# The Landscape's Contribution

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**Studying complex agricultural systems helps us manage nature's resources in effective, sustainable ways**

A "system" can be conceived of as a comprehensive and ordered set of rules that facilitate effective management. Systems theory, currently a rapidly developing field, originated from primary biological theory with the study of systems that are nearly ideally ordered.

Within agricultural activity, 4 different systems are customarily identified: the conventional, integrated, precision, and ecological systems. They are distinguished based on different ratios between the industrial and natural factors of production involved in the production process, and also based on the level of technology applied. The lines between these systems are not precisely delineated - although the ecological system, which rules out industrial means of production, is the most distinct. However, even it is nowadays heading increasingly in the direction of the industrial systems, as more than 20 different chemical pesticides are now permitted for use there. It is useful to adopt a uniform criterion for distinguishing the systems based on indexes of input amount and effectiveness "input-output relations," which introduce a division into high-, medium-, and low-input agriculture.

## Farming and the environment

Agricultural lands in Poland make up 61% of the country's total area. On the one hand the farming of that land represents significant production potential, on the other it poses threats to the environment. It also performs numerous non-production functions. Through the use of industrial means of production (mineral fertilizers, pesticides, non-renewable energy sources) it has an impact on the condition of the agricultural habitats that are harnessed.

One problem that remains technologically unresolved is the inefficient use of means of production. Only about 65% of the nitrogen and 22% of the phosphorus contained in mineral fertilizers actually gets harnessed. Pesticides, aside from their impact on the targeted pathogens, also affect other organisms. We might conclude that there is a simple, linear dependency between the amount of means of production applied and their emissions into the environment and their consequences. But that is nevertheless not the case - due to the varying systems of production used in agriculture, and also due to the natural structure of the agricultural landscape, which impacts on matter cycling and energy flow processes.

A more specific breakdown of agriculture based on production type distinguishes between the plant production and animal production sections of a farm. Which of these sections is dominant is decisive for both the overall production type of farm and its environmental impact. The system of animal production generates the heaviest environmental burden (for dairy-type farms, the overall balance of emissions into the soil and atmosphere is 113 kg/ha of nitrogen and 21 kg/ha of phosphorus, while the plant production system generates the lightest burden (for exclusively plant-cultivating farms, the same overall balance stands at 39 kg/ha of nitrogen and 6 kg/ha of phosphorus). Models of chemical compound flow identify certain subsystems of production that leave behind elemental surpluses of various size, paving the way to more efficient management of the production process. The plant production system, however, is generally characterized by a great threat posed to the organic matter resources in the soil. Models forecast a 26% drop in soil carbon content over 20 years of farming. This is an unfavorable phenomena, degrading the soil and contributing - via $CO_2$ emissions from the soil - to global climate change.

Within the plant production process, two systems of mechanical land working are distinguished: the till (traditional)

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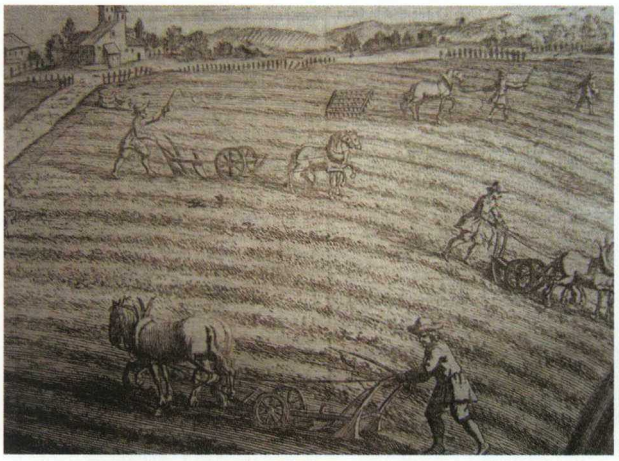
**An agricultural landscape with biogeochemical barriers - a strip of shelterbelt and a small in-field water reservoir**



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**Modern farming methods differ significantly from those once employed in the past: on the left a copperplate engraving showing surface tilling (Weigel Christoph, Nürnberg 1682), on the right a tilling and sowing unit currently used in the reduced-tillage system**

system and no-till system, the latter acquiring increasing significance in the world in view of its environmental and economic advantages (68% of cultivated land in the United States is now already worked with no tillage, 31% in Switzerland, 23% in Germany, and 24% in Ukraine). The no-till system is more broadly considered to include what is called direct seeding (sowing directly into uncultivated soil after the reaping of previous production), simplified tillage (surface mechanical working, without a plow, down to depth of 10–12 cm), and deep loosening (down to 25 cm).

Simplified tillage, which is also called surface or conservation tillage, helps boost the organic matter content in the soil while improving its chemical and physical condition and its biological properties. As a consequence of these changes, the soil's water retention increases significantly.

By lowering the energy input and labor input into cultivation, the simplified tillage system reduces the direct costs of plant production by an average of 32% compared to the traditional, intensive tillage system. In view of these advantages, the simplified tillage system stands chances of becoming widespread in Poland. This represents a return to historic methods of cultivation, but with completely different equipment and working methods. The effects are also incomparably better. As this example shows, the history of technological development sometimes comes full circle.

## Landscape functions

The environmental impact of agricultural systems can be strongly compensated for by the structure of the landscape, especially its elements which form what are called biogeochemical barriers: shelterbelts, strips of meadows, mid-field water bodies, and clumps of forestation.

Recognizing and studying the mechanisms by which such buffer barriers operate and how they modify the cycling of matter and energy flow within the agricultural landscape is a unique research specialization of the Institute of Agricultural and Forest Environment, Polish Academy for Sciences. Among other findings, studies have evidenced a very strong reduction in concentration of biogens in groundwater flowing away from cultivated fields through soil situated under shelterbelts (even a six-fold reduction in $N\text{-}NO_3$ concentrations) and reduced local evaporation from fields embraced within a network of shelterbelts.

Such results show that with a properly shaped agricultural landscape, even intensive agricultural production can be pursued without posing a significant environmental threat in terms of non-point source pollution. This is one of the landscape's multifunctionality effects.

## The contribution of natural resources

It is very difficult to assign a value to the non-production functions of the landscape, or the contribution of natural resources to the generation of useful products. Traditional economic methods employ measures that are correspondingly scaled to market prices, most frequently without sufficient physical and biological justification. Our Institute has been the first in Poland to employ the "emergy" (embodied energy) method of evaluating the effectiveness and environmental sustainability of production. It is based on the laws of thermodynamics, systems theory, and ecology, and it enables us to gauge how much solar energy, via various transformations in the biosphere, was utilized in the production of a specific product or service. This makes it possible to express such evaluations in economic relations. For example, the market value of the services which wheat farming draws "for free" from the environment amounts to 387 euros per 1 ha of area. The direct surplus from such cultivation, in turn, is reduced by 92%.

Finding a way to ensure that production activity can appropriately account for damage to the environment and the value of its services generates an opportunity to make economic assessment more objective and to manage natural resources more efficiently. That lays the foundation for sustainable agricultural development. ■

**Further reading:**

Ryszkowski L., Jankowiak J. (2002). *Development of Agricultural and Its Impact on Landscape Functions.* [In:] Ryszkowski L. (Eds.). *Landscape Ecology in Agroecosystems Management.* Washington: CRC Press. Boca Raton.