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The European Agroforestry Federation, an NGO representing national agroforestry associations, researchers, farmers and foresters
www.agroforestry.eu

**CDAF**
Centre de Développement AgroForestier de Chimay, Belgium
www.cdaf.be

**TUBEX**
Designers and producers of specialty treeshelters for the establishment of quality trees
www.tubex.com

**Acknowledgments**

This first edition of *A Guide to Agroforestry* summarises the benefits of planting trees in mixtures with crops or livestock. It provides examples of agroforestry, reasons for its use, and guidance on how to establish agroforestry projects. Examples are shown of research trials and farmer initiatives throughout Europe.

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AGROFORESTRY

What is it?
Main Types of Agroforestry

Agroforestry is the integration of woody vegetation with crops or livestock on the same area of land. It is the intentional mixing of trees/shrubs into crop or animal production systems to produce environmental, economic, and social benefits. More diverse, productive, profitable, healthy, and sustainable land-use systems are then created.

Silvopasture combines trees and grazing of domesticated animals in a mutually beneficial way. In mature stands this may be called woodland grazing or forest grazing.

Silvoarable practices combine widely-spaced rows of trees with alleys of arable crops. When trees are placed in rows this is often called alley-cropping. Shrubs or cover crops are sometimes grown within the tree-rows.

Windbreaks or shelterbelts are also a type of agroforestry since the trees provide shelter and shade to both crops and animals. They often increase the yields of crops and reduce the stress experienced by animals. Wider shelterbelts replicated in the landscape, are sometimes called forest-belts.

Riparian buffer strips are forested areas adjacent to streams. They filter nutrients, prevent much of the erosion from neighbouring fields reaching watercourses and improve water quality and biodiversity.

Forest farming where food, herbs (medicine, aromatic, spice), mushrooms, honey, foliage, berries, seeds, bark, resins, dyes, craft materials and decorative products are harvested under the protection of a tree canopy. These non-timber forest products can be harvested from agroforests and from woodlands generally.
These practices can be combined with orchards (e.g., streuobst, prés-vergers, pomaradas) or dehesa and montado, where traditional high-stem fruit or oak trees are combined with either crops or pasture. They can also include timber-trees.

Increasingly, agroforestry is used to produce bioenergy and chemical raw-materials for the ‘bioeconomy’.

In Europe, tree-based agricultural systems have existed since ancient times. Forests are still used for grazing, fodder, fruits and nuts in all biogeographic regions of Europe. Historic agriculture was a mix of scattered timber or fruit trees, with many more hedgerow trees than today. The distinction between forestry and agriculture was less clear and much of the organic matter, fertiliser and energy used in agriculture came from trees or shrubs.

During the past century trees have been progressively removed from agricultural land as crop production intensified. Modern agroforestry practices are a mechanism to reverse this trend and make agriculture more ‘ecologically intensive’. Grants are available in an increasing number of European countries to establish new agroforestry areas, and farmers’ direct payments from the Common Agricultural Policy (CAP) are usually protected. Importantly, the areas planted with agroforestry remain classified as ‘agricultural land’ and (if implemented by EU Member States) will count towards a farm’s ‘greening’ requirements.

Agroforestry is a traditional practice, but modern science is helping to understand the impact of the variables which can be managed by the farmer; like tree species, subsoiling, tree-spacing, row-orientation, crop-rotation, ploughing, spraying, formative-pruning, high-pruning, side-pruning, fertilising, thinning and felling. Computer models of crop and tree growth have been used with information on soil and climate to predict the optimum biological yields and profitability.

