Keeping the Landscape Running

ANDRZEJ KĘDZIORA
Research Center for Agricultural and Forest Environment, Poznań
Polish Academy of Sciences;
Agricultural University, Poznań
Kedan@poczta.onet.pl
LECH RYSZKOWSKI
Research Center for Agricultural and Forest Environment, Poznań
Polish Academy of Sciences
Ryszagro@man.poznan.pl

Shelterbelts and forested patches surrounding cultivated fields are far more than just an aesthetic component of the rural landscape. They have an impact on vital cycles of matter and energy

The perpetual flux of solar energy makes all thermodynamic processes - the essence of nature - possible. The most important of these processes is the cycling of matter, and the cycling of water in particular. The Earth's so-called surface processes are strongly linked to the transfer of water or water vapor to and from the atmosphere, whereby water reaches the surface as precipitation, with one part returning to the atmosphere through evapotranspiration and another reaching the sea by runoff. The rate of evapotranspiration is primarily determined by solar energy, but we cannot lose sight of the biological factors that influence this process. Among the most important of these are the kind of plants that cover the Earth's surface and the stage of plant development.

Zbigniew Pniewski

A colorful mosaic of cultivated fields and patches of trees is one of the best methods for properly managing the landscape's heat balance and water regime

Earth, wind and fire

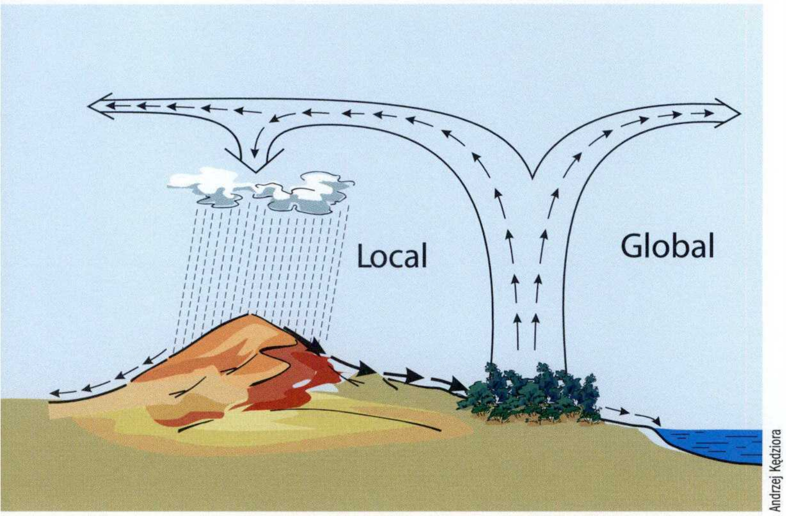
In general, the heat balance (i. e. the balance between the input and output of energy fluxes) is mainly determined by three factors:

- the amount of incoming solar energy reaching the Earth's surface
- the physical features of the surface, mainly the richness and structure of the plant cover and its "albedo" (the ratio of reflected to outgoing solar radiation)
- the moisture level of the habitat, which determines the availability of water and the transfer of energy (latent heat) in water vapor.

The balance between all sources of incoming and reflected radiation as well as the energy emitted by the active surface defines the amount of energy intercepted by the landscape. This balance is called the net radiation and it determines the amount of energy used in the functioning of the ecosystems.

Through the latent heat flux (or evapotranspiration), there is a direct coupling between the heat and water balance of an particular area under investigation. The links between these balances play a fundamental role in the cycling of water within the terrestrial system. When Earth's surface has no plant cover, or when there is not enough water for evapotranspiration, the solar energy works to heat the air. Such areas (for example crop fields after harvesting) become landscape "ovens," generating strong atmospheric turbulence.

Our research has shown that shelterbelts (mid-field rows or patches of trees) or forests consume about 50 per cent more energy for evapotranspiration than cultivated fields do. Grasslands, in turn, show intermediate values. This means that trees function as "water pumps" with respect to water cycling in the landscape. According to data obtained for agricultural landscapes during the plant growth season (20 March through 31 October), over 200 liters/m^2 more water evaporated from coniferous forest patches than from wheat fields. For mid-field shelterbelts, this difference was also almost 180 liters/m^2.



