar-los o rehabilitar-los.

or pig slurry, which helps to reestablish the biological activity in inert mineral substrates.

In the remaining cases, soil heritage that is mainly used for agricultural and forestry purposes must be managed so that its properties are not diminished. Soil conservation measures in Catalonia refer in particular to those that are designed to combat water erosion, which is one of the main processes of degradation. This is due to the high aggressiveness (erosion potential) of rain, which is characteristic of the Mediterranean climate; the marked relief in Catalonia; and the lack of organic matter in many agricultural soils, which reduces their capacity to withstand erosion.

Soil conservation measures are classified according to the component of erosion that they affect. A first group include measures to manage plant cover, which is the layer that protects the soil from the impact of rain drops. This group includes the management of stubble, herbaceous cover for tree crops and all kinds of mulch. A second group of measures are those that improve the resistance of aggregates (clods) of soil to the impact of raindrops or flows of surface runoff. This includes the entire group of organic soil amendments (manure, sewage sludge, green manure, livestock bedding, and others) that act as aggregates of mineral particles, to strengthen the soil structure. It also includes all conservation crop techniques (no-crop, minimum crop, etc.) that are designed to reduce physical changes in the soil due to working it. This promotes the action of soil fauna as the main generator of porosity and reduces the energy cost of machinery. A third group of measures are those that are specifically focused on controlling surface runoff so that erosion does not occur as a result of runoff volume or speed. Suitable design of farms, surface drainage channels, ditches on terraces, dykes

and small reservoirs are included in this group and help to prevent forms of erosion such as channels, rills, torrents and ravines.

If we know the properties of our soils and the threats that could cause loss of quality, we can design the most suitable measures to conserve and manage these resources, so that we can pass them on to future generations in the best conditions for their use.

05 Further reading

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06 Author



Rosa M. Poch Claret
Chair of Edaphology, Department of the
Environment and Soil Sciences
Universitat de Lleida
rosa.poch@macs.udl.es

IMPORTANT SOIL PROPERTIES FOR SUSTAINABLE AGRICULTURAL PRODUCTION

AN OVERVIEW



Figure 1: These plane trees were planted at the same time: the growth curve reveals the diversity of the soils. Segrià (Lleida). Author: J. Porta

01 Introduction

In practice, a wide range of users need a description of soil properties. These include farmers who manage the land directly, companies that provide agricultural services, companies that manage organic or mineral fertilisers, consultancies or engineering firms that want to measure certain soil properties, and government bodies that need objective data for mapping, statistics, monitoring or regulatory control. Soils are also studied by universities, research, experimentation and agricultural extension centres; the data are an important part of their work. Therefore, there is a clear demand for information about soils from a wide range of users.

In all of these cases, soil properties need to be measured and described for characterisation, handling, agronomic management, monitoring and experimental results.

In this article, we summarise the soil properties that have the greatest impact on agricultural production. We describe where and how this information can be obtained, des-

cribe the most important laboratory analytical methods, and include some practical examples that illustrate the relevance of soil information.

02 Is soil information really required?

The question is relevant, as many agricultural lands are managed without a suitable base of information or even without any information on the soils. It is not unusual to see blank faces when someone requests the analytical records for a field; or asks how often analyses are carried out; or what the phosphorus levels are in that field of millet in which some leaves are violet coloured; or what happens with the salination risk in irrigated land. It is difficult to manage the land in a way that provides the best economic, qualitative and environmental performance if we do not have any soil data. Clearly, in practice it is not entirely true that land is managed 'without data'. Behind each decision is empirical knowledge, accumulated over the years through trial and error, which keeps things going. However,

in today's highly competitive world, in which there are greater environmental concerns, it is advisable to manage soil with great care and precision and use objective, accurate, reliable data that we can save on a computer and relate to yield and quality.

This need for information is based on a very clear fact: soils are not a uniform layer. They are different. Their properties, the variability in each profile, and the distribution in the landscape is related to the driving forces or forming factors (Figure 1) and the way the 'manager' has handled the land: the farmer, livestock breeder, forester, as well as 'managers' associated with the urban environment, industry and even land use planners (Figure 2).

Cases such as that seen in Figure 2 are found frequently. The description of soil properties meets a need for this knowledge. We should know the properties at the study point, and we should know the distribution of characteristics throughout the landscape, as they may require a different kind of management. Taking on board the fact that 'soils are diffe-

rent' and therefore require ad hoc management is the first step towards measuring their properties in the field and in the laboratory.

03 Where and how can soil information be obtained

Some of the properties and characteristics of soils are practically permanent (surface stoniness, texture, calcium carbonate content in chalky soils, mineralogy of components, among others). Others vary on a much shorter time scale, over the course of years (organic matter content, soil structure, etc.); a year (water content, soluble salt content and nutrients); or even over a day (surface temperature of the soil).

The more permanent properties and general characteristics can be determined from a detailed soil map of a farm. This Technical Dossier looks at soil mapping in Catalonia, an activity that has been undertaken by the Catalan Ministry of Agriculture for many years, and is now the responsibility of the Cartographic and Geological Institute of Catalonia. Detailed soil maps are not available for all of the provinces of Catalonia, but they can be found for the most important agricultural areas. These maps are scale 1:25,000. Therefore, some detailed information has to be excluded. However, they are a good starting point. For example, they can be used to find out where it would not be a good idea to establish a peach tree orchard due to lack of oxygen for roots.

04 What data are required to make decisions?

A wide range of people use soil information, and their objectives are also very diverse. Therefore, the focus of a study must be adapted to each case. A description of horizons in a soil profile is a mapping project, required to draw up a soil map. The information differs from the data on nutrient content that is required to adapt a fertiliser plan. The design of an irrigation system should be focused on properties related to the storage and movement of water through the soil, which differs from the information required for an organic amendment plan. To monitor the risk of salination in the perimeter of an irrigation system, specific analyses are required. Nevertheless, a series of general, common properties

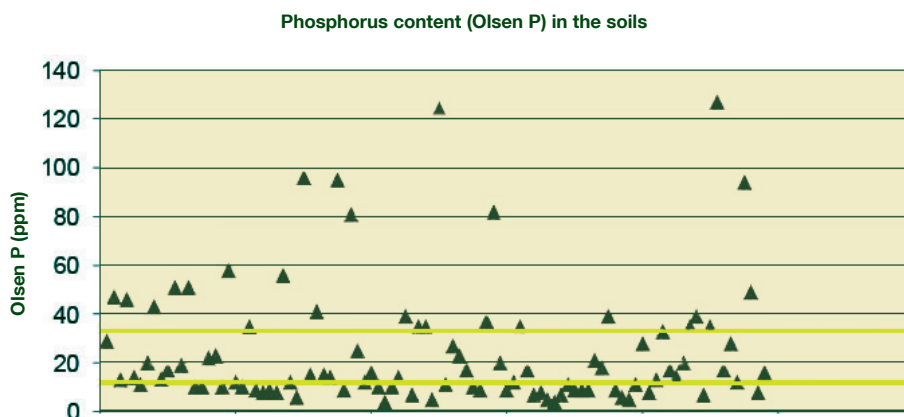


Figure 2: Example: phosphorus content (Olsen P, ppm = mg P/kg of soil) in soils in an area of the Ebro Valley. The content varies widely. Some soils lack phosphorus (< 10 ppm), whilst others have very high levels (> 40 ppm). The practice of phosphate fertilisation must be clearly differentiated in each case for optimum soil management. These results are due to management of mineral or organic additions that do not take into account the P levels in the soils.

that can be measured and recorded are of practical use in a range of tasks. To present them, we can divide them into two groups: data obtained *in situ* from the field, and data generated in the laboratory.

04.01 Data obtained *in situ*

The description and measurement of soil properties in the field is a key stage of soil studies. It is essential to soil mapping. In many of the demands for soil information, it is advisable to observe and measure some of the properties directly in the field. Some of the main properties that can be directly observed are:

- Observations of the environment, soil landscape: where the soil is found
- General and local relief and slope: characteristics of the land
- Surface stoniness and rocky outcrops: determining factors
- Evidence of erosion processes: loss of organic matter and nutrients
- Drainage problems: lack of oxygen and root suffocation
- Effective soil depth: volume that can be explored by roots
- Essential characteristics of soil horizons, detail of the properties of the surface horizon
- Crop status: visual diagnosis



Figure 3: Comparison of the depth of soils in two very different cases. In the image on the left, the effective depth of the soil is limited to a few centimetres due to the presence of rock near the surface. In the image on the right, the auger penetrates to a depth of 100 cm in a clayey soil. The difference in the behaviour and potential of the root system of plants will be very great. Author: M. Aran.

- Evidence of salinity problems: presence of halophytic plants and saline efflorescence

Observation of the surroundings at the control point are a first step in the assessment of soils and help us to situate the point in a specific soil landscape. Properties such as the relief and the slope of the soil are related to infiltration capacity, erosion risk, mechanical work and exposure.

The depth of the soil, its effective depth, can be used to calculate the volume that can be explored by the roots, which may be limited by layers of materials that impede the normal progression of the root system. This depth has a considerable influence on the availability and absorption of nutrients and the availability of rain or irrigation water (Figure 3).

