Chapter 16
Agroforestry in the Netherlands

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Abstract Early farming activity migrated originally from forests. A high rate of cultivation led to almost complete degradation of Dutch forests. To conserve them it was necessary to prohibit grazing of forests. Since a few decades, grazing has been used as a measure to improve the natural values of forests. An agroforestry system, which existed for a long period in the Netherlands, was high-growing fruit trees (*boguards*) with an underlayer of grass, which was mowed or grazed by cows and sheep. Recently there has been an increased interest in combining trees as multipurpose natural elements with agricultural activities. Research and demonstration projects have been established in different parts of the Netherlands. Walnut (*Juglans regia* L.) is the most widely planted tree species. Density varies between 25 and 100 trees per hectare. Understorey vegetation is mostly grass, which is grazed by sheep, cows or horses/ponies or is mowed and ensiled. Other combinations of tree species with understorey are explored. Some research has been carried out regarding the attitude of modern farmers. Farmers from different regions had different attitudes. The needs of an urbanising countryside seem to favour chances for agroforestry.

Keywords Fruit trees, history

Agroforestry in Ancient History and More Recent Times

Nowadays, agroforestry activities in the Netherlands are limited. Since the 1950s, high labour costs and land prices have forced farmers since the 1950s to expand their farms for large-scale agricultural production. This has been realised with a rational, intensive use of fertilisers and chemicals to increase growth and to control weeds and

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diseases. Agricultural enterprises specialise in monocultures, rather than mixing crops or mixing crops with trees. But due to the negative effects of intensive agriculture with monocultures, interest in agroforestry has been growing since the early 1990s. In this paper we describe the development of agricultural and other land use activities in the Netherlands up to the present day.

Growing agricultural crops and husbandry activities in the forest are the first agroforestry activities recorded in the Netherlands. By about 2500 BC farmers started individually farming in the forest, which mainly consisted of deciduous species such as birch, alder, oak, ash and elm, but also Scots pine. They cut and burnt the forests, starting with the open, easily reached dryer parts on sandy soils, grew grain on small cultivated fields and domestic stock (sheep, pigs, cows) on the perimeter of the forests. Since bronze tools could be made (ca. 1500 BC), forests could be felled easier. This led to an open landscape with heath-fields on sandy soils (eastern part of the Netherlands). In the period after 500 BC, when tools made of iron were introduced, agricultural methods became more intensive and low situated areas in the west and north of the country were settled. During this period meadows had already been established in the coastal zone, using sheep and cows for grazing. Also ship-building activities, especially after the arrival of Romans in 50 BC, which needed a great amount of timber, contributed to a decrease in forest cover. By now, the increasing population needed a growing volume of firewood including charcoal.

After the retreat of the Romans (AD 270) and the invasion of the Celts and Germans, many forests disappeared due to reclamation for permanent farming. During that period the first settlements appeared. They used a system of inner and outerfields, with cropfields (inner fields) around the village and heaths (outer fields) behind the cropfields. During the day sheep grazed on the heath fields and at night they were kept indoors where they left their manure. This manure was used to fertilise the fields.

After AD 800 the feudal lords, bishops and monks took on the duty of reclaiming land and this accelerated forest loss. With expanding commercial activities and development of cities an increasing amount of timber for buildings and ships was needed. All these processes led to a gradual reduction in the Dutch forest area. In the 17th century almost all forest (except some protected areas) had disappeared. Since the beginning of the 19th century new forests have been planted, originally on inland drift sands, to protect the villages against wind-blown sand. In the 19th century and the first ten years of the 20th century new forest areas were established, especially on the former heath fields. Most of these forests were conifers, such as Scots pine (*Pinus sylvestris* L.), spruce (*Picea abies* L. Karst.), larch (*Larix kaempferi* Lamb.) and Douglas fir (*Pseudotsuga menziesii* (Mirbel) Franco*)*. In the second half of the 20th century new forests also appeared on the new, reclaimed land in the polders. These forests consisted of broadleaved tree species such as poplar, willow, oak, ash, elm, lime and maple. Nowadays, forests in the Netherlands cover 360,000 ha (7% of the total area), with *Pinus sylvestris* as most important species (33%) and oak (mainly *Quercus robur* L.) (18%) as the most important broadleaved species. However, since the forest law was introduced (1938) forest grazing, as in many places in Europe, was prohibited in the

Netherlands. The main functions of the forests were protection against soil erosion, timber production and for hunting.

