The importance of perennial trees for the balance of northern European agricultural landscapes

F. Herzog

The environmental, socio-cultural and economic functions of Streuobst, *hedgerows and riparian buffers.*

Felix Herzog prepared this article while working at the Centre for Environmental Research Ltd in Leipzig, Germany. He is currently at the Swiss Federal Research Station for Agroecology and Agriculture in Zurich, Switzerland.

In temperate agricultural landscapes, forests as well as trees and shrubs outside forests are indispensable for maintaining the equilibrium between the landscape's productive and ecosystem regulation functions. The amount, type and arrangement of woody perennials on farmland depend mainly on the farmers' decisions. But other social groups and the authorities intervene as well, because trees have always attracted public attention.

In the twentieth century, trees have been increasingly removed from European agricultural landscapes, mainly because of agricultural mechanization, land reallocations and the increasing specialization of farming enterprises. In recent years, however, enhanced awareness of the functions of trees in agricultural landscapes has provoked efforts to conserve them.

In temperate Europe trees and shrubs in agricultural landscapes occur in a variety of systems including windbreaks, rows of timber-producing trees (e.g. poplar), trees that produce non-wood forest products such as nut-trees on agricultural lands (both croplands and grazing lands) and small blocks of natural forest retained on farmlands. This article focuses on three of the most prominent systems: *Streuobst* (fruit-trees scattered on agricultural land), hedgerows and riparian buffers. The article briefly describes the systems, summarizes their history and discusses their major environmental, socio-cultural and economic functions. Together, they help preserve the ecological balance of the landscape, mitigating the loss of biodiversity and the pollution of ground and surface water caused by industrialized farming methods.

STREUOBST

Streuobst is the most prominent traditional agroforestry system in temperate Europe. It consists of fruit-trees that are scattered (*gestreut* in German) on agricultural land, as also expressed in Spain by the term *árboles en diseminado*. The French and the English terms *près vergers* and "fruit-tree meadows" basically designate the same system, but are restricted to fruit-trees on grassland. The trees, however, can also be underplanted with arable crops. This was common practice until the early twentieth century. Today, *Streuobst* most frequently occurs on grassland.

Typically *Streuobst* consists of common fruit-trees with densities of 20 to 100 trees per hectare. Rows of fruit-trees along streets are also considered a form of *Streuobst*. Fruit-trees in home gardens, on the other hand, are not, nor are intensively managed orchards consisting of trees managed exclusively for fruit production.

The history of *Sreuobst* started in the sixteenth century, when fruit-trees were increasingly planted outside home gardens on open agricultural land. At that time, market production started to gain importance and fruit was increasingly processed into products that could be stored, such as cider, must, dried fruits, fruit purée, preserved fruit in syrup and walnut oil, to name only a few. The market demand increased further in the nineteenth century when the development of railways made it possible to sell fresh fruit on a larger scale in urban markets. Subsistence fruit production has always been important as well, particularly in times of war. In Germany, the last large-scale planting activities of *Streuobst* fruit-trees took place during and after the Second World War, when the market provision of fresh fruit was insufficient (Weller *et al.*, 1986).

Market forces and subsistence production only partly explain the success of *Streuobst*. The political authorities supported its development from the begin-

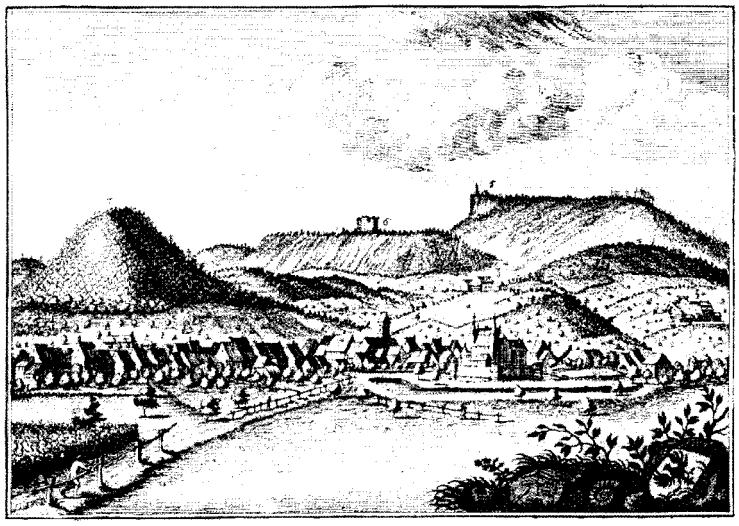

FIGURE 1
Landscape in northwestern Switzerland in the eighteenth century, with fruit-trees scattered around the village and on the hillsides (drawing by Emmanuel Büchel) ...