Water evapotranspired by forest is involved in both local and global circulation

In almost all the cases studied, evaporation during the plant growth season in Wielkopolska region (the western part of Poland) was higher than the precipitation recorded during the same period. This demonstrates that water stored over from winter and autumn precipitation importantly contributes to soil moisture during the summer season. Boosting the water storage capacities in the landscapes of the region therefore plays an important role in the sustainable management of the Wielkopolska countryside.

Green water managers

The introduction of shelterbelts into a uniform agricultural landscape composed mainly of cultivated fields is one of the best tools for managing the landscape's heat balance and water regime. The plant cover efficiently controls evapotranspiration rates, surface runoff and the percolation of water across the soil profile. The high infiltration capacity of soil under permanent vegetation strips and the resistance to flowing water effected by plants significantly reduces surface runoff. In landscapes with shelterbelts or strips of meadows the runoff is low (excluding very intense rainstorms). The subsurface outflow in such areas is relatively high in comparison with the surface runoff, and is very stable over time. In contrast, the surface runoff in row crop fields or in grain crop fields is intensive and rapid. In uniform agricultural landscapes the surface runoff arises quickly, lasts a short time and often causes erosion. So the introduction of diversified plant cover structures affects both evapotranspiration as well as runoff fluxes of water in the landscape.

> Our research has shown that shelterbelts (mid-field rows or patches of trees) or forests consume about 50 per cent more energy for evapotranspiration than cultivated fields do

Long-term studies carried out by our Center have shown that plant cover structure is a factor which, by channeling solar energy, increases the diversity and variability of energy and water fluxes within various ecosystems of the landscape. One of the interesting facts this research has uncovered is that air heat fluxes induced by different rates of solar energy conversion into air heating (for example, over cultivated fields and shelterbelts) form thermal gradients which influence air movement. Air movement forced by these gradients could transport energy from cultivated fields to shelterbelts. This effect is documented by very high rates of evapotranspiration in

Zbigniew Pniewski

Shelterbelts and small mid-field water reservoirs located in upland parts of watersheds, have an impact on the chemistry of water passing through the landscape

shelterbelts. Such influx of additional heat energy can enhance transpiration rates in shelterbelts. But on the other hand, by improving micrometeorological conditions, a network of shelterbelts can reduce evapotranspiration from the cultivated fields located between them. Shelterbelts or forest patches play a very important role in recycling water within the landscape, because water evaporated by them is only partly involved in global circulation (this water is lost to the specific landscape). It is predominantly involved in local or regional circulation instead, enhancing the total sum of precipitation. Thus, the heat balance of a landscape as a whole will not be a simple sum of the heat balance components of the all ecosystems treated separately. Rather, it must be considered the result of various interactions.

Natural chemical barriers

Long-term studies carried out by our Center have indicated that shelterbelts, stretches of meadows and small mid-field water reservoirs located in upland parts of watersheds also have an impact on the chemistry of water passing through the landscape. Because of their impact on ground water chemistry, these landscape structures are called "biogeochemical barriers." Nitrate concentrations were observed to decrease substantially when ground water carrying them from under fields passed under biogeochemical barriers. Both shelterbelts or small mid-field forests were able to decrease concentrations of incoming $N\text{-}NO_3$ from fields by 63% to 98%. The detected decrease of nitrate concentrations in meadows was similar, ranging from 79% to 98% of input. Taking the above facts into account we hope to abolish the misbelief that shelterbelts and meadows represent nothing more than wasted cultivable ground. A mosaic of fields and forests (or at least tree rows) actually keeps a rural landscape running, supporting the sustainable circulation of nutrients, water and energy. ■

Further reading:

Kędziora A., Olejnik J. (2002). Water balance in agricultural landscape and options for its management by change in plant cover structure of landscape. In: Ryszkowski L. (Ed.) *Landscape ecology in agroecosystems management.* CRC Press. Boca Raton.

Ryszkowski L., Kędziora A. (2003). Studies on agricultural landscape management in Western Poland Plain. In: K. Helming and H. Wiggering (Eds.) *Sustainable development of multifunctional landscapes.* Springer-Verlag, Berlin, Heidelberg, New York.