The arrangement and characteristics of the soil horizons can be used to assess the potential for root development, the movement of water in the soil, and the potential for internal drainage in the case of rain or irrigation. The characteristics of the surface horizon are very important: risk of soil sealing, type and degree of structure, effects of erosion, description of organic remains, infiltration and root development.

Knowledge of these characteristics and properties can be used to put laboratory information into a specific context, to enhance understanding of the problem, and to make

better use of the data and their interrelations. The observation process in the field is designed to provide data on the external properties of soils in a plot, and to provide a representative sample of the soils in the study (Figure 4).

04.02 Soil properties measured in the laboratory. The required data

The description of properties in situ should be completed with laboratory analyses, which generate quantitative data on very specific properties that describe and define soils and their influence on plant growth and crop yield.

These analytical data are obtained via quite specific laboratory procedures for each of the properties, which is a laborious task. Analytical methods and their use are a complex area, due to the fact that there are many possible variants and standardisation is essential to assess the results. Furthermore, intercalibration tests are required, and the results need to be interpreted. For the purposes of this dossier, we consider analytical determinations made using the *Official Methods for Soil Analysis (MAPA, 1992)*, which are essential guidelines. The same methods are used in most European laboratories.

Laboratory work is based on a good, representative sample. It must be subject to

rigorous control procedures by the laboratory itself and by external bodies, through internal control activities, standard samples, statistical control, intercalibration exercises, recognition and accreditation. All of these activities aim to ensure the reliability and accuracy of the data. We should be familiar with all these aspects before we decide who to entrust with our analyses.

04.02.01 Obtaining and preparing the sample

When the sample reaches the laboratory, it should be dried at a temperature between 35°C and 40°C, then homogenised and sifted to 2 mm. In this stage, the percentage of large elements can be estimated (larger than 2 mm) if the sample has been taken for this purpose. Subsequent analyses are carried out on what is known as 'fine earth' or the fraction with particle size below 2 mm. In the case of nitrate analysis, a specific sampling procedure and analysis is required, due to the instability of this component.

04.02.02 pH and electrical conductivity

The pH and the electrical conductivity (an initial test of salinity) are two determinations that can be used to measure the acidity/alkalinity of soil (pH) and the content of soluble salts (electrical conductivity, EC). These tests are carried out on a suspension of soil: water in the proportion of 1:2.5 (pH) or 1:5 (EC), respectively. The results are very useful in the characterisation and assessment of soils, given the importance of the properties involved and the inferences that can be made. For example, $EC_{1/5}$ values between 0.5 and 1 dS/m at 25°C could be indicators of levels of salinity that are potentially damaging to certain plants. pH values that are very far from neutral increase the risk of a wide range of problems caused by excess acidity or alkalinity.

04.02.03 Calcium carbonate equivalent content and active limestone

The content of calcium carbonate equivalent, $CaCO_3$, is a permanent property of soil. It is an indicator of the geological material from which the soil was formed, or of soil proces-



Figure 4: Observation of the area surrounding a control point in the field and careful soil sampling are essential. For example, the presence of stone walls, as in the figure on the left, is an indicator of the possible potential of the soil and the degree of control of erosion. It is essential to take a representative sample in the field observation stage (see the image on the right). The image on the right shows a sample obtained with an Edelman auger, in which two horizons are mixed (Ap and Bk), which could make it difficult to interpret the results. It is crucial to obtain a representative sample. Author: M. Aran.

Calcium carbonate equivalent content

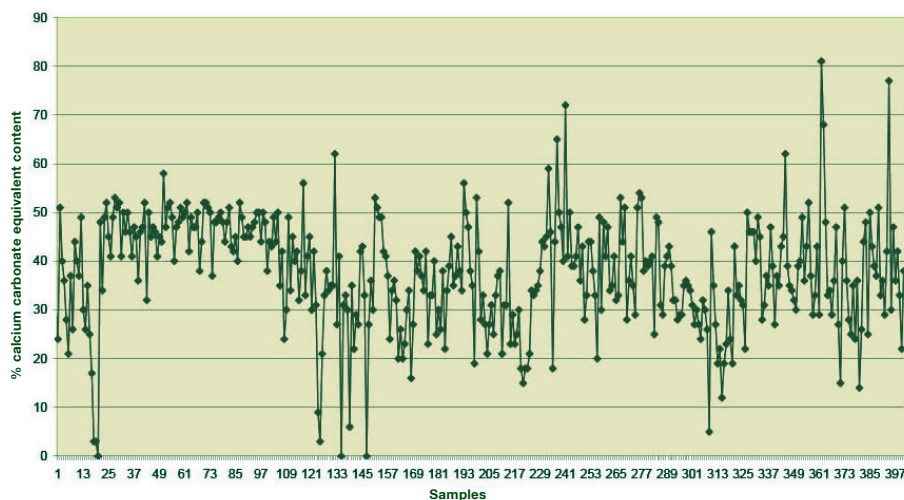


Figure 5: Content of calcium carbonate equivalent in a set of samples from Catalonia. a wide range of results can be seen from non-chalky soils to extremely chalky soils.

ses associated with the movement of calcium carbonate in solution through the soil profile in semi-arid and arid regions (Figure 5). Calcium carbonate equivalent is analysed using a volumetric method (measurement of CO_2 emitted after attack with a solution of hydrochloric acid). It can also be measured using a potentiometric method, with assessment using standard methods, among others. The analysis should be carried out for each soil horizon, once for each soil unit. The resulting values should be considered in the future.

The determination of active limestone, which is considered a chemically more active fraction of calcium carbonate, is of interest due to its potential to induce iron chlorosis, particularly in sensitive species (vines, peach trees and others). This analysis should be done up to the rooting zone before planting to choose the right rootstock and, if necessary, diagnose chlorosis problems in a plantation.

04.02.04 Organic matter

Organic matter is determined by measuring oxidisable organic carbon. The value obtained provides a measure of relatively stable organic matter in the soil. This component has an impact on the soil structure, water storage, and the retention and supply of nutrients to plants. In Catalonia, the normal levels are between 1% (worked, drier land) and 3% (irrigated areas). This analysis should be undertaken at least every five years in conventional agriculture. In organic agriculture it

should be carried out more frequently, as this kind of farming is based strongly on nutrients released by organic matter and their role in soil structure. It is also important to know the value of the C:N ratio, which should be around 10 in agricultural soils.

In this case, the Walkley-Black method is used, which consists of oxidation of organic carbon using an oxidising agent (potassium dichromate). This method measures the ex-

cess of dichromate to find out the amount of oxidised organic carbon. Then, the figure is corrected to transform the result into easily oxidisable organic matter. The result has a practical impact on the determination of soil properties and the capacity of soil to generate nutrients. Organic matter acts as a reserve of nutrients for plants, which are released in the mineralisation process.

04.02.05 Measurement of grain size

The grain size composition of soils, otherwise known as the 'texture', is one of the most important properties for users in qualitative terms. The impact of grain size on the soil's work and on the retention of rain or irrigation water is very clear. The capacity to retain nutrients also varies greatly between 'large' or more sandy textures and 'heavy' textures, that is, soils with more clay. The effects of the type of texture on hydraulic conductivity and soil percolation are also relevant and easily seen in the soil management post-irrigation or post-rain.

Grain size is determined in the laboratory by obtaining the sand fraction by sifting and the silt and clay fractions by sedimentation. The most common technique used is the Robin-

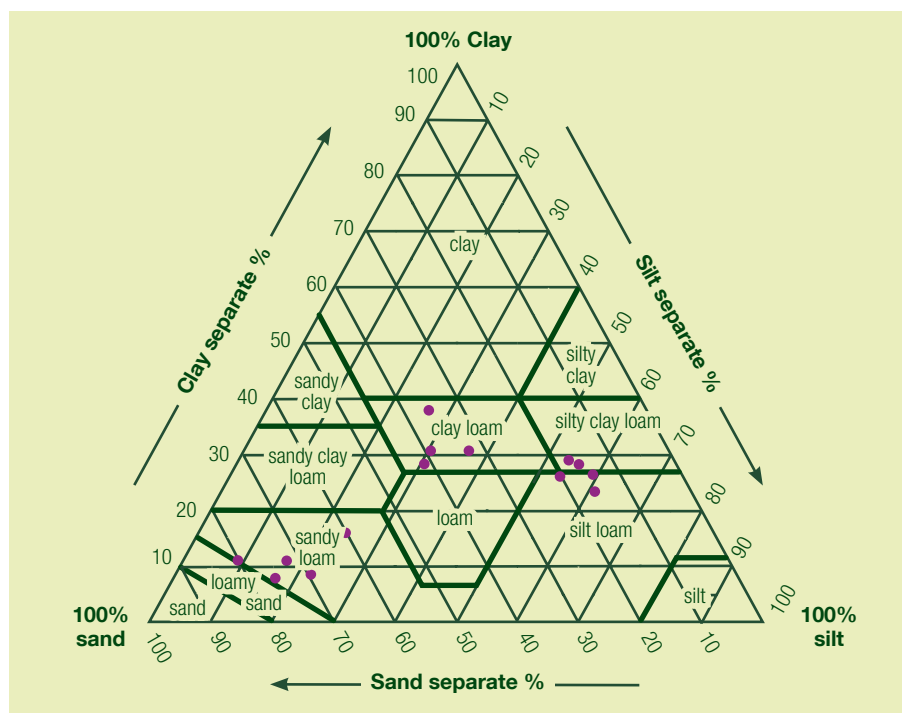


Figure 6: Distribution of texture classification in an irrigated farm. The schedule and amount of irrigation can be adjusted depending on the soil texture classification. The capacity to retain available water can range between 9 to 11 cm/m in the sandiest soils and between 16-19 cm/m in the finest soils.

son pipette method. First, organic matter in the sample is broken down and dispersed, sand is recovered by sifting, then there is a sedimentation process and pipetting of the silt and clay fractions. The texture classification is obtained from the weight of the three fractions and their percentage distribution, with the help of a texture triangle. The USDA classification is the most commonly used in our environment (Figure 6).

