# Future Issues

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**Abstract**

Soils constitute one of the greatest assets of Argentina. This resource, coupled with the climatic conditions, confers this country the capacity to produce food for more than ten times its current population. Although it is largely known among local scientists that soils constitute the country's main natural resource, this fact remains largely unknown to the public and policy makers. Those who work in soils should be aware for spreading these concepts to the rest of the population. In Argentina, the agricultural practices leading to the sustainable use of soils are already known but not always applied. In most cases, this is due to a combination of economic factors, land tenure system, and the lack of legal support to regulate land use. At present, discussions on agricultural practices are focused on how to increase yields rather than on how to make the agricultural systems more sustainable. However, the concept of soil conservation must be urgently reinforced because the objective of increasing or even maintaining crop yields will not be possible in a context of continuous soil deterioration.

**Keywords**

Soil conservation • Agricultural practices • Nutrient balances • Soil maps

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Soils constitute one of the greatest assets of Argentina. This resource, coupled with the climatic conditions, confers this country the capacity to produce food for more than ten times its current population. Agricultural products constitute a large part of the country's exports, which is a situation that is expected to continue in the future. Soils, which are the base of all agricultural production, are a non-renewable natural resource that can be degraded by human activities. This is what has happened to many of local soils. Although it is largely known among local scientists that soils constitute the country's main natural resource, this fact remains generally unknown to the public and policy makers. Those who work in soils should be aware for spreading these concepts to the rest of the population.

Argentina has been blessed with some of the most fertile soils in the world, especially those located in the Pampean Region. But these soils, with a high content of fine silt, are also subject to the laws of nature that indicate that soils are fragile and must be managed in such a way that prevents their degradation. In Argentina, the agricultural practices leading to the sustainable use of soils are already known but not always applied. In most cases, this is due to a combination of economic factors, land tenure systems (e.g., more than a half of the land is not managed by owners but by tenants who rent the land), and the lack of legal support to regulate land use. At present, discussions on agricultural practices are focused on how to increase yields rather than on how to make the agricultural systems more sustainable. However, the concept of soil conservation must be urgently reinforced because the objective of increasing or even maintaining crop yields will not be possible in a context of continuous soil deterioration.

Until a few decades ago, Pampean crops were grown following rotations involving extensive crops (mainly wheat and maize) and pastures for extensive livestock raising. Fertilization was an uncommon practice while the main nitrogen sources were the original soil content and the nitrogen fixed by forage legumes included in the crop rotation. This fixed nitrogen was not enough to balance the nitrogen cycle.

The conventional tillage system employed by that time (moldboard plowing, disking, and harrowing with long and/or frequent fallow periods) left the ground uncovered for long periods accelerating the carbon loss through organic matter mineralization. This tillage system initially produces an intense mineralization of labile organic fractions, leaving the more recalcitrant fractions as remnant. It also affects macroaggregate structure and produces loss of structural stability. Inclusion of pastures in the rotation partially restored soil properties affected by conventional tillage by increasing above- and below-ground residue contributions and soil organic matter contents. Continuous growth and death of the pasture dense root system increase soil microbial activity and production of binding agents and other labile organic fractions.

The traditional Pampean agricultural system radically changed in the last two decades, mainly due to the expansion of soybean cropping, the displacement of pastures, and the widespread utilization of no-till farming. The expansion of soybean generated a debate in our society about its influence on the sustainability of the agrosystems, including voices identifying this crop as detrimental to soil health. Soybean contributes with less and more labile residues to the soil than other crops like wheat or maize. Under soybean monoculture, soils remain largely uncovered and without living roots during the winter fallow periods which may accelerate soil degradation. Despite all these disadvantages, it is fully feasible to achieve a sustainable soil management including soybean cultivation, taking into account the agro-environmental aptitude of each particular site. In this sense, soybean should be cultivated within a technological package including rotations with gramineous species (e.g., wheat, oat, maize, sorghum, cover crops), no tillage, and nutrient replenishment. Argentina is internationally recognized as one of the world leaders in no tillage, which is currently the predominant form of cultivation in most agricultural areas of the country. However, no tillage must be combined with crop rotations and control erosion practices in soils with more than 1% slope, to favor soil quality and sustainability. There is an increasing concern on the lack of progress in this issue, which opaque the benefits of no tillage. In such sense, it is relevant the implementation of national policies to promote crop rotations and control erosion practices.

The local agricultural extensive systems still show a deficit in nutrient replenishment. In terms of soil fertility, it is necessary to promote research aimed to increase fertilizer use efficiency, promote nutrient replenishment, and develop integrated nutrient management strategies. As historically our soils have received low doses of fertilizers, the level of environmental pollution caused by them is minimal. In that sense, we are in an advantageous position, although it is an issue that must be followed carefully. Some local aquifers show high nitrate concentration, probably related to high fertilization rates in intensive production areas and sometimes to organic matter mineralization. Nitrogen fertilization allows increasing crop yields but, since this nutrient has an open biogeochemical cycle, it is prone to be lost and to affect the environment in different ways. Studies about the local contribution to the global climate change in agricultural extensive systems do not show denitrification from fertilized soils as a main source of nitrogen oxides.