Since the 1970s grazing has been used as a specific measure to improve the natural values of forests, including biodiversity. In more recent times different types of combinations of agriculture with trees have been developed and these will be discussed here.

Agroforestry Today

Nowadays agroforestry is practised on some farms in the Netherlands. Several experiments have been carried out to demonstrate the possible advantages of the implementation of agroforestry systems. The types of agroforestry practices that can be found in the Netherlands are presented below.

Farm Agroforestry Systems Practices

One of the most common types of agroforestry is the combination of fruit trees with husbandry. In the 20th century, a large area (5,000 ha in 1984) of fruit orchards were situated on clay soils between the rivers Rhine and Meuse. These had mature fruit trees like apple, pear or cherry and were spaced at 50 to 150 trees per hectare. The grassy vegetation in the shade under the trees was largely "*boguard*" species, like *Dactylis glomerata* L., *Holcus mollis* L. and *H. lanatus* L., which were usually mowed or grazed by cows and sheep (sometimes even pigs, for example under plum trees as a secondary use of the system). It was a system which developed using different products, without subsidies. Since the 1970s most of the high stem fruit-tree orchards have been replaced by intensively managed low stem trees of new cultivars, with high stem numbers per hectare. In the most intensively used orchards, however, the combination with livestock farming did not work particularly well due to insolvable problems such as the need to protect the trees, and soil compaction by livestock. The only combination that sometimes worked out well was when poultry was the animal component (Bloksma et al. 2002).

The second type of agroforestry system which has been used for a long time is a combination of growing poplar with husbandry. In the province of Noord-Brabant in the southern part of the country, farmers have been growing poplar for industrial purposes (veneer for matchsticks) over a large area (ca. 3,000 ha). The grass cover has been used for hay-making or for cattle grazing. In this system, in which poplars were established at 100–200 trees per hectare, some research has been carried out on grass production under competition for light, moisture and nutrients.

A third example, which can be considered as a type of agroforestry system, is farming between rows of alder (*Alnus glutinosa* L. Vill). At the borders of the wetlands of the northern part of the country, the landscape has developed into a dense

network of alder rows, between which the farmers kept their cows or harvested grass. During summer cows grazed the meadows between the alder rows. In winter time the alders were pruned vertically (branches were used as firewood) or felled (for firewood or construction timber) in a 25 year rotation. Presumably grass growth was increased by the biological nitrogen fixation by the alders (De Boer and Oosterbaan 2005).

As stated earlier, grazing is being used nowadays as a specific measure to improve the natural state of forests. Since the 1980s grazing of forests by domestic ungulates has become a more common practice in the Netherlands (Kuiters 1998). Natural processes, such as grazing by wild and domestic grazers, were given more priority in forest management. Subsidies for tree planting were stopped by the government and since then spontaneous regeneration is considered as a key process to guarantee sustainable timber output. Grazing can improve conditions for tree regeneration by reducing the accumulated litter layer, thereby creating better conditions for germination and establishment of tree saplings. For successful further growth the applied grazing pressure must be extensive at densities of no more than 1–3 animals per 100 ha on nutrient-poor sandy soils (Jorritsma et al. 1999). In the Atlantic area of Spain it was found that grazing can enhance tree regeneration (McEvoy et al. 2005).

Grazing by domestic ungulates can be applied as a management tool to create semi-open park-forests with species-rich transition zones between closed forest and open grassland or heathland (Kuiters 1998).

The total cover of Dutch forest landscapes grazed by domestic stock was estimated around 31,000 ha (9% of the total forest area) in 2003 (Table 16.1). Most sites are composed of a mosaic of forest, heath- and/or grassland which are integrally grazed. Cattle are mostly used, often in combination with one or more other domestic grazers such as horses or sheep. Either year-round or seasonal grazing is practical. The average size of

Table 16.1 Overview of forest grazing in the Netherlands in 2003 (seasonal grazing is either summer-grazing (period April–October) or winter-grazing (November–March). Mean-stocking rate amounts to ca. 20–30 livestock units per 100 ha, in year-round grazed areas ca. 3–10 livestock units per 100 ha, depending on grassland cover)

	Year-round grazing	Seasonal grazing	Total
GRAZED SITES			
Cattle grazing	40	64	104
Horse grazing	7	2	9
Sheep grazing	26	36	62
Goat grazing	2	4	6
Combined grazers	37	37	74
Total number of sites	112	143	255
COVER			
Total area (ha)	16,831	14,129	30,960
Minimum size (ha) per site	5	5	5
Maximum size (ha) per site	3,900	1,733	3,900
Median size (ha) per site	57	45	50

the grazed sites is rather small, approximately 50 ha. The largest grazed forest areas cover several thousands of hectares with free-roaming, extensively managed grazer populations, often combined with wild ungulate populations. Sometimes nature management organisations have their own livestock, but mostly animals of farmers are used. Grazing of forested sites can be economically very profitable through the production of certified 'green' meat. This is produced without recourse to any fertilizers, pesticides or antibiotics and is of a very special quality (Kuiters 2005).