As can be seen, analysis of texture is laborious and there are shortcuts that a laboratory client should be aware of so that they know which product they are buying. Texture can be determined 'by touch', by rubbing

a wet sample between your fingers. With a little practice, this technique can be perfected, but it does not provide numerical data. What is not acceptable is for a laboratory to assess texture by touch, then use the triangle to obtain numerical 'results' and charge for an analysis of the exact determination of fractions. Another shortcut consists of determining two fractions correctly and then calculating the third fraction of grain size by subtracting from one hundred. This last option is easier to do than determining the three fractions, therefore it should cost less. Nothing is free, therefore you should ask the laboratory which method they use and what they are going to charge.



L'observació al camp, una correcta presa de mostres i una anàlisi de sòls que inclogui les propietats fonamentals són eines valuoses de coneixement del sòl.

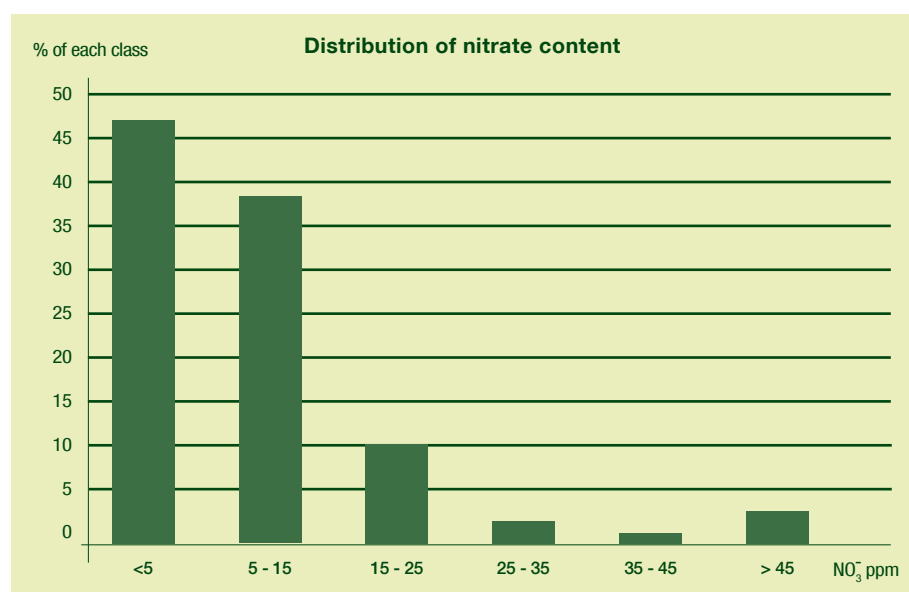
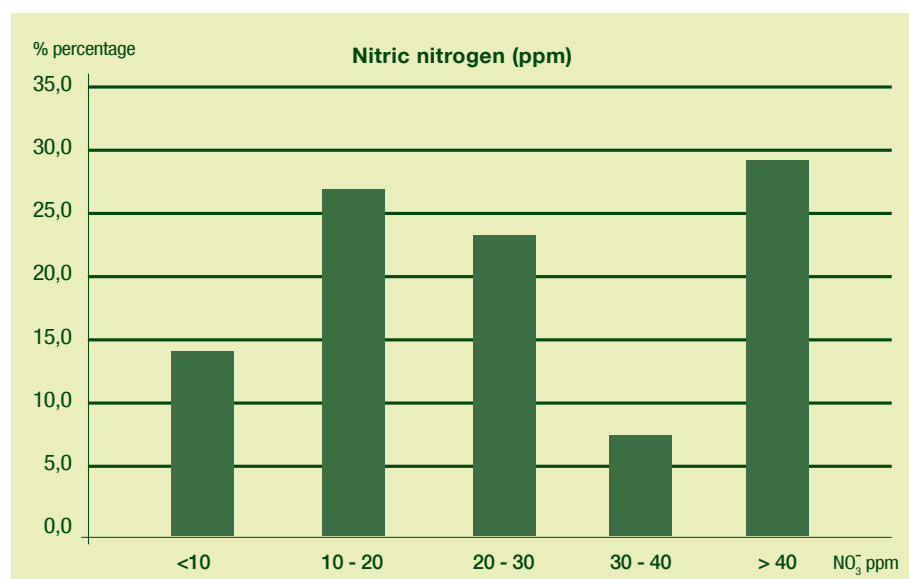


Figure 7: Example: average levels of nitrates in the soil in a very intensive agricultural area (left) and a more extensive agricultural area (right). In the area of intensive agriculture, the contents are higher overall. This means that the management of nitrogen fertiliser should be more demanding in areas with high contributions.

04.02.06 **Macronutrients. Key elements: nitrogen, phosphorus and potassium**

Soil properties do not necessarily have a one-to-one effect on the plant's behaviour. In fact, there may be considerable interrelations between properties. Therefore, an analysis must consider the entire set of properties if it is to be accurate. However, if there are no other determining factors, the soil nutrient content has a major impact on agricultural production. Nutrients are the key to fertilisation and therefore to profitable production. They also affect quality and environmental aspects.

For example, there are many studies on the behaviour of nitrogen in the soil, and in many areas specific regulations are implemented whose aim is to optimise its use as a nutrient and minimise its impact. Analytical monitoring provides systematic information on the mineral nitrogen content in the soil (Figure 7).

There are various forms of nitrogen in soils. Mineral forms (nitric and ammoniacal) are of particular interest in fertilisers, as this is the fraction that is most readily absorbed by the plant. Frequent monitoring of the nitrate content of soil is essential to carefully adjust nitrogen fertilisation, taking into account variability in the soil profile due to the properties of soils, the rate of extraction by plants, and the rate of leaching. It is essential not to cause physiological imbalances in the plants, not to lose nitrates through water drainage from the soil to surface groundwater and, of course, to optimise nitrogen fertilisation.

Phosphorus and potassium are the other two key macroelements in plant nutrition. Plants need large amounts of them, in ad-

dition to nitrogen. Export of 300 kg/ha of potassium (K) is common in certain intensive crop systems.

Phosphorus levels are determined using the Olsen method that determines the amount of P available to the plant within the pool of the forms of P in the soil. The analysis of potassium content is based on extraction with ammonium acetate, which is also known as assimilable or exchangeable potassium, based on the process described in the method. In both cases, these are key determinations in the plan for nutrition of the plants and fertilisation (Figure 8).

04.2.7. Other relevant properties in soil analysis

The list of recommendable analyses also includes, in many cases, cation exchange capacity and interchangeable cations (Mettson method); determination of the content and type of salts by determining cations and anions in an extract of saturated paste; determination of micronutrients by the action of various extractants, whether through the analysis of soils or leaves; the total content of heavy metals through acid extraction; the water retention capacity available between different potentials; the index of chlorosis

power; as well as other specific determinations depending on the soil context and the problem.

05 Conclusions

Determination of the soil properties means obtaining field data with assistance, if necessary, and obtaining data from an expert, reliable laboratory. Both sets of data are required to provide the information needed to take a technical path towards quality production that is feasible, economically sustainable in the long-term, and respectful to the environment, which are all requirements for sustainable development.

Recognition of the importance of soil properties and adapting the management to the characteristics and properties measured in the field and the laboratory is a working method that is highly justified in advanced, science-based agriculture. Experimentation supports this systematically: decisions relating to soil properties are more cost effective when they are supported by objective information from the field and the laboratory.

Ensuring the feasibility of a new plantation (a soil map combined with field and laboratory data); determining the right amount of water to add in terms of quantity and time (soil data combined with the use of sensors); promoting the protection of soils from erosion and conserving water (implementation of measures to control runoff that are compatible with mechanisation); adapting and benefiting from agricultural and livestock waste, improving the control of salinity (salination stress occurs if the irrigation water contains salts; therefore salinity should be monitored in irrigated fields); and avoiding a shortfall or excess of macro- and micronutrients (that can be verified by an analysis of soils and leaves) are all examples of operations in which suitable information about the soil is of immediate use.