***... and at the end of the twentieth century (photo), with hillsides still devoted to* Streuobst**

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ning. For example, decrees and regulations linked permission for citizenship or marriage to the obligation to plant a certain number of fruit-trees or mandated the installation of tree nurseries in the villages to provide planting material for farmers.

In 1752, Frederick II (the Great) ordered that: "In each village, a cooperative, well-furnished tree nursery must be installed and run by a man trained in the handling and nursing of trees and capable of educating the villagers. In these tree nurseries, an adequate stock of fruit-trees must always be available so that, once all gardens have been planted, the planting can be extended to streets in and near the village. ... If a surplus of fruit is produced, it is to be sold to the cities" (translated from Lucke, Silbereisen and Herzberger, 1992). Intellectuals supported *Streuobst* as well, forming what would be considered today non-governmental organizations (NGOs). In the early nineteenth century, priests, medical doctors, chemists and teachers gathered in pomological societies (pomology being the science of the growing, storing, processing and marketing of fruits) and collected, described and evaluated the numerous existing fruit varieties in order to promote those of particular value (Lott, 1993).

Streuobst reached its height in the middle of the twentieth century, when intensive fruit production systems based on dwarf trees began to replace it. Today, most European table fruit stems from intensively managed orchards. Again, this development can be explained by the interaction of market forces and government intervention. National governments and the European Union (EU) subsidized the removal of *Streuobst* apple, pear and peach trees because the system was no longer considered profitable. In Baden-Württemberg, Germany, for example,

the number of *Streuobst* fruit-trees was reduced from 24 million to 11 million between 1951 and 1990 (Statistisches Bundesamt Wiesbaden, 1954; Maag, 1992).

Today, 11 European countries have about 1 million hectares of *Streuobst* (Herzog, 1998). A belt of *Streuobst* stretches through northern France, southern Germany and Switzerland to Poland (Figure 1). The share of the agricultural area planted with *Streuobst* is particularly high in hilly areas, where the topography limits the potential of more intensive forms of land use. In northern Spain, in the French departments of Normandy, Lorraine and Alsace, in the German federal state of Baden-Württemberg and in parts of Switzerland *Streuobst* covers up to 5.4 percent of the agricultural surface (Herzog, 1998). Unfortunately, statistics on extent of *Streuobst* or other systems of trees in agricultural landscapes are not available for many European countries. Similarly, national statistics on trends in coverage are generally lacking.

HEDGEROWS AND RIPARIAN BUFFERS

Hedgerows and riparian buffers are linear structures. Hedgerows are rows of shrubs or bushes forming a hedge, sometimes with a central row of trees. They are often coppiced. Riparian buffers are small strips of forest trees located along streams or rivers.

Traditional "hedgerow landscapes" are seen in Europe's coastal areas and in hilly and lower mountain regions. Examples are the *bocages* in Brittany and Normandy in France, the hedgerows in southern and central England and Ireland, the *Knicks* and *Wallhecken* in Schleswig-Holstein and Westphalia in Germany. Originally, hedgerows were planted in order to separate individual agricultural fields and/or possessions, often on earth banks (in northern Germany, for example) or on stone walls (in calcareous hilly and mountainous regions). They serve as natural fences, often between pastures and arable fields, and at the same time yield timber and non-timber tree products such as fuelwood, small fruits, fodder and herbs for traditional medicine.

The earliest written documents on hedgerows date from Roman times. For example, Caesar reported (in *De Bello Gallico*) that the farmers on the lower Rhine had established living fences consisting of trees and thorny shrubs which were cut and shaped in order to interweave the branches and create "walls which often provided such strong protection that it was impossible either to walk or see through them" (translated from Speier, 1997). Hedgerow planting was intensified in the late Middle Ages, when in many places there was a shortage of wood because of overexploitation of the forests. Hedgerows provided wood and replaced wooden fences. Their planting peaked in the eighteenth century and then started to decline. The reduction became particularly marked in the second half of the twentieth century as a result of reallocations of agricultural holdings to create larger field plots. Bazin and Schmutz (1994) have estimated that since 1960, 40 to 80 percent of the European hedgerows have disappeared or degenerated through lack of maintenance. In France, for example, the total length of hedgerows was reduced from about 1.2 to 0.6 million km between the late 1960s and 1980.