Experiments and Experiences of Agroforestry Systems

Since the negative effects of agricultural practices with intensive use of chemicals in large-scale monocultures are known, the search for alternative ways of producing crops and food has been intensified. This led to the establishment of experimental plots and individual efforts of farmers throughout the country (Table 16.2).

Between 1989 and 1994 an experiment was carried out mixing *Populus robusta* Schneid. (202 and 404 trees per hectare) with sugar beet, maize and grass (*Lolium perenne* L.) grown each year with three levels of fertiliser. After six years, the growth of grass under 202 trees hectare (tree height was about 10 m) was 30% lower than grass without trees, at a fertilisation level of 300 kg N ha^{-1}. For grass under 404 trees hectare, the reduction in yield was 60%. The growth of sugar beet and maize under 202 trees per hectare was, respectively, 45 and 55% lower than without a tree cover. These figures include loss of area for the rows of trees (Oosterbaan et al. 1997).

The growth of crops between the trees is economically feasible for at least six years, even without direct subsidies to stop agricultural production. This form of mixed cropping is an interesting way of establishing a tree plantation. When the number of trees is reduced, mixed cropping should be possible on a permanent basis (Oosterbaan et al. 1997). Although it has not yet been investigated, the use of small crowned poplar clones at 50–100 trees per hectare would allow a rotation period of 30 years with a permanent crop mixture.

An intergovernmental program "Sustainable Technological Development" is aimed at developing new sustainable means for issues such as food production. This led for example to the establishment of several experimental multipurpose plantations in the eastern part of the Netherlands. In cooperation with eight farmers and estate owners 10 ha of walnut (*Juglans regia* L.) (cultivars 'Broadview', 'Buccaneer'), cherry (*Prunus* sp.) and sweet chestnut (*Castanea sativa* Mill.) were planted at different spacings of 10–20 m. For these plantations, multipurpose tree species were chosen, e.g. those that produce fruits and valuable timber (Peeters et al. 1996; Oosterbaan and Van den Berg 1997; Oosterbaan 2000). The established plots had trees with grass as the agricultural crop. The grass was either mowed and made into silage or grazed by cows, sheep or ponies. An overview of these silvopastoral experiments is presented in Table 16.3. Investigations carried out from 1999 to 2003 focussed on: grass production and composition; tree development and growth; fruit production; ways of harvesting the nuts and the routes for selling them;

Table 16.2 Agroforestry experiments and experiences in the Netherlands

Type of agroforestry	Tree species	Crop	Location	Area (ha)
Poplar/grass, beet, maize	Populus	Grass, sugarbeet, maize	Estate De Eese (province Overijssel)	4
Walnuts/grass	*Juglans regia* and hybrids, *Castanea sativa*, *Prunus avium*	Grass (+cows, sheep, horses)	Winterswijk (province Gelderland)	10
	Juglans	Grass	Hengelo (province Gelderland)	2
	Idem	Grass(+cattle)	Kallenkote (province Overijssel)	9
	Idem	Grass	Piershil (province Zuid-Holland)	2
	Idem	None	Idem	1
	Idem	Grass	Elst (province Gelderland)	2
	Idem	Horticultural species	Breedenbroek (province Gelderland)	4
	Idem	Hazelnuts	Ommen (province Overijssel)	2
	Idem	Hazelnuts and Hippophae	Luttelgeest (province Flevoland)	1
	Idem	Grass (recreation)	Province Noord-Brabant	5
Poplar, *Sambucus*, bulbs	*Populus spec*., *Sambucus nigra L.*	Hyacinths	Boelenslaan (province Friesland)	1
	Pinus sp.		Donkerbroek (province Friesland)	2
	Cedrus sp.		Province Friesland	1
	Gleditsia sp.		Province Friesland	1
Robinia/ potatoes	*Robinia pseudoacacia L.*	potatoes	Province Gelderland	1
Alnus/ horticulture	Alnus cordata(Lois) Duby.	Horticultural species	Province Drente	

Table 16.3 Area allocated to different spacing plantations with walnut, sweet chestnut and cherry

	Narrow spacing (10 × 10 m)		Wide spacing (20 × 20 m)	
Tree species	Grazing (ha)	Mowing (ha)	Grazing (ha)	Mowing (ha)
Walnut	1	1	3	3
Sweet chestnut and cherry	½	½	½	½

biodiversity; the prospects for income from tourism. In 2003 the plantations were surveyed for the presence of butterflies, grasshoppers and crickets.