This essential information, which is not difficult to obtain or hard to interpret, has a very high cost-benefit ratio and is of great use in sustainable agriculture. Information on each plot can be stored in a computer, together with data on management and production. This information complements the experience accumulated empirically over many



Figure 8 Examples: average levels of phosphorus (P Olsen ppm) in soil in an area with intensive agriculture (left) and in an area with a high concentration of livestock waste production (right). Doses need to be adjusted depending on the results obtained for the scale of the plot.

years, the farmer's knowledge, from which technicians learn and to which they contribute, to make progress on the basis of what farmers already know.

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07 Authors



Miquel Aran Mayoral

Agricultural Engineer, Master of Science
Laboratori Eurofins Agroambiental, Sidamon (Lleida)
miquelaran@eurofins.com



Dr. Jaume Porta Casanellas

Professor emeritus, University of Lleida,
Department of the Environment and Soil Sciences
jporta@macs.udl.cat

THE SOIL MAP (1:25000) OF CATALONIA

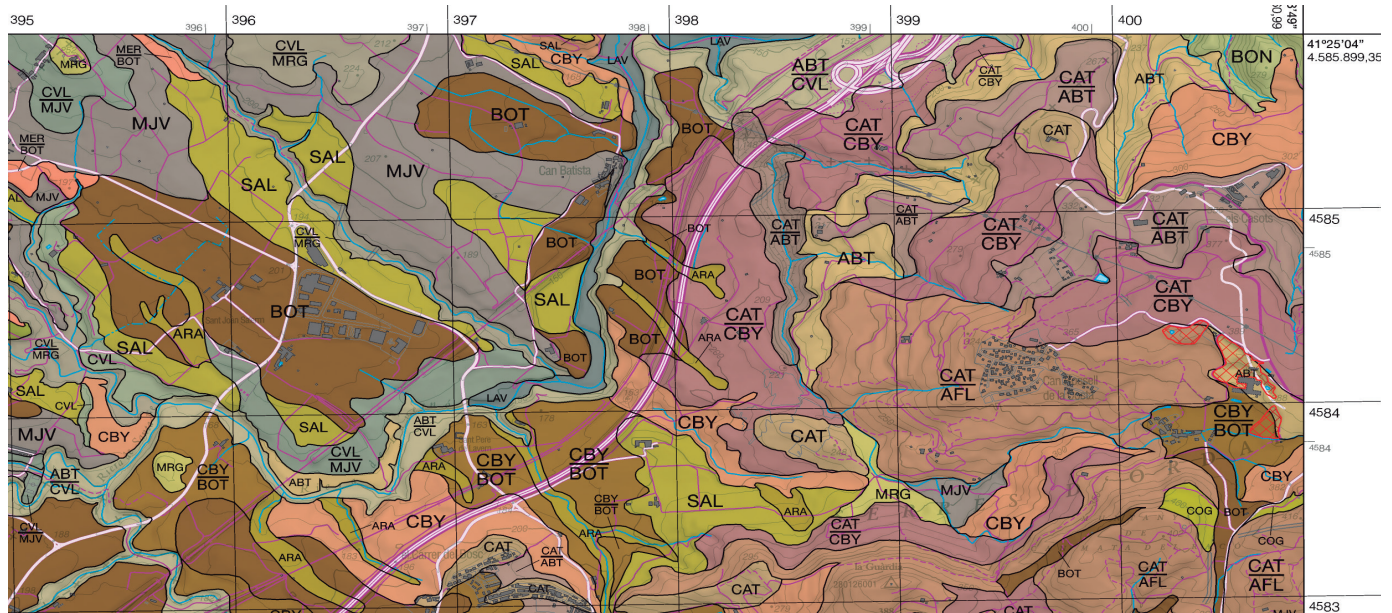


Figure 1: Fragment del mapa de sòls corresponent al full de Vilafranca del Penedès 419-2-2.

01 Introduction

The concept of soil has different meanings depending on the field of activity of the person who defines it: farmer, engineer, planner, geologist, politician, among others. The European Commission has defined soil as the upper layer of the Earth's crust that is comprised of a mix of mineral particles, organic matter, water, air and living organisms.

This mix, which is located at the interface of lithosphere, hydrosphere and atmosphere, is a natural living body that is dynamic and non-

renewable in the short- to mid-term. It has a series of functions that tend to be divided into two major groups, one that is more ecological and another that is closely associated with human activities.

The importance of soil information is reflected in the large number of specific applications that can be generated for basic, georeferenced information about soils. Examples of these applications are maps to interpret soil characteristics (texture classifications, pH levels, salinity levels, and water retention capacity, among others), and maps for evaluation that can be used to analyse any situation that involves soil information (assessment of the productive capacity of the soil, erosion risk, adaptability of irrigation systems, suitability of land, etc.).

For many years, specialists have worked to develop suitable, efficient methods for determining and illustrating the spatial distribution of soils in the landscape. Soil mapping is a term that describes the processes of understanding and predicting this spatial distribution of soil. These processes include the description of profiles, sampling, analysis of soil properties (in the field and in the laboratory), the interpretation of results and, finally, the creation of maps. Therefore, soil maps are the documents that best show the different kinds of soil in an area, their morphological characteristics, physicochemical properties and spatial distribution.

In 1983, the Government of Catalonia's Ministry of Agriculture, Livestock, Fisheries and Food (DARP) started a project to obtain a 1:25,000 scale soil map of the areas of most agricultural interest. After some time, the project was named the Soil Map (1:25,000) of Catalonia (Herrero *et al.*, 1993).

The strengths and weaknesses associated with the approach of this project were maintained until 2007, when, under Law 19/2005 of the Parliament of Catalonia, the Geological Institute of Catalonia (IGC) was created. The functions of this Institute include promoting and carrying out actions related to knowledge, prospecting and information on soil within the jurisdiction of the Government of Catalonia.

Since 2013, these functions have been taken on by the new Cartographic and Geological Institute of Catalonia (ICGC). Through the ICGC's geological mapping programmes and specifically Geowork IV: Soil Map, the Institute has continued to work on and promote the project that was initially started by the DARP, under a collaboration agreement signed between the two institutions.

02 Soil study and mapping

The study of soil in the field starts with a systematic description and characterisation of soil morphology (Figure 2).



Figure 2: Soil profile. The morphologies can be seen.



Figure 3: Some complementary determinations for soil characterisation: hydraulic conductivity using a Guelph permeameter, and determination of the bulk densities of a horizon.

The description of soil generally includes the following blocks of information:

- General information: reference of the profile, date of the description, people who undertook the description, location, etc.
- Description of the place: position of the soil in the toposequence, morphology of the place, presence of outcrops, surface stoniness, parent material and underlying material, vegetation and use of the area.
- Description of the soil profile, horizon by horizon: soil depth, thickness of the different horizons, characteristics of the boundaries between horizons, moisture content at the time of the description, colour, flecks, grain size or texture, content of large elements, structure, consistency, compactness, presence of cracks, secondary accumulations, biological activity, root system, anthropic activities, field tests to verify working hypotheses and make a more accurate diagnosis.

A macromorphological study of soil is complemented by characterisation of its hydrological properties (water retention capacity, infiltration, hydraulic conductivity) in the field, and determination of the bulk densities of the different horizons (Figure 3).

In the laboratory, a physicochemical characterisation is carried out on samples collected during the description of the soil profiles. Research studies may use other more specialised techniques (micromorphology, electron microscopy, X-ray diffraction, nuclear magnetic resonance, fluorescence, differential thermal analysis, image analysis, etc.) to study soil or-

ganisation and the nature of soil components in greater depth.

To establish the different types of soils that are shown on the maps, an approach proposed by Dokutxaiev is generally used, which was rigorously described by Jenny in 1941. According to this model, soil is the result of the combined action of some processes of formation (additions, losses, transformations and translocations) on a series of ecological factors of soil formation (parent material, position in the relief, living organisms, climate and time).

These types of soils comprise the taxonomic units of the soil map; that is, the units for classifying this entity.

The taxonomic units are defined for each mapping project, according to the objectives of the scale of the work, and they share a range of unique characteristics. However, over time, as the mapping progresses and new information is analysed, these ranges are adapted. For this reason, most of the soil classification systems are open and can be modified easily.

The spatial distribution of the different kinds of soils is represented on the maps by delineations, which are also called polygons or tiles, that are represented in the same way: colour, pattern, code or symbol. All of the delineations formed by the same type of soils, which are therefore represented in the same way, constitute one mapping unit.

Mapping units are comprised of one or several main or predominant kinds of soils and other

types of soils that cannot be represented on the map, at the scale of work, due to the small surface that they occupy. These other kinds of soils are called inclusions or impurities on the map.