Whereas hedgerows are often planted, riparian buffers are often remnants of former river plain forests with willows (*Salix* sp.), alder (*Alnus glutinosa*) and a variety of hardwood trees (*Fraxinus excelsior, Ulmus* sp., *Acer* sp., *Quercus robur*). Riparian forests protect against sedimentation of water bodies from soil erosion on adjacent agricultural lands.

ENVIRONMENTAL FUNCTIONS OF TREES IN AGRICULTURAL LANDSCAPES

Modern, industrialized agricultural production in Europe has boosted food security, but to a great extent it has done so at the expense of the environment. The main environmental problems attributable to modern agriculture are the loss of biological diversity and the pollution of ground and surface waters. Trees help mitigate these problems.

Biodiversity

The potential of trees to enhance biological diversity in agricultural areas can be explained by the numerous physical gradients (for example, dry/moist, shaded/sunny) that occur when trees and annual plants are interspersed. A variety of ecological niches is created which offers a range of habitats for plants and animals with different environmental requirements.

The biodiversity harboured by the *Streuobst* system has been widely noted, with emphasis on the frequency of endangered species (cf. Bünger and Kölbach, 1995).

Funke *et al.* (1986) found that, as a consequence of the abundance of easily decomposing biomass and the close interaction of biomass producers and consumers in a small area, the overall biomass of arthropods in *Streuobst* was 2.7 to 7 times higher than in nearby forest ecosystems.

The type and frequency of meadow utilization (pasture or mowing or both) and application of fertilizer strongly influence the plant associations found at a site. The diversity of herbaceous species increases with light availability and is greater if the site is mown rather than grazed. It decreases with the inten-

sity of the meadow's utilization (Breunig and König, 1988).

Streuobst provides habitats that have become scarce in European agricultural landscapes. The system is an important refuge for small mammals (including bats), reptiles and amphibians. It receives particular attention, however, for its potential to host birds, including numerous species whose populations are declining or endangered. Woodpeckers, nuthatches (e.g. *Sitta europaea*) and treecreepers (e.g. *Certhia brachydactyla*, *Certhia familiaris*) feed on insects in the trees' wood and bark. Holes or crevices in older trees provide nesting opportunities for birds that nest in caves.

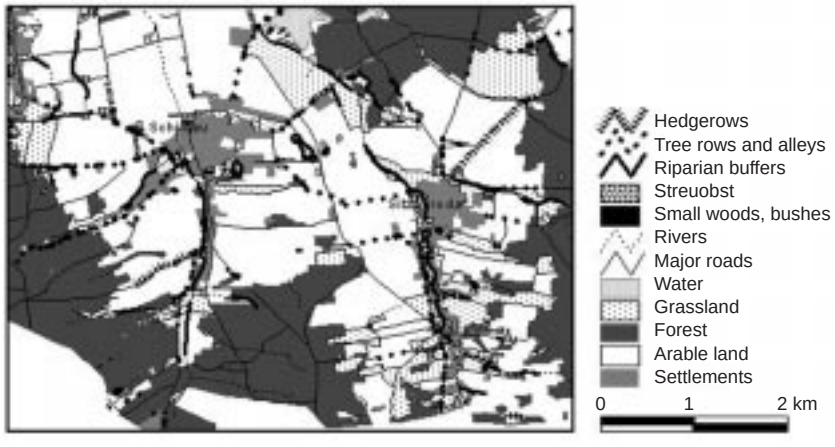
Streuobst systems have a large amount of intraspecies as well as interspecies variability. Fruit varieties selected by local farmers have traditionally differed regionally. S*treuobst* sites normally consist of several varieties and types of trees, chosen by farmers for their different pollination characteristics, different times of maturity so the harvest will be spread over time and different utilization and storage properties of the fruit. The preservation of fruit-tree varieties in *Streuobst* systems creates useful synergies between the conservation of genetic material and nature conservation (Herzog and Oetmann, 1997).