TUBEX Ventex Design for Agroforestry

In the early studies of establishing trees for agroforestry, INRA (France) recognised the need to modify the design of treeshelters to improve the height and girth growth of trees. A PhD research study was conducted which led to a patent granted to Bergez and Dupraz and to the design of a new treeshelter TUBEX Ventex/Equilibre. TUBEX Ventex/Equilibre creates a balanced microclimate favourable for good and fast establishment of young trees while preventing damage by domestic or wild animals. These treeshelters have been successfully employed for both broadleaves and conifers in most regions of Europe.
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Why?
Trees can increase yields and profitability of crops and pasture

The economic advantage of agroforestry comes from its better use of resources, its environmental benefits and the high value of the quality timber which can be grown.

Trees of choice include walnuts, wild cherry, maple and fruit trees. Veneer quality logs can be worth €250-350 /m³. Farm income can be almost doubled when this quality timber is taken into account, together with the rapid growth of widespaced trees. The farmer will have additional weeding and pruning costs however, since it is vital to ensure that stem is straight, free of knots and is as cylindrical as possible (i.e. the bole has low ‘taper’).

In silvoarable practices the choice of crop (e.g. winter cereals) and ploughing can be optimised to encourage tree roots to first grow vertically and then to spread under the crop, where they act as a “nutrient safety net” to absorb fertilisers leached below the crop. This ‘deep and stable’ form of root growth also makes the mature trees more resistant to damage from storms and increases the capacity of soil to sequester carbon.

The performance of agroforestry is measured using the Land Equivalent Ratio (LER) index. The combined yield of both the tree and crop/livestock components are compared to those obtained separately.

“Yield LERs” of 1.2 to 1.4 are frequently observed, meaning that the relative yield of agroforestry is 20-40% higher than the tree and agricultural components grown separately on the same overall area.

The “Economic LER” can be even higher since the financial value of the timber is higher per unit volume and many of the management operations are cheaper because of improved access to the trees. Additionally, a range of less quantifiable benefits are available like fruit or fodder production and the benefits to crops and animals of shade and shelter.

Finally, it should be stressed that much European forest land is left unmanaged, with no cleaning, pruning or thinning due to the cost and difficulty of this management. Agroforestry allows part of the revenue from agriculture to be invested in tree management, improving the quality of the trees and bringing together other benefits such as reduced fire risk.

*Example of Land Equivalent Ratio for an agroforestry plot with 70 trees/ha - Dupraz C. and Liagre F. Book Agroforestry, trees and crops. Ed France Agricole.*
It has been shown that agroforestry plots are the host to more insect species which predate on crop pests, meaning that the populations of aphids and other pests are often lower than in crop monocultures. Biodiversity is encouraged by the greater diversity of microhabitats created by trees. Birds, bats, carab beetles, hoverflies, endangered flowers, earthworms all increase in agroforestry systems. An increase in game animals can provide revenue from hunting.

Bees ensure pollination of over a hundred crop species. In the past, native bees and feral honey bees could meet the pollination needs of smaller orchards, fields of sunflowers or pumpkins and berry patches. Today many farms are large and have less nearby natural habitat. They rely on honey bees for crop pollination and pesticides to control weeds and pest insects. Agroforestry practices can help to reduce the unwanted side effects of pesticides and provide a refuge for native insect pollinators.

Windbreaks, hedgerows, riparian buffers and other agroforestry plantings offer a strong line of defence against drifting pesticide sprays, alternative resources for beneficial arthropods and a refuge in a landscape commonly treated with chemicals.
Using trees to reduce floods, erosion and nitrate leaching

Riparian areas naturally occur along most streams and rivers. These riparian areas are essential ecosystems.

Riparian areas can be enhanced and extended with agroforestry planting, particularly in areas which are mapped as ‘sensitive’ under the EU Nitrates Directive and the Water Framework Directive. The combination of reduced erosion and treeroot safety nets in agroforestry, with planted riparian buffers will stop much of the nitrate reaching watercourses.

Wide-spaced tree-rows have been planted in chevron patterns alongside some French rivers prone to flooding. The floodwater is therefore channelled into adjacent floodplains. The tree-rows tend to become choked with detritus and develop into natural bunds (or berms) which control floods more cheaply than traditional engineering works. In areas prone to flooding it is also possible to establish tree-rows at the top of artificial bunds (berms) where the ditches (swales) help to divert or hold floodwater.