The ICGC soil maps use two types of mapping units (Figure 4):

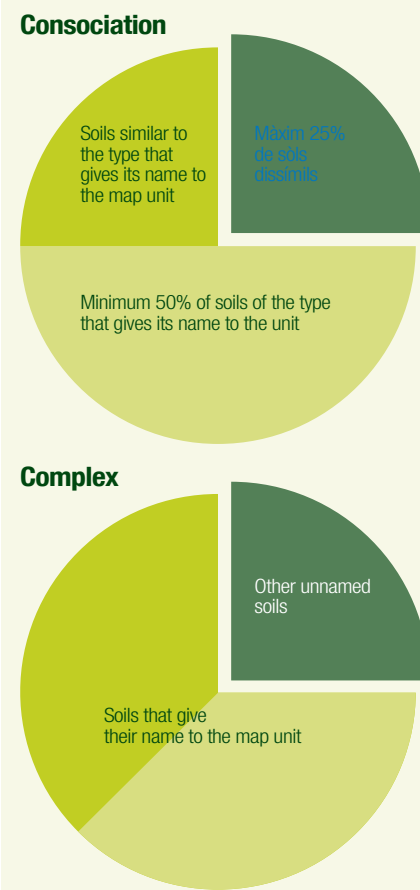


Figure 4: Types of mapping unit in the DARP-ICGC maps.

- Consociations. These are mapping units with a predominance of one type of soil in over 50% of the surface area. In addition, the surface occupied by dissimilar soils is less than 25%.

- Complexes. These are mapping units with a predominance, in over 75% of the surface area, of the types of soils that give their name to the unit.

Similar soils are defined as soils that belong to a different type to that represented on the map, but respond similarly to use and management; and dissimilar soils are those that belong to another type of soil to that represented on the map, and respond very differently to management and use.

On the maps, the graphic representation of soils shows clear limits between delineations, although in practice soils tend to present continuous, more or less gradual lateral variation. In addition, this variation is not generally the same for all the characteristics that define the different types of soils. Therefore, when we use a soil map we must take into account that the limits in the field may not be as clear as they appear from the lines and polygons that represent them.

Today, all of the data that are compiled and generated during the creation of maps are included in geographic information systems. These enable the capture, storage, updating, editing, analysis and presentation of data.

03 Soil Map (1:25 000) of Catalonia

The sheets provide information on the spatial distribution of the different types of soil that appear in the region, their morphology (soil depth, presence and distribution of genetic horizons, colour, texture, large element content, structure, consistency, compactness, human and biological activity, presence of cutans and accumulations), on their chemical characteristics (soil reaction, electrical conductivity, organic matter content, carbonate content, cation exchange capacity) and their physical characteristics (grain size and bulk density).

Traditionally, soil maps are divided into two parts: the map itself, and an explanatory report.



Figure 5: Soil Map 1:25 000 of Catalonia (MSC25M). Sheet on Tèrmens 359-2-2 (64-28). The elements that form part of the sheet are: 1.- Title Page, 2.- Soil map on the scale of 1:25,000, 3.- Legend, 4.- Description of the main types of soils, 5.- Summary of the method, 6.- Table of the physicochemical properties of the main types of soils, 7.- Map diagrams at scale 1:100,000, 8.- Diagram of classes of land capability, at scale 1:5,000, 9.- Credits and authors, 10.- Legend for the topographic base of the map.

Both should be considered complementary documents. The Bellví series, which was created some time ago, is one of the best examples of what a soil map should be like.

To make the tasks of editing easier and to adapt to ICGC publishing policies, the Soil Map (1:25,000) of Catalonia (MSC25M) uses a more simplified presentation in sheet format. The main soil elements are represented with a suitable resolution for land use planning. The 304 sheets covering the territory of Catalonia are continuous with adjacent sheets, in mapping terms. Therefore, they should be considered one soil map.

The soil information that is included in the sheets is drawn from mapping work and other past and recent soil studies carried out directly on the land; chemical analysis of samples gathered during these studies; field work undertaken to determine physical characteristics; and the analysis and interpretation of aerial photographs from past and recent flights, orthophoto maps, and digital models of the elevation of land generated by the ICGC.

Information on the MSC25M sheets is organised in such a way that it can be interpreted at different levels: the most basic, in which a user identifies the type of soils at a specific point in the territory (two dimensions); predictions of what can be found at depth at a specific point, using the sequence of horizons for the type of soils (three dimensions); and the suitability of the soils for different potential situations (soil assessment, four dimensions).

Each sheet is comprised of a soil map, a set of graphic elements (photographs, diagrams and tables) and texts to understand the soil characteristics in the represented territory. Therefore, these are documents with internal consistency that contain all of the information required to read and interpret them correctly (Figure 4).

The main element of the sheet is the soil map 1:25,000. This map contains a series of delineations that represent areas with different soils, and some headings that refer to the main soils within each delineation.

The soil map legend consists of a list, organised under headings, of all the map units included in the soil map. The legend was drawn up using a combination of three letters that refer to the name of the type of soils.

Wherever possible, the map units include consociations of the main types of soil on the sheet, as defined in the Soil Survey Manual (SSS, 1993). When this was not possible due to variability in soil distribution, complexes were mapped.

The types of soils defined in the MSC25M were determined on the basis of the parent material, the effective rooting depth, the kind of drainage, the horizons that have been determined and their arrangement, the texture or grain size of the horizons, and the content of large elements. Soil types were classified on the basis of the US Department of Agriculture's (USDA) Soil Taxonomy system. To standardise and harmonise the information, they were correlated with soil groups in the World Reference Basis for soil resources, endorsed by the International Union of Soil Sciences (IUSS).

The sheets in the MSC25M series present a detailed description of the main types of soils that are present. To make this description clearer, a photograph of the sample that is considered the most representative of the zone has been included. In addition, the sheets contain a table summarising some of the most notable physicochemical characteristics of each soil type. These characteristics were determined using analytical methods approved by the Ministry of Agriculture's Committee for Official Methods of Analysis and Laboratories (MAPA, 1986).

On the sheet, there is also a brief summary of the method used to create the map and the criteria used to define and describe the different types of soil and map units.

The map diagrams that are included facilitate the interpretation and visualisation of some important soil characteristics that appear on the map: soil depth, available water retention capacity, underlying material and drainage, among others. In the diagram of land capability classes, the aim is to provide a simple assessment of the production potential of the map units, which is why this aspect is presented on a bigger scale.

A soil map always has an interpretative component and therefore the authors of the map should be indicated, as well as everyone who has made it possible to publish the sheets, and the dates on which various tasks were undertaken.

The sheets of MSC25M are distributed in print, and online in a vectorial and geoPDF format on the ICGC website.

Finally, we should indicate that the websites of the DARP, the ICGC and the Institute for Catalan Studies include very valuable information that could complement and enrich the information presented in the sheets of the Soil Map (1:25,000) of Catalonia.

04 Authors



Marc Vicens Ferrer

Cartographic and Geological Institute of Catalonia. Ministry of Territory and Sustainability, Barcelona
marc.vicens@icgc.cat



Emilio Ascaso Sastrón

Cartographic and Geological Institute of Catalonia. Ministry of Territory and Sustainability, Barcelona
emili.ascaso@icgc.cat



Carmen Herrero Isern

Soil and Environmental Management of Agricultural Production Service DARP, Lleida
carmen.herrero@gencat.cat