Hedgerows and riparian buffers each represent an ecotone, or a transitional zone between vegetation types, known to harbour a rich assemblage of species (Risser, 1990). Riparian strips also contribute to fish habitats, providing shade and the shelter offered by roots and fallen woody matter. Hedgerows and riparian buffers are a major habitat for birds and invertebrates. The invertebrates contribute to the stability of the adjacent agro-ecosystems. In early spring, hedgerows provide fodder for herbivorous insects, leading to buildup of their populations, which in turn leads to rapid increases in the populations of entomophagous parasites and predators. Later, the parasites contribute to the control of aphids on the nearby agricultural crops (Schulze and Gerstberger, 1994).

Hedgerows and riparian buffers are not only valuable habitats but also corridors for the movement of birds and insects. They link forests, small woods and *Streuobst* sites, allowing for an exchange of individuals between populations, preventing isolation and genetic degradation. An example from eastern Germany is shown in Figure 2. Even in this landscape, which is characterized by large field plots and intensive agricultural management, hedgerows, riparian buffers and tree rows provide at least a fragmentary network of biotopes (regions uniform in environmental conditions and plant and animal populations).

Soil conservation and water quality

Water pollution mainly results from soil particles (in surface water), leached agrochemicals and excess fertilizers (in ground and surface water). Prevention of erosion and leaching is thus a priority. It can be achieved by adapting the cultivation techniques and by modifying the landscape structure – a combined approach being the best solution (Haycock and Muscutt, 1995). Linear landscape elements such as hedgerows and buffer strips are the most powerful tools of landscape planners because they have the potential to control the fluxes of matter and energy in landscapes while requiring only relatively



Source: Digital biotope map of the Saxony Agency for Environment and Geology (SLUG), Dresden.

FIGURE 2
Ecological network around two villages in the Torgau District, western Saxony, Germany, consisting of* Streuobst *sites, fruit-tree rows, hedgerows and riparian buffers

Winter landscape in northwestern Switzerland

limited surface. Investigations at the catchment level have shown that linear structures of perennial vegetation distributed across agricultural areas in densities adapted to the local conditions and agricultural practices contribute to improved water quality (Mander, Kuusemets and Ivask, 1995; Vought *et al.*, 1995).

Hedgerows have been planted as windbreaks in regions vulnerable to wind erosion, such as the loess plains of France and eastern Germany and the sand dunes of the coast of northern Denmark. Windbreaks protect pasturing animals not only from wind, but also from excessive temperatures. In Denmark, planting of hedgerows was found not only to help prevent erosion, but also to help improve the microclimatic conditions. Comparative studies suggested that effectively spaced hedges could contribute to an average annual increase of 5 percent in the yield of agricultural crops (Bazin, 1994).

Hedgerows and shelterbelts root deeper than annual crops and have higher evapotranspiration. As a consequence, they function as "ecological water pumps" (Ryszkowski, 1992) and at the same time intercept nutrients contained in lateral flows of water in the subsoil. For example, a 19-fold decrease in nitrate concentration has been observed in groundwater passing under shelterbelts in Poland (Ryszkowski, 1992).

Similar mechanisms are at work in riparian buffers maintained between farmland and surface waters to mitigate negative impacts of agricultural management. Riparian buffers prevent soil eroded from adjacent land from washing into rivers or streams, where it would silt up the aquatic system. A buffer zone consisting of a stepped structure with a herbaceous strip adjacent to a strip of shrubs and bushes, followed by a forest strip next to the river or lake shore, retains nutrients (nitrogen and potassium) and pesticides from polluted overland and subsurface water. The tree strip also filters air polluted with agrochemicals and reduces the growth of aquatic plants by shading their environment (Mander *et al.*, 1997).

SOCIO-CULTURAL FUNCTIONS

The landscape's socio-cultural services are beneficial for human well-being. Scenic values, recreation and regional identity are closely linked. Landscapes are perceived as pleasant if they are structured in certain patterns (which may vary according to the culture), and visual aspects are often a major factor driving landscape change. The visual quality of most traditional agricultural landscapes in temperate Europe is related to the harmonious contrast of an ensemble of landscape elements including closed forest, structured arable fields and green meadows, interspersed with small woods, hedgerows, etc. Fruit-trees, which are often grouped around settlements, connect them to the open agricultural land. As patches, rows, scattered individuals and even single trees, *Streuobst* can enhance the local topography. With the differing shapes, sizes and colours of blossoms, leaves and fruits, fruit-trees enrich the scenery's variety and diversity in space as well as time.