This diversion of flood-water into afforested flood plains also improves water quality.

Tree roots in silvopasture make the soil more porous and assist the infiltration of water into pastures. This reduces surface runoff and flooding. Both silvoarable and silvopastoral trees tend to evaporate less intercepted rainfall from their foliage than denser trees in conventional forestry. Transpiration per tree is greater, but overall transpiration per hectare is lower than with conventional forestry or short rotation coppice. Furthermore, the water transpired tends to come from deeper in the soil.

Windbreaks, riparian plantations and trees planted with deep root system, also reduce wind and water erosion which are examples of what agroforestry can achieve.
Agroforestry, if adopted on a large scale, provides a mitigation strategy since trees enrich soil carbon, absorb carbon in their roots and store it in structural timber. Planting trees within agricultural land will reduce the net emissions of carbon and other greenhouse gases from agriculture.

Agroforestry also provides an adaptation strategy since it gives the opportunity for farmers to manipulate the tree canopy to provide shade for crops, to mitigate drought stress and to help adapt farming systems to the predicted shortening of crop-growing periods (driven by changes in phenology and earlier maturity).

Agroforestry systems have the potential to sequester up to 14 tons of CO₂ equivalent/ha/year (assuming between 100 and 150 trees/ha). A significant part of this carbon is injected into deep soil through the death and replacement of the fine tree-roots.

Both silvoarable and silvopastoral systems are effective in preventing fires. These currently destroy half a million hectares of forest and scrub annually in Europe and are predicted to become much more damaging as the climate warms up.

Tree foliage has also been shown as effective in absorbing ammonia (a particularly damaging greenhouse gas) emitted by high concentrations of farm animals and poultry. This is an argument in favour of planting trees around animal houses, or even better, allowing animals and poultry to graze within silvopastoral systems.

Boost your lands soil carbon content, store carbon dioxide and help fight climate change

Climate change has the potential to seriously hurt agricultural producers. The increased water and heat stress, coupled with more frequent extreme events like storms and floods may lead to yield reductions or crop losses.

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Diversification of farms and landscapes

Agroforestry allows considerable flexibility for a farmer. The land is almost always classified as ‘agriculture’ in the EU Integrated Administration and Control System (IACS), which is not the case with conventional forestry. Direct Payments are therefore retained for the lifetime of the plantation.

Trees can be thinned, highpruned or even sidepruned with a hedgecutter if they are casting too much shade on crops or pasture. Tree shade can be controlled by thinning and pruning, but if it becomes too high, late in the rotation, the crops can be replaced with grass. While trees seldom need fertilizers to become established on agricultural soils, they will benefit from fertilisers applied to crops and will grow faster than in forests.

Farmers tend to spot any disease occurrence on the trees quicker than would be the case in conventional forests. As an economic tool, agroforestry generates opportunities to create skilled jobs in arboriculture, and produces raw materials for other economic activities such as bioenergy, fruit production, and other craft products. It therefore diversifies farm types and creates a range ‘green veins’ in the landscape to link existing areas of forest and woodland.
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How?
Understand the processes of competition and mutualism

Agroforestry farmers should understand the interactions between individual trees and agriculture. Beneficial interactions between trees and crops should be exploited whilst minimising damage due to competition.

Trees and crops should exploit different sources of light, water and nutrients in both time and space. For example, maize or other tall crops can stimulate height growth in trees for the first 1-2 years. After that it is best to focus on winter-crops which achieve most of their growth before the tree is in leaf and which deplete resources in the upper layers of the soil.

The net effect is to force the trees to root deeper under the crop, due partially to ploughing and partially to a shortage of resources at the surface.

The art of agroforestry is to choose and manage trees and crops species to minimise competition and maximise mutualism.