The application of phosphorus fertilizers entails the risk of phosphate runoff and eutrophication of water bodies. This problem has been identified in soils with more than 3–5% slope cultivated with high-value irrigated semiextensive crops such as potatoes. However, in agricultural extensive systems, the low soil phosphorus concentration and the low fertilizer doses applied by local farmers have prevented these processes from becoming relevant so far. In fact, the widespread phosphorus depletion observed in most Argentinean agricultural soils was caused by many years of nutrient exports without reposition. Although it is known that some local rivers, streams, and lakes show some degree of eutrophication, it should be taken into account that most cities and towns pour their effluents and sometimes also sewage sludge in those water bodies. On the other hand, and differently from other areas, in the Pampas, an important proportion of phosphates in surface water have geochemical origin. There are few studies about this subject and this is a matter to be considered in the future.

A particular picture could be found in suburban and urban soils, in which rapid action is required to stop degradation of soils and aquifers. Suburban areas often suffer the impacts of intensive irrigated greenhouse production of vegetables, fruit, and ornamentals, in which intense tillage reduce organic matter content. The low quality of irrigation water alkalized the soils affecting the physicochemical properties. In some of these environments, the high doses of fertilization have resulted in the appearance of areas with contaminated soil. Alerts about this fact were announced, but solutions are far from being achieved. In some areas, attempts were made to reduce degradation through deep tillage techniques and the addition of large quantities of manure and organic material with high lignin content, which increases leaching and improve infiltration. However, many of these practices lead to groundwater pollution.

In the last years, a number of factors favored the intensive use of herbicides, particularly glyphosate. The presence of residual pesticides and derivate compounds has been detected in some soils, and there are concerns about the capacity of the soil to degrade these compounds. The dominance of soybean monocultures and long winter fallow periods were identified as the main reasons of the increasing use of herbicides. This problem encourages the development of crop production systems from an environmental point of

view, including soil management, tillage systems, crop rotation, crop diversification, integrated production systems, animal husbandry inclusion, and pesticide doses reduction.

The Argentinean soils, in general, and particularly the Pampean ones have a low concentration of heavy metals and other toxic elements. Regarding the impact of man-made constructions on landscapes and soils, we must learn from previous mistakes so as not to repeat them in the future. There are numerous examples in which the construction of roads and canals has resulted in the congestion of drainage basins and the delay in the natural water flows. In recent times, landslides, silting, and floods have been ascribed to the advance of urban areas in vulnerable lands like deforested hillsides and wetlands.

Regarding the urban spaces, although there are some good examples, the scarce development of public parks in cities across the country is noteworthy. Unfortunately, a clear tendency of change on this issue is not observed yet and, therefore, recreational use of soil in urban areas should be promoted. In terms of the expansion of new urbanizations, agriculture should receive high priority in allocation of all naturally fertile land.

One of the great challenges of this book was how to regionalize this vast country. Across this expanse of land, an intricate pattern of soils converges with an intricate pattern of climates, vegetation, and landscapes, which in turn intermingle with human activities to configure the current geography. In the different chapters of this book, we tried to summarize the available information and group it into regions. This regionalization was not necessarily concurrent for each individual components (e.g., climate, parental materials, vegetation). It must be taken into account that the boundaries of regions are not exact, for the simple fact that nature itself has no exact limits.

Argentinean soils have been mapped at different scales. The work of INTA in this subject was remarkable. Although the majority of these maps have been made several decades ago, they are still widely useful and valid as tools for designing sustainable soil management practices. Most of the cartography has been done using the USDA Soil Taxonomy, which has proven to be very suitable for local soils. Current soil maps show large variations in scale, for example, the Pampean Region has been mapped on a 1: 50000 and 1:100000 scale, whereas in other regions available maps are in a lower detail (1:500000 and 1:1000000), which highlights the need to upgrade the soil surveys. Great progress is being made in the mapping of extra-Pampean regions recently converted to agriculture as some sectors of the southwest of the Pampean region, northeastern Patagonia, northwestern Argentina, and Mesopotamia. However, the advance of the agricultural frontier has occurred at a higher rate than the progress in soil cartography. In recent years, great advances have been made in the digitization and publication of soil maps through open access Web platforms. For example, several Pampean provinces have their maps in digital format. One of the main challenges is to have all the cartographic information on free and open access institutional repositories.

On the other hand, urban and peri-urban areas have not been surveyed yet mainly because soil mapping was originally performed in rural areas to provide basic information for farmers. There is a growing demand for soil maps in these areas, especially those devoted to horticultural activities. Another issue that may become relevant in the near future is the development of new soil survey tools such as the digital soil mapping. This promising methodology can complement and optimize survey tasks and provide continuous maps of soil type and/or properties.

The national science and technology network has played a key role in the advance of soil science in the country. This network is mainly based on several public institutions such as INTA, CONICET and universities, and NGO's (e.g., IPNI, farmers`s associations as AAPRESID and AACREA). INTA is disseminated across the country with a federal network of experimental stations, extension agencies, the Institute of Soils, and a Research Program on Soils that gather a great proportion of research and transfer efforts across the country.

The Argentinean Soil Science Society (AACS) and its large group of members have also played an important role in the advance of the soil science along its 57 years of presence. Among the several achievements of this institution, the organization of biannual congresses and the publication of a biannual journal (Ciencia del Suelo) are remarkable milestones. The strength of this institution arouses admiration in other scientific societies in the country.