Trees have always had an important role in myths and customs. In ancient societies, trees were symbols of fertility and well-being. Among the fruit-trees, cherry and apple trees have particularly often been associated with myths, beliefs and customs. In many regions, the blossom of fruit-trees is a symbol of spring. Today, images of trees are often used in the marketing of products that are supposed to be particularly environment friendly. In a political con-

text, they symbolize the green or alternative movements. The particular aesthetic role of trees in landscapes was recently underlined in a cultural event in which the famous artist Christo wrapped 178 trees with polyester in northern Switzerland. The "Wrapped trees" event, linked to an arts exposition on "The magic of trees" and to the presentation of the nature protection activities of several NGOs, was highly publicized in the international press and attracted tens of thousands of visitors.

ECONOMIC FUNCTIONS

The reasons for the observed reduction in the number of trees in European agricultural landscapes in recent decades have mainly been economic. Above all, the trees have been removed to increase the efficiency of mechanized agriculture. *Streuobst* is not generally seen as a profitable branch of farming activities (Herzog, 1998). Nevertheless, apples from *Streuobst*, for example, have a considerable impact on the European fruit market (Rösler, 1996). The fact that *Streuobst* is still quite popular in hilly areas indicates that in certain environments it has comparative advantages over other types of land use. It integrates well with cattle and crop production on medium-sized family farms, if the fruit-picking season is between the labour-intensive planting and harvesting seasons and if family members are available to help with the harvest.

In Germany, *Streuobst* is an example of successful cooperation between nature protection and agriculture. Pursuing a "protection through utilization" approach, numerous environmental NGOs have allied themselves with farmers and developed alternative marketing systems for *Streuobst* products. There are about 90 initiatives that organize production and marketing, mainly of must and cider (Lobitz, 1997). *Streuobst* products are sold at a higher price than products from intensive agriculture. They are labelled as particularly environmentally friendly and healthy, and increasing numbers of consumers are ready to spend extra money for this kind of food. The higher prices are an incentive for farmers not only to harvest the fruit, but also to maintain the *Streuobst* trees and with them the entire system.

Qiu and Prato (1998) have estimated the potential financial benefits of riparian buffers in terms of cost savings relative to achieving water quality objectives by other measures. Many vital environmental and socio-cultural benefits, however, cannot be monetized, and these would have to be taken into account in order to judge what Barbier (1990) calls the "social efficiency" of the system.

THE FUTURE OF TREES IN AGRICULTURAL LANDSCAPES IN EUROPE

Recognition of the importance of the services provided by trees has led, since the 1970s, to endeavours to stop the removal of *Streuobst* and hedgerows from agricultural landscapes, to conservation of the remaining sites and even to replanting. This movement was initiated by proponents of nature protection and has induced policy changes. In Germany, for example, the policy of the 1960s which subsidized the removal of *Streuobst* has been reversed. Today, *Streuobst* is protected in five of the 16 federal Länder, and most of them have implemented specific programmes to support the management of *Streuobst* systems. Similar programmes exist for hedgerows and riparian buffers (e.g. Schulze and Gerstberger, 1994). In France, up to 1 500 km of hedgerows are planted every year (Schmutz, 1994). In most European countries, the establishment of hedgerows and forested riparian buffers is subsidized by agro-environmental programmes which are based on EU regulation EEC 2078/92, on agricultural production methods compatible with the requirements for protection of the environment and maintenance of the countryside. The implementation and effect of those programmes varies strongly between member countries, however.

A general, underlying problem rests in the fact that the presence of trees on farmland may change the legal status of the land, bringing it into the domain of forestry and nature protection laws. These laws often restrict the farmers' options. Knowing that *Streuobst* or hedgerows cannot be removed once they are established, farmers may be reluctant to install them or may even remove some of them before laws that protect them come into force.

The future of European agricultural landscapes is closely linked to the fate of its trees. Only a "landscape approach" can lead to coherence between agricultural, forest and environmental policies (European Union DG VI, 1998). *Streuobst*, hedgerows and riparian buffers can contribute to mitigating the pollution of ground and surface water and the reduction of biological diversity. They are valuable tools for maintaining ecological balance. In addition to the traditional systems discussed here, the development of novel agroforestry systems combining hardwood trees for timber production with arable crops or grassland (Dupraz and Newman, 1997) will provide new approaches for the integration of trees in farming systems in temperate, industrialized countries. ◆

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