To predict the development of trees and grass production, data on young plantations were combined with data from older plantations on similar soil types in the eastern part of the Netherlands.

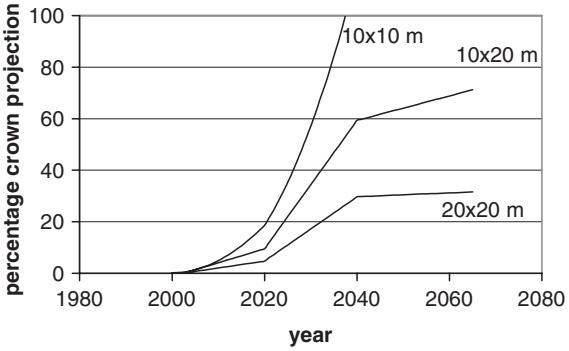

Fig. 16.1 Predicted crown development of walnut plantations with different tree distances

Grass production varied from 3 to 9 t dry matter per hectare per year. In the four years of investigation there was no visible evidence that the trees had negatively affected composition or production of the grass crop. Based on predicted crown development (Fig. 16.1), reasonable levels of grass production will be possible for a long period. So far, the nut production from the young plantations has not been profitable. This is similar to results found in Great Britain (Newman and Adams 1997; Oosterbaan et al. 2005). Compared with flower-rich grasslands, the multipurpose plantations harboured more grasshoppers.

The initial investment required to protect the trees, namely poles and wire netting to protect against animals, resulted in a low net income for the first five years. Later, the income from the combination of walnuts and quality timber with grass is reasonable and may exceed the income from subsidised, extensively managed grass (see also Fig. 16.3).

Walnuts, better adapted to cooler weather conditions, were selected from green areas in the north and evaluated for their characteristics. This resulted in at least two cultivars ('*Dionym*' and '*Amphyon*') with excellent yield potentials together with a good form and timber quality. Both cultivars have a low susceptibility to diseases and are particularly suitable for organic cultivation. '*Dionym*' and '*Amphyon*' are planted in private gardens, but also in a commercial organic orchard of 1.5 ha, in which 200 walnut trees were grown together (mixed cropping) with cultivars of hazelnuts (*Corylus avellana* L.) and Sea Buckthorn (*Hippophae rhamnoïdes* L.) (Oosterbaan and Schepers 2005). The rest of the experiments with different combinations of trees species and crops (Table 16.2) are private initiatives and are spread throughout the country.

Social Aspects of Agroforestry Systems Implementation in the Netherlands

Most agricultural activity in the Netherlands takes place on large farms. Since they have specialized production systems, mixing crops with trees is a novel idea to many modern farmers. Depending on the landscape type, different systems have been established in different places.

Attitude

As a contribution to the SAFE (Silvoarable Agroforestry for Europe) project, farmers' attitudes towards agroforestry in the Netherlands has been investigated. A group of farmers from the small-scale land use landscape on sandy soils in the east of the country was compared with a group of farmers in the open, large-scale landscape on clay soils in the northern part of the country. The first group was more optimistic towards the introduction of agroforestry than the second group (Postma 2005). The most likely explanation was that the 'small-scale farmers' were already used to working with trees around their fields. They were also used to small fields and did not have the feeling that working with trees was something 'new'.

Agroforestry in an Urbanised Society

In urbanised societies it is very important to maintain a green living environment. With "multipurpose plantations" agroforestry can contribute to sustainable cities and urban environments which are more pleasant to live in.

"Multipurpose plantations" consist of multipurpose trees and crops, preferably interacting in a positive way. Multipurpose trees deliver different tangible products like fruits, leaves, bark, twigs, timber, roots and extracts for medicines or other use (Fig. 16.2). Besides these products, trees provide protection against climatic influences (wind, snow, rain, sun, fine dust), enhance biodiversity, C-fixation, dust fixation and protect against erosion (De Boer and Oosterbaan 2005; Oosterbaan et al. 2006a). Crops such as mixed-species grass vegetation deliver fodder, higher biodiversity (compared with monocultures of *Lolium perenne*) and contribute to an attractive landscape (Oosterbaan 2004).