THE SOIL MAP AS A TOOL FOR DECISION-MAKING AND LAND USE PLANNING

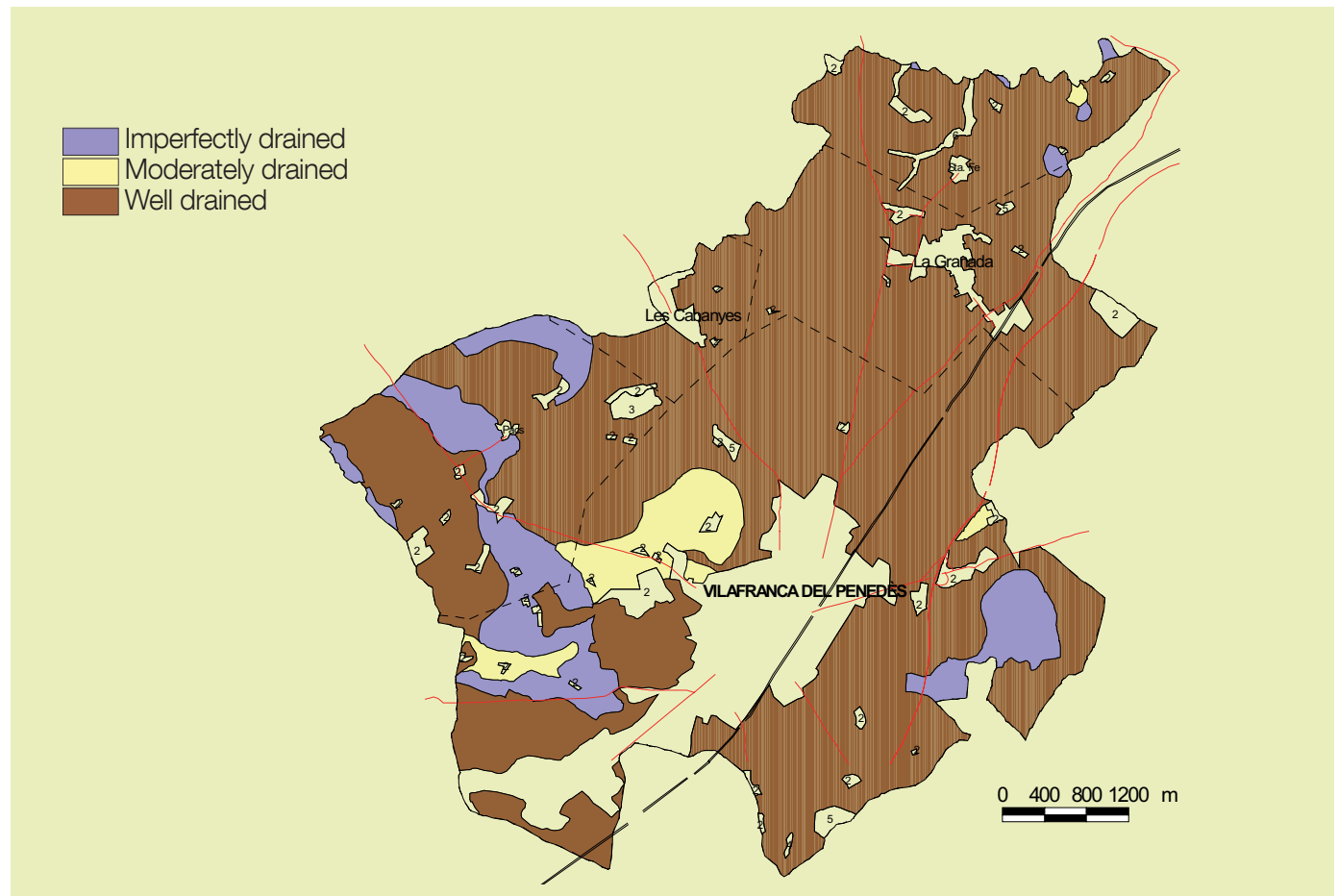


Figure 1: Classes of drainage in soils

01 Introduction

As we have seen in this monograph, soil has many intrinsic physical and chemical properties. In addition, some extrinsic properties such as slope, orientation of the plot and surface stoniness should be taken into account in soil assessments issued on suitable crops or on a specific agricultural or other land use.

The user friendliness of technological tools, the amount of digital information that is currently available, and the opportunity to study it together has led to results that are presented below.

From an agricultural perspective, there are increasing demands for product quality and respect for the environment. Consequently,

agricultural production needs to be differentiated. It must be carried out in a suitable place, from the perspective of climate and soil. The aim is to produce quality products with as little added as possible. The identification of highly suitable areas for agricultural use should be essential in the land use plans for a territory. This information leads expert planners and/or politicians to promote agricultural use and prioritise it over demands for the unceasing 'consumption' of land for other uses.

The aim of a soil assessment is to identify and compare the most promising types of uses in relation to specific units of the territory.

A soil assessment can be carried out using a soil map in which the properties that are described are very stable over time.

02 Study of unique properties

After a study of soil maps, we can represent isolated properties, such as levels of salinity/sodicity, drainage (Figure 1) or active limestone content (Figure 2) for a specific rooting depth. These are specific subject maps, such as those that represent a chemical or physical characteristic in the entire mapped area.

For most crops, we need land that is free of salinity. Therefore, a map of the soil's electrical conductivity will help to find quality land with lower salt levels.

Users may need to know these and other properties. For example, good drainage is needed to plant fruit trees. A search for suitable land for alfalfa, millet or other crops should take into account that these crops need a lot of water to develop.

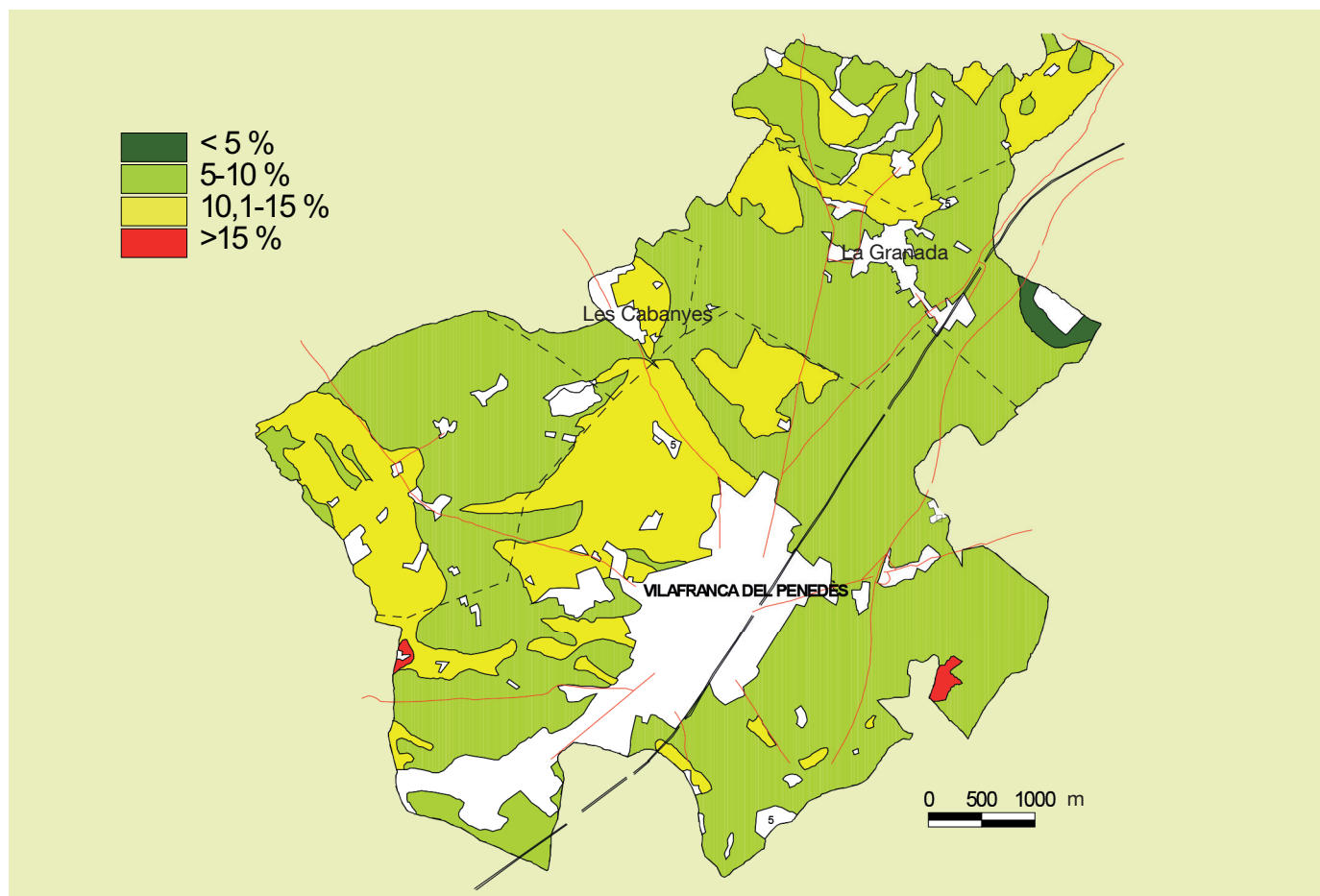


Figure 2: Content of active limestone (%) in soils.

Therefore, the land should have good water retention or must be irrigated more frequently.

If we want to plant fruit trees or grapevines, we should use suitable rootstock depending on the content of active limestone in the soil (Figure 2).

03 Assessment of soils for crops

Soils were assessed for crops using the FAO method. In addition to soil properties, this method examines climate criteria, slope maps and geomorphology. Soil information is drawn from 1:25,000 scale soil maps created by the DARP over the last three decades, and crop information provided by specialists from the Institute of Agrifood Research and Technology (IRTA), cooperatives, the Plant Protection Association (ADV) and crop experts that assess each case.

A comparison of the qualities of the land and the requirements for use shows the degree of suitability in each case. There are three classes:

- Recommended (the crop is very suitable for the map unit under assessment).
- Usable (special management of the crop and/or plot is required).
- Not recommended (limitations make it inadvisable to use the species or variety).

The use of soil information at this scale (1:25,000) provides general assessment maps for a large area, such as a province, a designation of origin, or a municipal area. If we wish to assess a particular farm, more detailed soil information is required, for example, at scale 1:5,000.

Figure 3 shows the varying suitability of soils in the same area of DO Penedès for two objecti-

ves: a Chardonnay crop for white wine and for cava production. Figure 4 illustrates that very little of the municipal area of Sant Climent de Llobregat is recommended or usable for a crop of cherry trees for wood.

In any case, the availability of soil properties in a georeferenced, consolidated database should help to meet the public's information needs in the future, to switch crops, change from dry farming to irrigation, etc.