Plan your project carefully and focus on high value agroforestry systems

Agroforestry is multifunctional. You can focus on the long-term investment in timber, or emphasise the ecological management of your farm.

Where possible, use high value timber species. Plant cautiously, focusing agroforestry on small areas each year. Consider mixing high-stem traditional fruit trees with timber species like hybrid-walnut, chestnut, cherry and ash. Olive and citrus groves can be mixed with timber species in southern Europe.

Think innovatively on the tree species, intercrops and cultivation methods to be used.

Choice of alley crops

Farmers should generally continue using the crops they are used to. With narrow tree-rows, 95% of an arable field can be kept in production and annual ploughing close to the tree-row can encourage trees to root more deeply. With mature trees it may be necessary to widen the unsown tree-rows. Herbicide spray may affect some species of tree, especially if these have suckers and treeshelters provide protection against this. Green mulches in the crop alley will benefit the trees.
Plant carefully and protect the young trees

Weed the soil well before planting. Use natural mulch, mulchmats or spot weeding for silvopasture and mulch or ploughing/harrowing for silvoarable. Consider subsoiling along silvoarable treerows to help the trees to root deeply. Space silvoarable treerows to match multiples of your spray-boom width.

Use the highest-quality planting stock available (preferably with green labels, signifying “selected”). Choose the youngest possible plants to benefit from their ability to develop root systems rapidly and don’t distort the roots while planting.

Control weeds in the tree-rows and prune rapidly-growing trees at least once a year if needed

Use cover crops, shrubs or herb-mixtures in the tree-rows to reduce weeding costs and to favour the biological control of pests and diseases. Mulches of wood chips, plastic or fibre will control weeds well and can increase soil-temperatures in northern latitudes and water availability in southern latitudes. Weed control is much easier and cheaper in agroforestry. The use of TUBEX treeshelter can even make it easier; in severe competition conditions mulching inside the treeshelter can be used. In the early years you need regular ‘formative-pruning’ to ensure that forks and multiple stems are removed. This labour-intensive operation can be significantly reduced and save money by using a quality treeshelter. After that ‘high-pruning’ is needed above the height of the treeshelter in order to remove branches in the bottom third of the tree.

Generally, any branch thicker than 2cm is removed. High-pruning ensures that knots are not present in the timber. This increases the timber’s strength, its suitability for veneer peeling or slicing and its value.
National Associations affiliated to EURAF

Belgium
AWAF - Association pour l’Agroforesterie en Wallonie et à Bruxelles
WERVEL - Werkgroep voor een Rechtvaardige en Verantwoorde landbouw
AF - Agroforestry in Vlaanderen

Czech Republic
CSPA - Český spolek pro agroesnictví

Denmark
POL - Plantning og Landskap

France
AFAC - Association Française Arbres Champêtres et Agroforesteries
AFAF - Association Française d’Agroforesterie

Germany
AG-AFD-GPW - Arbeitsgemeinschaft Agroforst

Greece
HAN - Ελληνικό Αγροδασικό Δίκτυο

Italy
AIIF - Associazione Italiana Agroforestazione
SISEF - Società Italiana di Selvicoltura ed Ecologia Forestale

Netherlands
AN - Agroforestry Nederland

Poland
OSA - Ogólnopolskie Stowarzyszenie Agrolesnictwa

Spain
AGFE - Asociación Agroforestal Española

Sweden
PS - Permakultur Sverige
ANNC - Agroforestry Network for Nordic Climates

Switzerland
IG Agroforst - Interessensgemeinschaft Agroforst

United Kingdom
FWF - Farm Woodland Forum

Portugal
CEF - Centro de Estudos Florestais (ISA, UL)

See also:
North America
AFTA - Association for Temperate Agroforestry

World
ICRAF - World Agroforestry Centre

A comprehensive list is available at www.agroforestry.eu/countrysection