Trees can be spatially orientated in different ways, for example in geometrically organised plantations or in a more natural random pattern. Generally people tend to prefer and appreciate semi-open landscapes which are easy to move through, have clear lines and open water (Van den Berg 2003). A well-defined structure and spatial variation are attractive characteristics to people and encourage visitors to explore (Van den Berg 2003). Multipurpose plantations, managed in a natural way, meet these demands. The most suitable situation to establish multipurpose plantations is the transition zone between the open landscape and the dense forest area. It is preferable that trees and crops influence each other positively. For example, the crop species used should be adapted to the shade of the trees. Animals could also benefit from the shade, for example, cows kept cool produce more milk under better animal welfare conditions. The crop may have a positive effect on the trees, for example by weed control or by contributing biological, microbial nitrogen.

Calculations for a walnut/recreation system showed that such a system can deliver a positive financial output. In a comparison (Fig. 16.3) of a multipurpose

Products:
- Attractive landscape
- Biodiversity
- Fruits
- Timber
- Bark, twigs and others
- Crop
- Other products (e.g. honey)
- Recreation

Fig. 16.2 Overview of the products which could be obtained from a multipurpose plantation

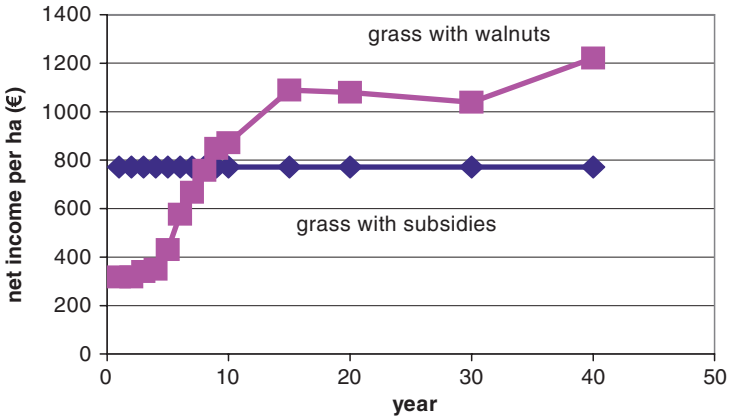

Fig. 16.3 Comparison of net yield per hectare between grass (with subsidies (♦)) and grass with walnuts (■)

plantation consisting of walnuts and grass (mowed or grazed) with subsidised grass farming for extensive management, the plantation option was the most profitable (Oosterbaan 2004, 2006b).

Agroforestry in a European Context

At an agroforestry meeting in Wageningen (2005), one of the most important outcomes was the growing interest shown by practioners and scientists in building a knowledge network in the Netherlands (Mayus and Oosterbaan 2005; Boomplan 2007).

The Netherlands was one of the partners in the European SAFE-project where a biophysical agroforestry model (Yield-SAFE) was developed. This model enables prediction of yields and the analysis of economic scenarios of modern agroforestry systems (Boomplan 2007). Some important conclusions of the SAFE-project are:

- Modern agroforestry systems are compatible with present day agricultural techniques. Specific tree management schemes are necessary (such as tree alignment and stem formative pruning). In modern agroforestry systems, low tree densities (30–100 trees hectare) allow crop production to be maintained until tree harvest.
- Average productivity of silvoarable systems is higher than the productivity of separated trees and crops. Productivity increases of up to 30% in biomass and 60% in final products were evidenced (exclusive result). Tree-crop systems are able to capture more resources from the environment than pure crop or pure tree systems: in facilitation, a process that explains why mixed plots are significantly more productive than pure plots.
- With the developed models, optimum management schemes can be provided for tree stand densities, tree spacing, tree row orientation, tree species choice, intercrop rotation choice, and specific tree and crop management techniques, such as tree root pruning.
- Economic calculations show that agroforestry plots are always as profitable as agricultural plots in a no-grant scenario, and that they are often more profitable with high value timber trees (such as walnut or *Sorbus* species). Annual crops maintain the annual income for the farmer, while managed low density tree stands will provide a capital for the future. Optimal densities of tree stands are between 30 and 100 stems hectare, depending on tree species and site fertility (SAFE 2007).

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