04 "The best soils"

As we have seen in the previous section, the same soil could be highly suitable for one agricultural or forestry use, but not so good for another (Figure 3). Consequently, we cannot classify a soil as good or bad: a deep, avera-

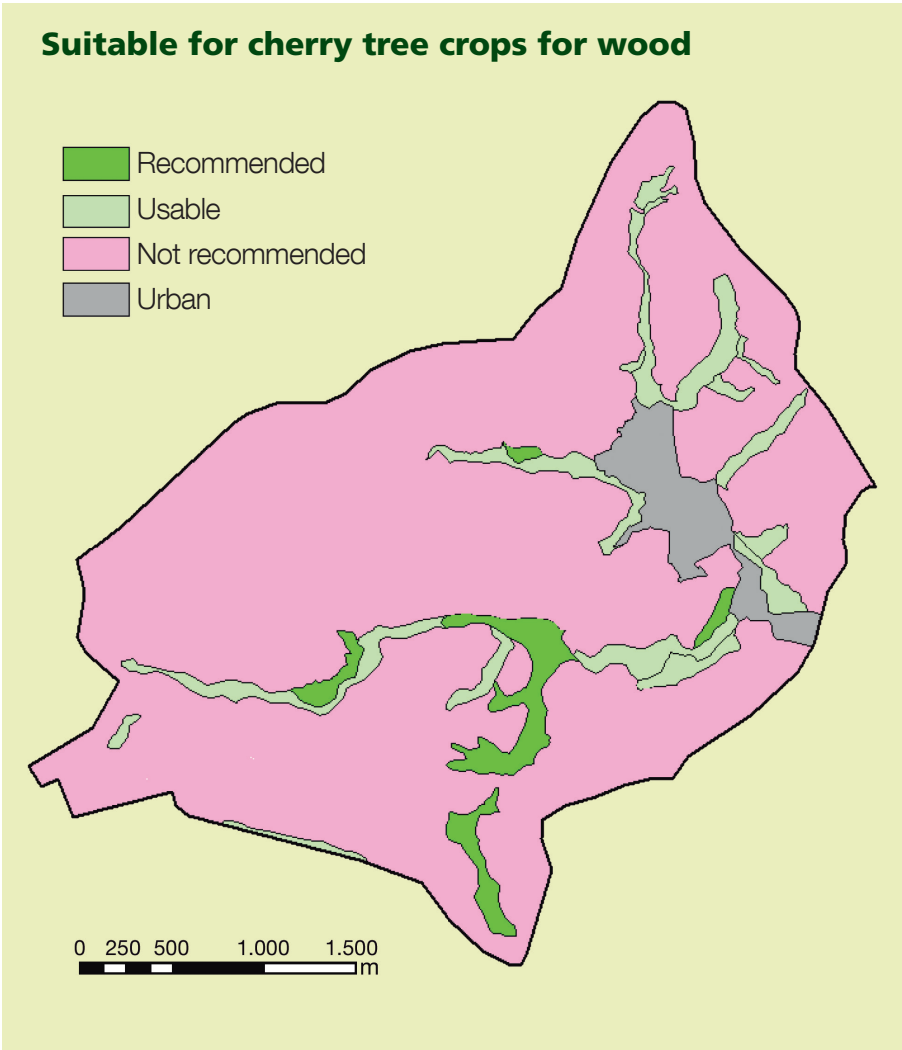


Figure 3: Assessment of soils in the municipal area of Sant Climent de Llobregat for a cherry tree orchard for wood.

ge texture soil without stones may be ideas for producing millet, but could be very bad for grape production for wine.

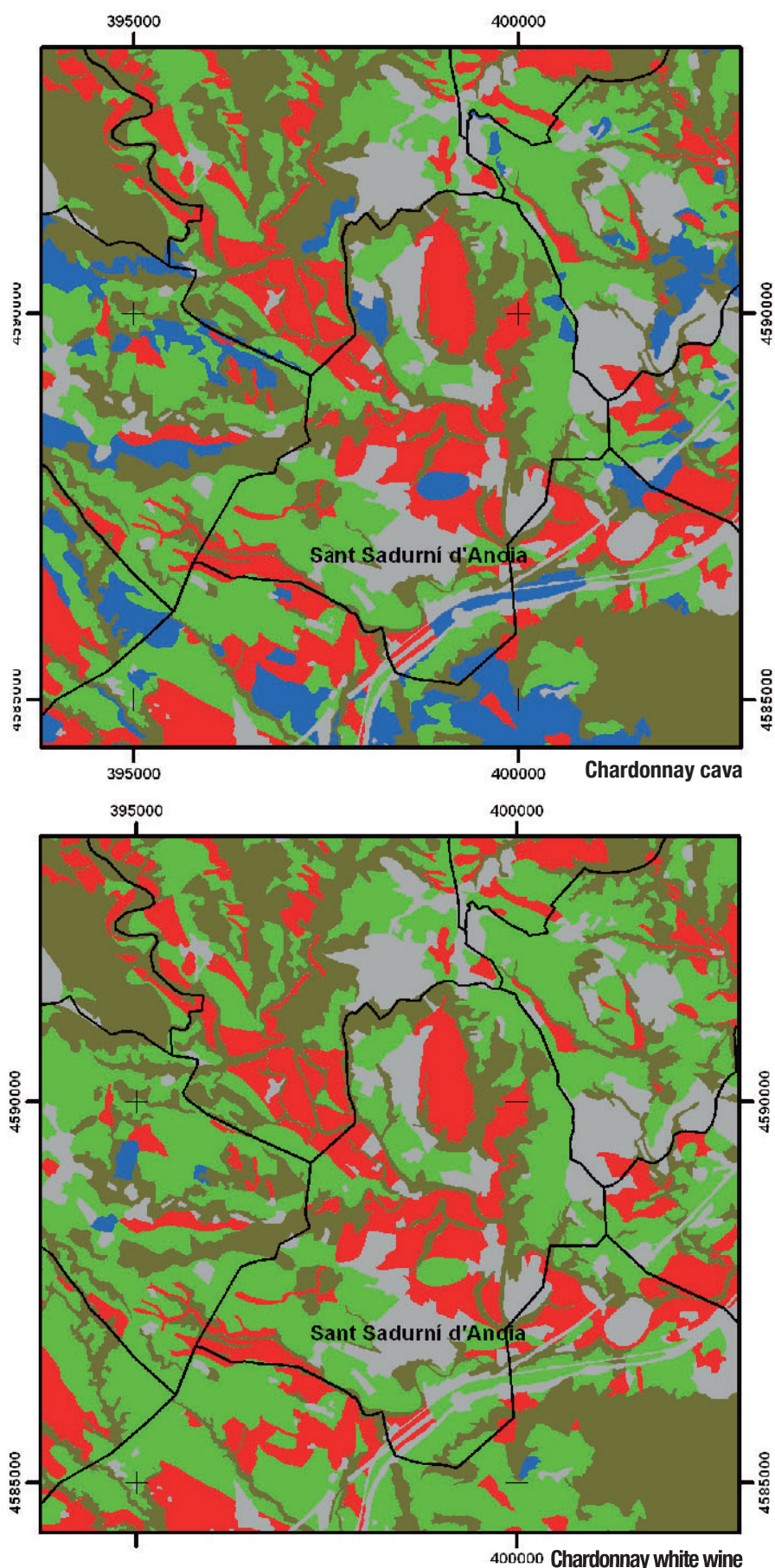
Despite this premise, everyone wants to classify soil from the best to the worst, particularly land use planners, land registry offices and agricultural services companies, among others. Within the wide range of existing assessment systems (Boixadera i Porta, 1991), Land Capability Classification and Prime Farmlands have been selected as the most interesting, given that we are concerned with agricultural use.

The first is a category system, drawn up by the US Department of Agriculture (USDA). It groups soil units according to their current productivity characteristics, without degradation of the soil resource in the medium to long-term (Klingebiel & Montgomery, 1961), and without referring to a specific crop or practice.

The system is based on establishing a limited number of categories, indicated by Roman numerals, ranked in increasing order of limitations and decreasing suitability and types of recommended uses.

The system has been adapted by the Soil Conservation Service (MAPA, 1974), to establish eight land capability classes (Table 1). The land capability subclasses are designated with a sub-index that accompanies the class number, and indicates the main limiting factor (soils, erosion, drainage, etc.).

Table 1. Meaning of the Land Capability Classes (MAPA, 1974).		
CLASS	LAND CAPABILITY	OBSERVATIONS
I	Suitable for crops. Few limitations restrict its use	
II	Suitable for crops with slight limitations.	Minimal conservation practices are required.
III	Suitable for crops with stronger limitations than the above class.	Moderate conservation practices are required.
IV	Suitable for occasional or very limited crops.	Very careful management is required.
V	Only suitable for pasture and forestry.	Crops should not be cultivated.
VI	Only suitable for pasture and forestry.	Crops should not be cultivated. Suitable for woods and pastures.
VII	Not suitable for crops, pastures or forestry.	Crops should not be cultivated. Suitable for pastures and woods.
VIII	Not suitable for crops, pastures or forestry.	Crops should not be cultivated.



- Recommended
- Usable
- Not recommended
- Mixed areas
- Forestry use and natural vegetation
- Limit of the municipal area

The United States Agricultural Department (USDA, 1983) includes various types of agricultural soils of special interest, including Prime Farmlands, which are defined as the best land for the production of food, fodder, fibres and oleaginous crops.

According to USDA criteria, for soil to be considered Prime Farmlands they must have:

- a) A suitable water supply.
- b) A warm temperature regime and a growing season that is long enough for crops that are suitable for the area.
- c) A pH of water (1/1) that is between 4.5 and 8.5 in the root zone.
- d) A water table that is deep enough during the crop growing period.
- e) An exchangeable sodium percentage (ESP) under 15, and electrical conductivity of saturation extract that is less than 4dS/m at 25°C within the root zone.
- f) No floods one of every two years.
- g) A product of the factor of soil erodibility (K) for the slope percentage under 2.0.
- h) Hydraulic conductivity that is at least 0.036 m/day in the first 50 cm.
- i) A surface horizon with less than 10% of elements larger than 7.5 cm in their largest dimension.

These soils have physical and chemical properties that are favourable to obtain good crop yields, in a sustained way.

As can be seen in Figure 5, which shows the soils in the municipal area of Riudellots de la Selva according to the two systems of assessment, the prime farmlands coincide with land capability classes I and Ia.

Figure 4: Assessment of the same geographic area for two types of wine production: Chardonnay for cava, and Chardonnay for non-sparkling white wine.

Riudellots de la Selva Soil Map

O. Palou, J. Boixadera

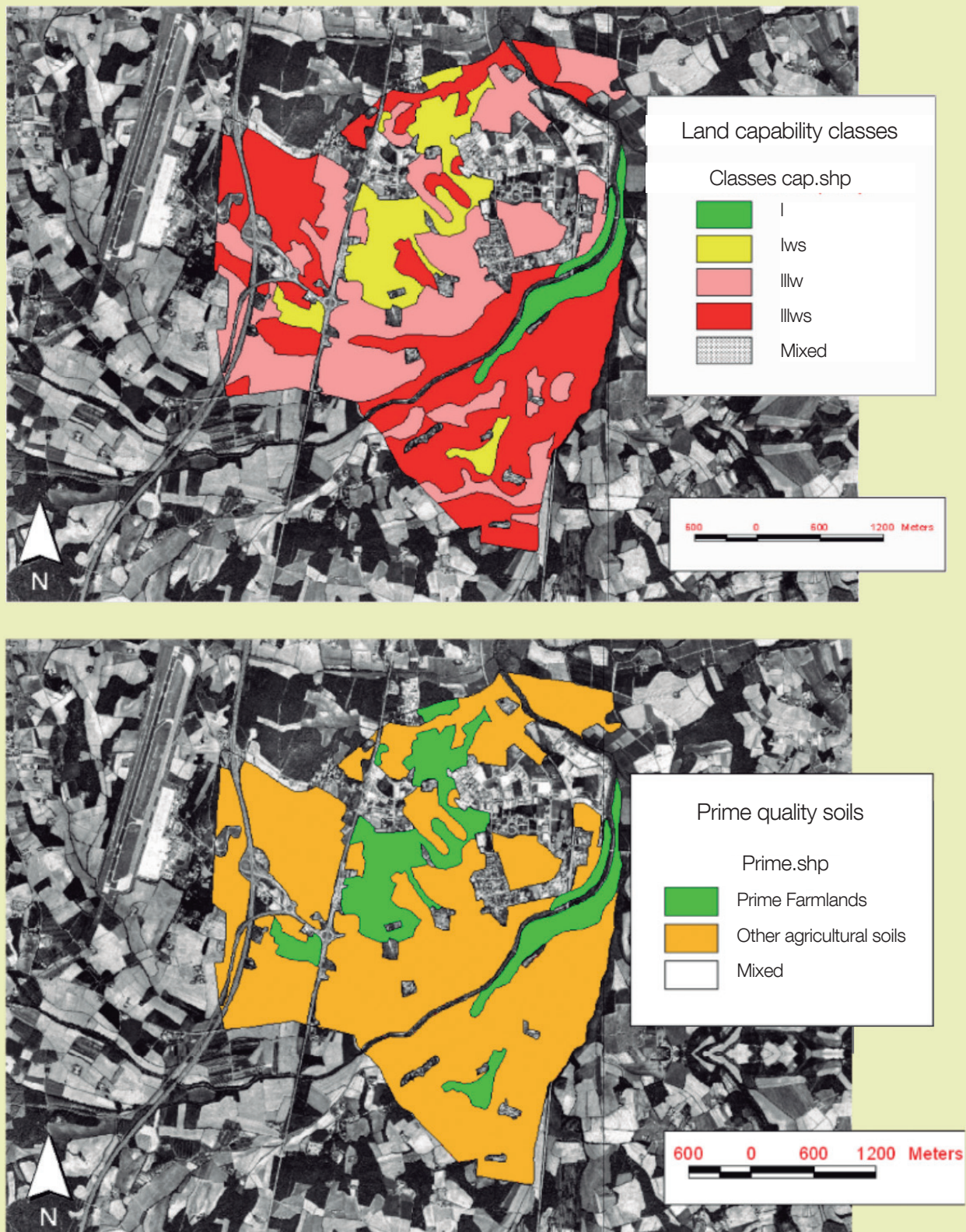


Figure 5: Assessment of soils from the Riudellots municipal area (La Selva), according to the Land Capability Classes and Prime Farmlands.

05 Find out More

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06 Authors



Jaume Boixadera Llobet

Soil and Environmental Management of Agricultural Production Service
DARP, Lleida
jaume.boixadera@gencat.cat



Carmen Herrero Isern

Soil and Environmental Management of Agricultural Production Service
DARP, Lleida
carmen.herrero@gencat.cat



Emilio Ascaso Sastrón

Cartographic and Geological Institute of Catalonia.
Ministry of Territory and Sustainability, Barcelona
emili.ascaso@icgc.cat



Francesc Domingo Olivé is an agricultural engineer who works for the Mas Badia Foundation in applied research and dissemination on well-considered, sustainable use of livestock waste in crop fertilisation.

On a farm, the cost of fertilisation is one of the biggest expenses. In this interview, we talk with Francesc Domingo about the Soil Map as an effective tool for fertiliser recommendations. Francesc is an agricultural engineer at the Mas Badia Foundation, and a specialist in fertilisation, use of livestock waste and soil management.

Should soil characteristics be considered in fertiliser recommendations?

Soil is the medium from which plants draw nutrients, to which we can add what they need to grow and develop. So, yes, we need to know the soil characteristics when we recommend fertilisers for crops.

Is the Soil Map a useful tool to obtain the parameters needed to recommend fertilisers?

Yes, because it provides useful information on some characteristics that could be of interest. However, it does not provide all the necessary information. The Soil Map of Catalonia essentially reflects the properties of soil that are more permanent, that do not vary much in the long term. In general, these properties influence recommendations indirectly (texture, depth, water retention, acidity or alkalinity, limestone, drainage and salinity, among others).

This Soil Map does not include the most important information on nutrient content, because this is directly related to the management of each plot

THE INTERVIEW

Francesc Domingo Olivé
PhD in Agricultural Engineering
Mas Badia Foundation
La Tallada d'Empordà (Baix Empordà)

"CONSULTING THE SOIL MAP CAN LEAD TO SUBSTANTIAL SAVINGS IN ANALYSES"

Excerpt from the interview published in www.ruralcat.net

over the years. There may be enormous variations between two adjacent plots or even within the same plot, depending on the history of fertilisation (use of livestock waste and fertiliser, amount and types) and the crops that have been grown.

Could fertiliser recommendations be improved with good soil information?

To make suitable fertiliser recommendations, we need to know about the soil in which the crop will be grown, through information available in the Soil Map, observation, direct studies or other alternatives. Fertiliser recommendations made without minimum knowledge of the soil in the plot are unacceptable, bad technical practice.

"Consulting the soil map before planning sampling could help to improve and rationalise the sampling process, and lead to savings and more accurate information."

Could consulting the Soil Map help to save on some soil analyses?

Yes, consulting the Soil Map could lead to substantial savings when we carry out soil analyses.

Often, we request the determination of parameters of soil samples without reflecting too deeply on whether they are necessary or whether we can find this information some other way. Soil properties that are invariable over time can be found out by consulting the Map; there's no need to analyse them again or repeatedly. Consulting the soil map before planning sampling could help to improve and rationalise the sampling process, and lead to savings and more accurate information.

In addition, when faced with a crop development problem, consulting the Soil Map could help to provide guidance on the possible cause (for

example, salinity, drainage, etc.) and which specific analyses should be carried out. This would save time and money.

How can the Soil Map improve irrigation?

Although this is an aspect that has not been examined in depth, I think the soil map could improve all stages of irrigation, from general planning to daily management of the irrigation of agricultural plots.

The Soil map contains important information for careful management of irrigation, such as the texture of the different layers and the rooting depth, which determine the capacity of each soil type to store water for plants, the drainage capacity, the abundance of salts, and other factors. All of these aspects could help to define the most suitable areas for irrigation, select an irrigation system, determine sectors to make watering as even as possible, and decide on the amount of water to apply and the frequency.

What do you think of the work done by the DARP and the ICGC on studying the soils of Catalonia?

I consider that these institutions have made a great effort, when this information is not generally highly valued, and with a lack of funds, particularly during this time of recession. But what is important is that, as a result of this effort, a soil map is available for most of the main agricultural areas of Catalonia on a large enough scale to extract useful information for soil management. The availability of this information for the entire territory would put us on the same level as the most developed countries in the world. This is one of the objectives that we must attain in the medium term. The other would be to provide tools to increase the use of this information.

